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Characterization of institutional contexts for the planning and adoption of instructional innovations: a theoretical model*

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Abstract

The adoption of pedagogical innovations often faces challenges that lead to their discontinuation in educational settings. Among the possible causes is the interpretation of innovations as standardized solutions, in which the particularities of educational institutions are not considered before implementation. In this article, we propose a theoretical model structured around six axes of analysis to characterize educational institutions in relation to an object of knowledge of interest. The objective is to assist individuals in assessing the need for change and to guide the planning and evaluation of potential adoptions of pedagogical innovations in educational institutions. This objective translates into the following research question: How can an educational institution be characterized, with respect to the teaching and learning process of a subject area, to support the planning and evaluation of innovative pedagogical proposals? The axes proposed in response to this question are: (i) institutional profile; (ii) profile of the actors; (iii) problems or needs; (iv) current teaching practices; (v) conceptions, principles, and norms; and (vi) material and logistical context. The model was developed based on the literature regarding barriers and facilitators to the adoption of teaching innovations in science education, as well as the Theory of Diffusion of Innovations. The model's potential is explored through analysis of a real-world case

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involving a second-year high school class in the Physics course, along with a proposal for an innovative activity. We believe this model can contribute to research aimed at characterizing educational institutions, with a view to implementing and adapting teaching proposals that are tailored to the specific context of interest.

Keywords: *Pedagogical Innovation; Instructional Change; Diffusion of Innovations.*

I. Introduction

In the field of education, pedagogical innovations are often interpreted from a technical perspective, reflecting the business origins of the term "innovation" (Rogers, 2003). This understanding suggests that the mere adoption of a new practice could, on its own, solve problems in educational institutions. Thus, the prevailing idea is that the absence of innovation is the main obstacle to education and that its implementation would automatically bring advantages to the teaching and learning process compared to current practices. However, although the literature offers numerous pedagogical proposals (Araujo; Mazur, 2013; Santiago; Arenas, 2018; Costa; Batista, 2020), many of them are implemented only to a limited extent and are often discontinued (Henderson, 2005; Henderson; Dancy; Niewiadomska-Bugaj, 2012; Petter, 2021).

We observe that this search for standardized solutions tends to overlook the specific characteristics of each institution, treating innovations as universal and applicable indiscriminately to any educational context. We therefore believe it is crucial to identify the particular characteristics and needs of each institution before proposing a pedagogical innovation that effectively proves to be advantageous over current practices. In this regard, the literature offers empirical studies and tools aimed at identifying the factors that may facilitate or hinder the adoption of innovations in higher education (Henderson; Dancy, 2007; Bathgate *et al*., 2019; Sturtevant; Wheeler, 2019; Carroll *et al*., 2023). However, these studies generally conduct this contextual mapping only after implementation, based on case studies or interviews with those who tested the innovations.

In this article, we argue that understanding the institutional context is essential and should guide the planning and implementation of instructional innovations. Avoiding a purely technical approach and taking local circumstances into account are key steps in ensuring that proposed innovations are not only relevant and effective but also sustainable in the long term.

We present a model structured around six axes of analysis, designed to map an educational institution based on a specific object of knowledge, in order to assess the need for change and guide pedagogical innovations appropriate to its context. This object of knowledge may encompass a field, discipline, or specific body of knowledge. We consider that this process requires an understanding of the characteristics of the object of knowledge within the

institutional context (for example, teaching and learning practices in Physics), along with an analysis of the environment in which it is embedded. This goal translates into the following research question: How can an educational institution be characterized, in relation to the teaching and learning process of a subject area, in order to support the planning and evaluation of innovative teaching proposals? In response, we propose in this article six axes of analysis that enable the characterization of educational institutions: (i) institutional profile; (ii) profile of the actors; (iii) problems or needs; (iv) current teaching practices; (v) conceptions, principles, and norms; and (vi) material and logistical context.

We emphasize that the analytical frameworks proposed in this article are neither exclusive nor definitive; in certain cases, other frameworks may be equally necessary and useful in helping researchers understand the need for changes in teaching practices and in introducing innovations specific to the institution's context. However, this proposal provides a starting point that offers an initial framework and fundamental insights for identifying factors indicating the need for change and guiding the implementation of teaching innovations.

II. Previous studies

The process of adopting instructional innovations, which can contribute to better teaching and learning outcomes, is not without its challenges. Potential adopters of teaching innovations often face obstacles both during the implementation phase and in terms of continuity (sustaining the innovation over time), due to a wide range of perceived factors (e.g., Rogers, 2003; Henderson, 2005; Henderson; Dancy, 2007; Henderson; Dancy; Niewiadomska-Bugaj, 2012; Müller, 2017; Espinosa, 2019; Petter, 2021; Siqueira; Pinheiro, 2022). In this regard, it is essential to understand the factors that both hinder and facilitate the adoption of teaching innovations.

In light of this, several researchers have conducted exploratory studies to identify the barriers perceived by science teachers that hinder the adoption of teaching innovations (e.g., Michael, 2007; Henderson; Beach; Finkelstein, 2011; Brownell; Tanner, 2012; Shadle; Marker; Earl, 2017; Sturtevant; Wheeler, 2019; Carroll *et al*., 2023). Among these identified barriers are: concerns related to covering the subject matter; class size; classroom layout; financial rewards or reduced teaching load for the effort involved in instructional change; and student resistance to change (e.g., Henderson; Dancy, 2007; Dancy; Henderson, 2008; Henderson, 2008; Brownell; Tanner, 2012; Dancy; Henderson, 2012; Turpen; Dancy; Henderson, 2016; Shadle; Marker; Earl, 2017; Finelli *et al*., 2019; Sturtevant; Wheeler, 2019; Borda *et al*., 2020; Apkarian *et al*., 2021).

Another significant barrier cited by teachers is the lack of time for instructional change, both due to the time required to transition from a lecture-based class (traditional pedagogical approach) to a class incorporating teaching innovations (active learning strategies), and due to the course's workload (e.g., Henderson; Dancy, 2007; Dancy; Henderson, 2008; Henderson;

Beach; Finkelstein, 2011; Brownell; Tanner, 2012; Shadle; Marker; Earl, 2017; Finelli *et al*., 2019; Sturtevant; Wheeler, 2019).

Just as there is research dedicated to identifying barriers, there are also studies that seek to identify facilitators and perceived support for the adoption of instructional innovations. In the literature, some of the identified facilitators include: financial support; assistance from experts and/or experienced colleagues in adopting instructional innovations; support from colleagues and/or the institution to innovate; familiarity and/or prior experience as a student with the instructional innovation (e.g., Henderson; Beach; Famiano, 2009; Dancy; Henderson, 2012; Wieman; Deslauriers; Gilley, 2013; Foote *et al*., 2016; Borda *et al*., 2020; Apkarian *et al*., 2021).

In addition to identifying potential factors, Yik and colleagues (Yik *et al.*, 2022a) analyze the association between 17 adaptable factors[2] (identified through a literature review) and the adoption and effectiveness of instructional innovations in introductory STEM courses, as well as the time devoted to oral presentations in the classroom. Other studies propose instruments that may allow researchers to quantify the extent to which a teacher perceives teaching innovations to be feasible and to intervene to help potential adopters explore innovative proposals available in the literature.

In this regard, Sturtevant and Wheeler (2019) propose a research instrument (FIBIS, or Faculty Instructional Barriers and Identity Survey) to map the perceptions of university STEM faculty regarding the use of evidence-based active learning strategies, the barriers they face, and their professional identity. Following this line of research, Carroll et al. (2023) use FIBIS as the basis for developing a tool to measure teachers' perceptions of the barriers to adopting these strategies. The final instrument developed by Carroll et al. (2023) contains 17 items (rated on a seven-point Likert scale) distributed across four factors, namely: (i) student readiness and engagement (e.g., My students are reluctant to engage in active learning); (ii) instructional support (e.g., The educational support staff does not provide enough personalized support for me to make changes to my classes); (iii) teacher comfort and confidence (e.g., I feel more comfortable in the role of lecturer than in that of facilitator); and (iv) institutional environment/rewards (e.g., My colleagues generally encourage the use of active learning). The second study differs from the first in that it conducts both exploratory and confirmatory factor analyses to test the reliability and validity of the constructs of the developed instrument and in that it restricts the instrument's objectives to barriers.

We understand that research conducted by the community of scholars dedicated to the teaching of physics and/or science has been fundamental in identifying the various barriers and supports for the adoption of teaching innovations as perceived by teachers. However, although

[2] These include: subject area, type of institution, teaching load, job security, departmental evaluation of teaching performance, student evaluations of teaching, class size, classroom layout, faculty decision-making, and the effects of interaction depending on class size and classroom layout (*e.g.*, large classes with a layout conductive to group work), use of innovations as a student, scholarships, teaching-focused courses, teaching related workshops, new faculty members' teaching experiences, instructors' beliefs, and satisfaction with student learning.

these factors show similarities across the empirical studies analyzed, each educational context may reveal a distinct set of factors due to the variety of realities and perceptions among the individuals studied. Given this diversity and with the aim of assisting researchers interested in fostering change, this article proposes analytical frameworks based on factors identified in the literature and on concepts from the Theory of Diffusion of Innovations. These frameworks offer a way to map an educational institution in relation to a specific area of knowledge of interest. This mapping, in turn, seeks to assess the need for change and guide potential pedagogical innovations in this context by identifying factors that may indicate openness to instructional change, especially in the teaching of Science/Physics.

III. Theoretical framework – The theory of diffusion of innovations

In this article, we draw on the Theory of Diffusion of Innovations (TDI), developed by sociologist Everett Rogers (Rogers, 2003). This theory provides insights into how, why, and at what pace innovations are adopted by a social system. We consider this theory suitable for understanding the aspects involved in the decision-making process regarding innovation, and it has been gaining traction in science education through studies exploring the adoption and diffusion of pedagogical innovations (Henderson; Dancy; Niewiadomska-Bugaj, 2012; Dancy; Henderson; Turpen, 2016; Müller, 2017; Petter, 2021). According to Rogers (2003), the meaning of an innovation is socially constructed, and its diffusion is influenced by social, cultural, and subjective factors that shape perceptions and acceptance of innovations within a specific context.

For Rogers, the social system represents "a set of interrelated units that are involved in jointly solving problems to achieve a common goal" (Rogers, 2003, p. 41). These units can vary; they may be individuals or a group with shared goals. For example, in this article we propose analytical frameworks that can be considered from the perspective of different groups of individuals; therefore, it is up to the researcher to decide which social system(s) are of interest – that is, to choose a group of individuals (composed, for example, of administrators, students, and faculty) with a shared goal related to the subject of interest.

The model proposed by Rogers (2003) for the innovation decision-making process, which is not necessarily sequential, consists of five stages: awareness, persuasion, decision, implementation, and confirmation. In the awareness stage, the potential adopter is expected to identify what the innovation is, how it works, and its underlying principles (why it works). During the persuasion stage, individuals evaluate the innovation and its effects (advantages and disadvantages). In the decision stage, individuals – whether individually, collectively, or through an authoritative decision – decide whether to adopt or reject the instructional innovation. In the implementation stage, the individual is expected to put the innovation into practice. Finally, in the confirmation stage, the individual decides whether to continue or discontinue adopting the innovation.

This process can be influenced by characteristics of the innovation, the adopter, and the context. Regarding the innovation, its adoption may be facilitated, for example, by offering relative advantages over current teaching practices and/or by aligning with the values and needs of the context in which it will be implemented. In this article, we proposed the axes of analysis, considering both the characteristics of the individual adopter and the context in which teaching innovations may be implemented.

About the adopter, their socioeconomic profile (socioeconomic status/characteristics) (social status, such as wealth and prestige), their personality (personality values/variables) (e.g., empathy, degree of dogmatism, attitudes toward change, and ability to handle uncertainty and risk) and their communication behaviors (social relationships, such as contact with experienced individuals) can influence the decision to adopt an innovation. For example, consider a teacher with an innovative profile who is highly motivated to experiment with new teaching practices. This teacher tends to be more receptive to learning about and adopting an innovation than one who does not possess these characteristics. A teacher who is less innovative or less motivated may fail to recognize the benefits of the innovation and is less likely to adopt it.

As for the influence of the context in which the innovation will be introduced on its adoption, we can point to values, social norms, and resources. According to Rogers (2003), social norms are established patterns of behavior for members of a social system; they serve as a guide to what is acceptable within that system. The adoption of an innovation is easier in contexts where its characteristics are more compatible or where there is greater openness. On the other hand, when the decision-making process regarding innovation is complex and/or the system is highly formalized – that is, when it is necessary to follow rules and procedures – the probability of adoption or continued use is lower.

Furthermore, according to Rogers (2003), the following are prerequisites for the innovation adoption process: the potential adopter's prior practices; the needs or problems perceived by the potential adopter regarding current teaching practices; the innovativeness of the adopter (a translation of Rogers' (2003) concept of "innovativeness," which refers to the degree to which an individual anticipates the adoption of an idea relative to other members of the social system); and the norms of the social system in which the innovation is to be implemented (in this article, the educational institution). An example of a precondition would be a teacher being dissatisfied with aspects of their current classroom practice and feeling the need to seek out information about an innovation. All of these preconditions were considered in proposing the axes of analysis for this article.

This article examines various aspects of TDI to propose analytical frameworks that explore the need for change and can guide that change, based on an analysis of the factors that facilitate or hinder it. Among these aspects, particular attention is given to the preconditions and characteristics of the adopter and the context in which the instructional innovation (instructional change) is adopted.

IV. Theoretical development and discussion of the literature

Based on an analysis of relevant articles regarding barriers and facilitators to the adoption of teaching innovations in science/physics courses and TDI, we propose six areas of analysis to assess an educational institution in relation to a subject area of interest. This need to examine the particularities of the educational institution and the object of knowledge stems from our understanding that pedagogical innovations can and should be reinvented (adapted) in light of the specificities of each educational institution in which they are adopted (Rogers, 2003; Espinosa; Araujo; Veit, 2019; Percheron *et al*., 2021; Petter, 2021). We understand that this mapping enables the researcher to assess the need for modifications and guide potential instructional changes (e.g., adoption of pedagogical innovations) developed within the institution's own context or externally.

To identify these themes, we applied thematic analysis (Braun; Clarke, 2022) in an integrated manner to a set of four sources[3], chosen because they are related to the adoption of innovations or instructional changes, which is the objective of the proposed model. This analysis incorporated four main sources: (1) a systematic review of 66 reviews on educational innovation (Petter *et al*., 2025), which mapped conceptions of the concept and factors influencing the adoption of innovations; (2) a literature review on the implementation and diffusion of teaching methods in physics (Petter, 2021), which identified barriers and facilitators related to instructional change in physics education; (3) an empirical study on the adoption of the Peer Instruction method in Professional Master's Programs in Education (Petter, 2021), which analyzed dissertations and questionnaires to understand adaptations and challenges with the method; and (4) the theoretical framework, Everett Rogers' (2003) Theory of Diffusion of Innovations, used as a source of factors related to the innovation process. These sources were not analyzed independently, but rather by considering the interrelationships among them to identify patterns related to the adoption of teaching innovations.

The selection of these sources stems from the objective of comprehensively understanding the phenomenon of innovation, drawing on established evidence in the educational literature alongside theoretical elements that influence adoption and diffusion. The analytical procedure followed the steps of the thematic analysis outlined by Braun and Clarke (2022). These are: (i) familiarization with the data; (ii) generating initial codes; (iii) searching for themes; (iv) reviewing themes; (v) defining and naming themes; and (vi) producing the report (i.e., article and thesis). The analysis began by familiarizing ourselves with the data; we then identified expressions and elements describing barriers, conditions, and other factors, and marked these aspects relevant to our study in the sources. Next, the identified elements were grouped by themes, which were then reviewed in the following stage. Finally, we defined and named the themes, which represent the axes of analysis of the theoretical model proposed in

[3] Although the references cited were compiled by us, the main themes were developed by consulting the primary sources whenever necessary.

this article, and presented the report, which in our case was the model itself. These axes aim to enable the characterization of educational institutions in relation to an object of knowledge of interest.

We consider that the six areas of analysis to be investigated in relation to the subject of interest at the educational institution are: institutional profile; profile of the stakeholders; problems or needs; current teaching practices; concepts, principles, and norms; and material and logistical context. For each area analyzed, it is essential that the researcher take into account the perceptions of the units involved with the subject of interest. Our intention with these axes of analysis is for researchers to be able to map educational institutions in order to identify whether or not a change is needed and the main factors (barriers or facilitators) that may influence the decision to adopt or not adopt a teaching innovation in this context. In this way, the units of the social system of interest (i.e., the individuals and actors involved with the object of knowledge) can prepare for the successful adoption of pedagogical innovations, modifying them if necessary and/or clarifying their advantages compared to current teaching practices.

IV. 1 Institutional profile

Through the institutional profile dimension, the aim is to identify factors related to the characteristics of the educational institution under analysis that influence current teaching approaches regarding the subject area of interest. This includes the characteristics of the institutional context, experiences with teaching innovations implemented in recent years at the institution under analysis, whether related to the subject area of interest, and the support provided for such innovations.

Regarding the characteristics of the institutional context, we consider, for example, factors related to the institution's integration with the local community, internal institutional relationships (e.g., between teachers and among students), and the participation of local organizations and parents (or guardians) in educational activities. Likewise, the region in which the institution is located, for example, whether it is a suburban, rural, or urban institution, and the regions served by the institution, can influence the activities that teachers plan. For example, Pasqualetto (2018) noted that serving students from various municipalities in the region influenced both the criteria for defining groups and hindered the extracurricular activities he planned. Understanding the context in which the institution works, including the specific characteristics of the population served, the potential limitations or opportunities inherent to its location, as well as the sphere to which it belongs (e.g., state, federal, private), can help in deciding which changes to make to teaching practices and how to implement them.

Several factors identified in the literature as barriers and facilitators to the adoption of instructional innovations can be considered to illustrate an individual's familiarity with an instructional innovation. Namely: testing an innovation in the classroom (e.g., Rogers, 2003; Müller; Araujo; Veit, 2018; Petter, 2021); experience as a student or teacher with an active teaching method (e.g., Pasqualetto, 2018; Anthony *et al*., 2020; Petter, 2021); knowledge of

one or more innovations (e.g., Gresnigt *et al*., 2014; Sánchez-Mena; Martí-Parreño, 2017; Anthony *et al*., 2020; Pellas; Kazanidis; Palaigeorgiou, 2020). In addition, courses on teaching innovations for faculty or professional development (e.g., Santos; Figueiredo; Vieira, 2018; Markelz *et al*., 2020; Carrete-Marin; Domingo-Penafiel, 2021; Castillo-Martínez; Ramírez-Montoya, 2021) are also experiences before the time of the educational institution's analysis that are worth mapping, given the intention to analyze the possibility of changing current teaching practices. We believe that initiatives of this type could be developed by researchers in the field in Brazil, with the aim of disseminating teaching innovations and supporting individuals interested in innovating during the adoption process.

Finally, with regard to support, we are interested in aspects related to helping teachers innovate. For example: financial support; support from experts in innovation in analysis; political and pedagogical support from the educational institution; recognition and autonomy for teachers provided by the institution; and adequate working conditions for teachers (*e.g.*, Henderson; Beach; Finkelstein, 2011; Henderson; Dancy; Niewiadomska-Bugaj, 2012; Smith, 2012; Pasqualetto, 2018; Dancy *et al.*, 2019; Strubbe *et al.*, 2019; Sturtevant; Wheeler, 2019; Petter, 2021).

IV. 2 Profile of the actors

The actors axis refers to individuals within the educational institution who are involved with the subject matter of interest (i.e., individuals, members of the social system who seek to achieve a common goal). This axis aims to define who these individuals are and identify their profiles. The actors to be identified may include teachers, students, interns, administrators, and others involved with the object of knowledge. If there is a perceived need for change, we consider that, among these actors, the teacher and/or intern play a central role in the decision regarding the implementation of an innovation. This is because, according to TDI (Rogers, 2003), the characteristics of the adopter (in this case, the teacher and/or intern), such as socioeconomic profile, personality, and communicative behavior, directly influence the decision to adopt or not adopt a pedagogical innovation. We understand that, although it is important to focus on the profile of potential adopters due to their significant influence, it is also relevant to map the profile of other actors of the social system, who may (in)directly influence teaching practices related to the subject of interest.

About the profile of the stakeholders, the aim is to identify aspects such as socioeconomic status, personality, behaviors, and dispositions (adapted from Rogers, 2003). Among the possible elements to be mapped regarding students are motivation and interest in the teaching and learning process (Anthony et al., 2020) and student resistance to change (e.g., Henderson; Dancy, 2007; Finelli *et al.*, 2019; Andrews *et al*., 2020). We understand that this resistance to innovation may stem, for example, from disinterest or uncertainties students have regarding new teaching practices or from previous negative experiences with innovations, that is, student dispositions. It is worth noting that, although this example considers resistance on

the part of students, it may also come from other stakeholders, such as faculty, interns, and administrators at the educational institution. Another student behavior that can be considered in this context is reading and study habits, the absence of which can hinder the adoption of certain teaching innovations (e.g., Pasqualetto, 2018; Petter, 2021), such as those that propose pre-class activities for students to gain initial exposure to the content.

Regarding teacher profiles, factors that can be identified include, for example, teachers' motivation to innovate, their creativity, their personality, their innovativeness, and their communication behaviors (e.g., Rogers, 2003; Pundak; Rozner, 2008; Pasqualetto, 2018). Still regarding teachers, other factors that can also be identified in this dimension relate to how receptive teachers are to innovations and how willing they are to make an effort to plan and carry out innovative activities (e.g., Sánchez-Mena; Martí-Parreño, 2017; Hallinger; Bridges, 2017; Segovia; Romero-Varela, 2019; Anthony *et al*., 2020). Finally, we emphasize that the examples presented here do not represent an exhaustive list of the actors related to the subject matter who can influence the current teaching practices of an educational institution, as well as the potential adoption of pedagogical innovations in this context.

IV. 3 Problems or needs

Problems or needs constitute a framework for analysis aimed at identifying frustrations, dissatisfactions, and/or perceived needs among one or more institutional actors (e.g., teachers, students, and administrators) regarding the subject of interest. This state of frustration or dissatisfaction occurs "when an individual's desires exceed the individual's realities" (Rogers, 2003, p. 175). Such a perception of dissatisfaction/frustration may be: (i) the result of personal reflections by one or more institutional actors (e.g., teachers, students, and administrators) on the object of knowledge, potentially leading them to seek innovations that deliver the desired results; or (ii) the result of knowledge of an innovation that highlights previously unrecognized needs, which may motivate one or more individuals to learn about it. Both ways of perceiving a need or problem can lead an individual to decide to adopt a teaching innovation.

In the literature, we have identified several factors that represent potential problems or needs, which, in turn, may prompt instructional changes (the adoption of pedagogical innovations). For example: faculty and student dissatisfaction with the learning outcomes achieved through the current teaching practices at the institution under analysis (e.g., Henderson, 2005; Pundak; Rozner, 2008); and faculty perception of a lack of student engagement in educational activities (e.g., Hasni *et al*., 2016; Pasqualetto, 2018; Petter, 2021). By recognizing these needs, one or more institutional stakeholders can make informed decisions about implementing changes that address these demands. For example, Eric Mazur reports in his book, Peer Instruction (Mazur, 1997), that, based on conceptual tests, he realized that his students' conceptual learning gains were very small with lectures based on oral presentations.

Faced with this perceived problem, he developed and adopted the active teaching method, Peer Instruction.

Sometimes, problems or needs can be confused with barriers; however, they are different. The former refers to aspects that an individual recognizes as needing improvement – aspects that do not yet achieve the results they expect – in other words, aspects that motivate change. The latter represents those aspects that hinder the implementation of a pedagogical innovation, that is, those that impede change. For example, a lack of student engagement in educational activities is a problem perceived by teachers that can, in turn, pose a challenge to the adoption of pedagogical innovations aimed at making the student the protagonist of their own teaching and learning process.

IV.4 Current teaching practices

We define current teaching practices as all teaching and learning activities regularly carried out by students, teachers, and other individuals involved with the subject of interest (i.e., key stakeholders). In this section, the objective is for the researcher to describe the teaching practices related to the subject of interest and the institution itself. For example, the following should be identified: which pedagogical approach(es) the teacher(s) use(s) to teach specific knowledge; what knowledge is taught; which student assessment strategies are adopted by the teacher; and, if applicable, how teaching assistants (monitors) assist in the classroom. In summary, this research area seeks to understand how the teaching and learning process is being conducted and where there is room for innovation, based on an overview of the teaching practices that prevail at the institution under analysis and, if possible, specifically for the subject of interest.

Unlike the other themes, this one is not based on conditions and barriers identified directly in the literature, but rather on aspects related to an institution's practices regarding the subject matter – specifically, those preceding an innovation. For this theme, we consider studies that investigate the activities carried out in the classroom. Such studies frequently indicate that a large portion of classroom time is devoted to teacher-led lectures (Stains *et al*., 2018; Dancy *et al*., 2024), which characterizes a teaching style identified in the literature as a barrier to the adoption of innovations (e.g., Pasqualetto, 2018; Petter, 2021). This axis incorporates Rogers' (2003) concept of prior practices, which relates to routine activities carried out in the school environment prior to planning or implementing an innovation.

Finally, we present some examples that may illustrate this dimension. In the presence of a science lab technician, one aspect to observe might be how they act during lab classes, for example, whether they assist the teacher or prepare the environment and necessary materials. Other factors that can be mapped on this axis are related to the activities carried out by the students; for example, whether they solve exercises in groups or simply listen to the teacher and copy the lecture notes from the slides or the board.

IV.5 Conceptions, principles, and standards

The axis of conceptions, principles, and norms refers to the object of knowledge and the methods recognized as legitimate for its teaching and learning. Conceptions and principles encompass, for example, the beliefs of relevant institutional actors (e.g., teachers) and the ethical, moral, and pedagogical principles associated with the object of knowledge. Norms, in turn, represent the rules and standards of behavior expected and accepted within the educational institution, which guide the actions of relevant institutional actors (Rogers, 2003). In addition to norms, which Rogers (2003) considers a prerequisite for the innovation decision-making process, we suggest that the conceptions and principles of the educational institution may also influence this decision. In other words, this axis seeks to map elements that guide the actions and decisions of individuals involved with the object of knowledge of interest (i.e., relevant institutional actors) and that may influence the potential implementation of changes.

In this area, we aim to identify factors – sometimes related to behavioral patterns – that, according to the literature, act as barriers to innovation. For example, challenges related to the institution's educational objectives, how assessment practices (summative or formative) should be conducted, and the perception that the faculty member bears sole responsibility for student teaching and learning (e.g., Gresnigt *et al*., 2014; Pasqualetto, 2018; Erdman; Miller; Stains, 2020; Petter, 2021). Other factors that can be mapped within this axis are expectations, which can be understood as the prospects of achieving certain learning outcomes through the teaching practices used at the educational institution or through the adoption of pedagogical innovations. We understand that these expectations regarding the subject matter of interest shape and are shaped by the principles and norms of the educational institution. Various expectations related to improving teaching and learning through the adoption of pedagogical innovations are highlighted in research on this topic, such as expectations to improve educational performance and increase student participation in teaching activities (e.g., Anthony *et al*., 2020; Palomino, 2021; Petter *et al*., 2025). However, some institutional expectations can also pose barriers to the adoption of teaching innovations, such as the expectation to cover all course content (e.g., Henderson; Dancy, 2007; Petter, 2021) and to prepare students to pass external assessments (e.g., college entrance exams) (e.g., Petter, 2021).

These factors were included in this line of analysis because they reflect concepts, principles, and norms related to teaching practices and their desired, perceived, and established outcomes, as viewed by institutional actors regarding the subject matter of interest. Although at first glance these factors may not reveal a direct relationship among themselves, they can guide the educational practices adopted and, consequently, influence decisions to experiment with, implement, and consolidate changes, such as adopting teaching innovations.

IV.6 Material and logistical context

The analysis of the material and logistical context seeks to identify the availability and management of time, as well as physical and financial resources, for teaching practices –

whether currently implemented or of potential interest – at the educational institution, as they relate to the subject matter. Among the factors we hope to identify in this area are aspects related to the educational institution's infrastructure, such as resources available and/or used in classrooms to teach specific content. Likewise, the presence or absence of teaching laboratories and instructional support materials for teaching practices at the institution under analysis, especially those related to the subject of interest, is considered. The absence of these aspects appears in the literature as a barrier to the adoption of teaching innovations; those who specify this barrier point to a lack of: appropriate physical facilities, such as science or computer labs; resources, such as internet access; teaching materials, such as conceptual tests or open-ended questions regarding specific knowledge; and classroom equipment, such as computers or projectors (e.g., Henderson; Dancy, 2007; Hasni *et al*., 2016; Pasqualetto, 2018; Papadopoulos *et al*., 2020; Petter *et al*., 2025).

Concerning time-related issues, factors that may affect teaching practices implemented in the classroom, as well as the adoption of pedagogical innovations, are often linked to the low number of class hours per course or to their distribution (e.g., Pasqualetto, 2018; Petter, 2021). In this area, we also expect to identify factors related to the workday, more specifically, whether there is a teaching workload overload and how much time is available for teachers to prepare activities, provide feedback on them, and/or adapt to new practices (e.g., Pundak; Rozner, 2008; Smith, 2012; Sturtevant; Wheeler, 2019; Petter, 2021).

While proposing areas of analysis, we observed differences between research and teaching practices in the U.S. and Brazilian contexts across both higher education and K-12 education. For example, in this area, we identified a barrier in U.S. universities: the prevalence of classrooms with layouts unsuitable for active learning (e.g., fixed seating) (e.g., Henderson, 2005; Henderson; Dancy, 2007; Apkarian *et al*., 2021), which are uncommon in Brazil. On the other hand, in Brazil, especially in the teaching of Physics in Basic Education, the course load is increasingly reduced, and teachers face excessive workloads due to the financial and social devaluation of the profession. We believe it is important to emphasize that aspects such as these were identified and taken into account when proposing the axes of analysis presented in this article, to include as many factors as possible mentioned in the literature.

Table 1 presents a summary of the six analytical dimensions of an educational institution with respect to an object of knowledge of interest proposed in this article, along with a brief definition and examples of factors (barriers or conditions) for each dimension. The authors developed the factors listed in Table 1 to illustrate the expected responses for each axis, based on the references consulted during their development. Therefore, they do not represent a specific reference consulted, but rather a combination of the identified factors.

Table 1 – Key areas of analysis for an educational institution regarding a subject of interest, along with their definitions and examples.

Area of analysis	Definition	Examples
Institutional profile	Profile of the educational institution under review, including characteristics of its local context and experiences with pedagogical innovations – whether or not related to the subject area of interest – as well as the support provided for these innovations.	The institution is a federal institution located in the suburbs. The institution has partnerships with community organizations. The institution is considered elite. The institution is open to new teaching proposals.
Profile of the actors	Profile of the institutional actors involved in the subject of interest, in terms of their socioeconomic status, personality, behaviors, and dispositions.	Science teachers are open to trying new teaching methods; Students enjoy group activities; Most students are from middle-class backgrounds.
Problems or needs	Frustrations, dissatisfactions, and/or perceived needs among the institutional actors involved with the subject of interest.	Principal: students are not being prepared for the challenges of today's society; Students: lack of awareness regarding the relevance of knowledge; Teacher: student demotivation.
Current teaching practices	Teaching and learning activities related to the subject area of interest are regularly conducted at the institution.	Students work on textbook exercises in groups in the classroom; the teacher's lessons consist mostly of lectures.
Concepts, principles, and standards	Concepts, principles, and standards regarding the subject matter of interest and the methods considered appropriate for teaching and learning it.	The teacher is solely responsible for teaching what the student needs to know; the institution must prepare students for external exams; knowing physics means being able to solve textbook problems.
Material and logistical context	Availability and management of time, physical resources, and financial resources to support current teaching practices and others of potential interest.	The course has a light course load; Classes are held in classrooms equipped with projectors. The institution does not have science labs.

Source: prepared by the authors.

We understand that the proposed analytical frameworks do not exhaustively describe the objects of knowledge of interest in educational institutions. However, these frameworks

may serve as a first step toward characterizing the specific features of the educational contexts under analysis and, when necessary, assisting researchers interested in innovation. We believe that this can contribute to the adoption of pedagogical innovations. We emphasize that the research described here did not involve human participants; it consisted only of studies published in journals or university repositories. However, this article is the result of the author's doctoral dissertation (Petter, 2025), whose stages involving human participants were previously submitted to and approved by the Research Ethics Committee of the Federal University of Rio Grande do Sul, registered under number 76735924.6.0000.5347, in accordance with the ethical principles governing research in the field of Education.

V. The model's potential – a real-world example

To illustrate the potential of the proposed analytical frameworks, we examined the data collected by Dias (2018), a student in the final semester of the Bachelor's program in Physics at the Federal University of Rio Grande do Sul (UFRGS), and reported in her final thesis.

The Bachelor's degree program in Physics at UFRGS requires students to write and submit a report on their experiences in the required course "Teaching Internship in Physics," which is recommended for the final semester of the program. In the first phase of the course, students observe approximately 20 class hours of physics in one or more classes at a K-12 school of their choice. Simultaneously, they plan to implement approximately 14 class hours in one of the observed classes. The final project includes: reports on the observations made and the classes taught; lesson plans for those classes; and descriptions of the school, the classes, and the physics teacher they worked with. In other words, these projects describe the institutional context and the teaching practices carried out in the classrooms.

The intern, Dias (2018), observed 11 class hours in a second-year high school class at the Colégio de Aplicação (CAp) of the Federal University of Rio Grande do Sul (UFRGS). CAp is a federal K-12 school with sports courts, laboratories, specialized and well-equipped classrooms for various subjects, a library, and a computer lab. From the intern's perspective, the school stands out for its infrastructure, working conditions, and the educational opportunities it offers students, such as workshops and exchange programs. The school's educational goal is to develop competencies and skills in high school students.

The class observed by the student teacher met twice per week for 45-minute physics sessions and consisted of 34 students aged 16 to 18. These students showed little interest in physics class and talked a lot during lessons. In addition to characterizing the school, Dias (2018) sought, through his observation reports, to describe the class's physics teacher's teaching and the students' dynamics.

The lead teacher observed by Dias (2018) holds bachelor's and master's degrees in Physics from UFRGS and has been teaching Physics at CAp for over 10 years. However, the lead teacher had not received any pedagogical training by the time Dias (2018) collected his data. The observations indicate that the teacher's teaching style consisted of briefly presenting

the content orally, without relating it to previously studied material and without waiting for student feedback. Furthermore, the teacher did not seem concerned about whether students were following his presentations and appeared to be methodical in his classes.

Based on Dias's (2018) accounts, it is evident that classes were heavily focused on the textbook and on solving exercises, most of which involved mathematical formulas and calculations. Even when the teacher used videos or gave oral presentations on a particular concept, the textbook was referenced, either to assign exercises or to indicate where students could find the content. The activities planned by the teacher, such as group work, summaries, and workbook exercises, consisted mainly of reading and solving exercises from the textbook. For example, in one class, the initial introduction to a topic took place in the classroom through an activity that involved summarizing the topic using information from the textbook, guided by a set of questions.

Often, the students did not seem committed to the subject, did not concentrate on the classroom activities, and sometimes arrived late to class. Students showed slightly more interest and concentration when the teacher used videos to explain and present the content to the class. According to Dias (2018), students experienced difficulties and felt disengaged because of the textbook's emphasis on solving problems using equations.

The intern was also present during the time outside class hours when the physics teacher set aside two periods for students to ask questions. However, despite the difficulties identified by Dias (2018) among the students in the observed class, no students showed up, a pattern the teacher described as recurring.

During the student teacher's observation period, the physics teacher assessed student learning through two unannounced individual assessments containing qualitative and quantitative questions, as well as an assessment based on the summaries and solutions to textbook problems in the students' notebooks. Dias (2018) reports that this assessment of summaries and problem solutions in the notebooks was unannounced and used to penalize those who did not keep their notebooks up to date by deducting points, with no indication that bonus points were awarded to those who did.

V. 1 A possible analysis

Table 2 presents the analytical frameworks, examples of questions that can guide the investigation of the subject of interest in an educational institution (in this example, related to the physics course in a second-year high school class at a federal K-12 school), and examples of answers to these questions for the case reported by Dias (2018).

Table 2 – Areas of analysis, guiding questions, and answers based on Dias' account (2018).

Guiding question	Dias case (2018)
What is the **profile of the educational institution**?	The institution is federal; it offers extracurricular workshops; it has a diverse socioeconomic background; and it provides support for participation in scientific events.
What is the **profile of the actors** of interest?	The teacher is organized but not very flexible; the student teacher is proactive and helps the students; the students aren't concentrating on their assignments.
What are the **problems and/or needs** identified by those involved in the field of physics?	Students have difficulty solving problems that require mathematical knowledge. Students show no interest in the subject.
What are the **current teaching practices** related to the physics curriculum in the class in question?	The teacher explains the material verbally; the students work through exercises in the textbook; the teacher uses videos to begin some lessons.
What **concepts, principles, and standards** influence current teaching practices?	The teacher believes that students should be assessed using both qualitative and quantitative criteria; the student teacher believes that students do not pay attention during class activities.
What is the availability and management of time and physical resources (i.e., **material and logistical context**) for current teaching practices?	Two class hours per week, spread over two days; No information provided regarding lesson planning time; Classrooms are equipped with projectors; The institution has adopted a textbook for the course.

Source: prepared by the authors.

The educational institution in question, a federal-level institution, features a learning environment characterized by significant socioeconomic diversity. Students are admitted through a lottery system, which contributes to the formation of heterogeneous classes that reflect different social realities. In addition to curricular activities, the school offers extracurricular workshops that enrich students' education and encourage their participation in scientific events, fostering a spirit of inquiry and collaborative learning.

However, the dynamics of physics classes reveal certain challenges. The teacher, known for his organization, shows little flexibility regarding educational activities. His classes are predominantly lecture-based, with content presented orally, sometimes using videos that explore and contextualize the topics covered. The students, in turn, do not seem to be fully engaged in learning the subject. The lack of interest is palpable, and many students struggle with exercises that require mathematical knowledge, which is essential for understanding physical concepts. This situation is exacerbated by the students' limited concentration during classroom activities, a fact also observed by the student teacher, who proactively assisted the students at appropriate moments, offering support in solving exercises and attempting to capture their attention.

Classes are scheduled for two hours per week, spread over two separate days. Although the classrooms include projectors, the lesson planning does not appear effective enough to engage students. The teacher advocates an assessment method that accounts for both qualitative and quantitative aspects, but in practice, the current approach is not achieving the goal of promoting greater student participation. The use of the institution's adopted textbook, combined with the method for solving assigned exercises, does not seem sufficient to motivate students to delve deeper into the content.

Given this description of the institutional context, teaching approaches could be sought that promote:

1. **Encouraging student participation**: Teachers can implement active learning techniques, such as group discussions, debates and case studies. These approaches can encourage students to become more engaged in class, allowing them to express their ideas and ask questions collaboratively.
2. **Diversifying lessons**: In addition to lectures, incorporating hands-on activities – such as simple experiments or simulations – can make learning more dynamic and engaging. Interdisciplinary projects that connect physics to other fields of study, such as mathematics and the sciences, can also spark greater interest.
3. **Integration of technological resources**: Teachers can make use of a variety of technological resources to enrich their lessons. For example, online simulations and interactive physics software can help students visualize phenomena and understand concepts more clearly and engagingly. In addition, short, animated educational videos can supplement the material covered, making learning more engaging.
4. **Focus on math challenge:** Given that many students struggle with mathematics, the teacher may include remedial sessions that cover the mathematical concepts necessary for physics. These sessions can be conducted in collaboration with the student teacher, fostering a collaborative learning environment.
5. **Diversification of assessment**: Assessment should be more diverse, including not only tests and exams but also formative assessments such as group work, presentations, and projects. These forms of assessment can provide a more comprehensive view of students' learning and their progress over time
6. **Continuous feedback**: Teachers must provide students with ongoing and constructive feedback. This can be done through one-on-one conversations or small-group discussions, where teachers can discuss students' performance and suggest strategies for improvement.
7. **Adjustments to the class schedule**: Teachers may consider reorganizing class time by setting aside specific periods for questions and clarifications, as well as making time for hands-on activities and group problem-solving. This

flexibility can help create a more collaborative and less rigid learning environment.

Based on insights from analyzing the institutional context and reflecting on the potential of new teaching approaches to physics content, teachers or other stakeholders interested in promoting changes to current practices can assess how closely certain proposals align with or deviate from the intended goal.

V. 2 A potential innovation

For example, suppose the intern wants to innovate in her classes and decides to organize a competition in which students teach concepts of electricity. The competition includes group activities for students, such as problem-solving, hands-on experiments, and digital simulations, all related to the topic. In this case, for example, simulations based on a guide would explore the behavior of electric charges and test circuit variations in an interactive, visual way. In the problem-solving activity, students would be required to design a circuit and calculate the battery voltage needed to power an emergency lamp during a power outage. For the hands-on activity, students would assemble basic circuits to observe concepts such as current, voltage, and resistance, including the challenge of lighting up an LED (of their choice). Throughout the competition, the teacher would provide constructive feedback, encourage students to reflect on the results, and evaluate each group's progress while taking into account students' individual development.

The proposal developed by the intern aligns with several points suggested for the Dias case (2018). First, the competition encourages student participation by prompting collaborative work and providing opportunities to learn from one another. The proposal also offers students a more engaging and dynamic learning experience that goes beyond traditional lectures. The integration of simulations helps students visualize and test phenomena, enriching the learning process and facilitating the understanding of abstract concepts. Furthermore, the presented problem, which involves calculations, allows classmates to help one another and share strategies for overcoming mathematical difficulties, fostering a collaborative learning environment.

In terms of assessment diversification, the competition goes beyond traditional tests by adopting a formative assessment approach that accounts for students' performance throughout the activity. Students' learning can be monitored and guided by the instructor on an ongoing and individualized basis at each stage of the competition. Furthermore, the flexibility in the time allotted for students to complete the activities allows each student to learn at their own pace. Thus, some groups may devote more time to solving the exercise, while others focus on exploring the simulation.

Thus, the competition fosters a shift not only in the teaching strategies employed but also in the manner and depth with which content is taught and learned. This activity, planned by the student teacher, contributes to a more collaborative learning environment tailored to

students' needs, promoting personalized instruction and motivating students to engage in teaching and learning activities.

VI. Concluding remarks

This study presented an analytical model for characterizing educational institutions in relation to areas of knowledge of interest, taking into account social, cultural, personal, and institutional factors. The model was designed to assist in assessing the need for change and to guide the potential adoption of pedagogical innovations by identifying factors that may hinder or facilitate their implementation.

Based on a review of the literature on science and physics education, the theory of diffusion of innovations, and the authors' own considerations, we address the following research question: *How can an educational institution be characterized, in relation to the teaching and learning process of a subject area, to inform the planning and evaluation of innovative teaching proposals?* In response, we proposed six axes of analysis to characterize educational institutions in relation to subjects of interest: (*i*) the institutional profile; (*ii*) the profile of the actors; (*iii*) the problems and/or needs; (*iv*) current practices; (*v*) conceptions, principles, and norms; and (*vi*) the material and logistical context. Although these axes do not cover all aspects related to the object of knowledge of interest, they provide a potential framework for characterizing educational institutions and assessing the need for change. Furthermore, we did not intend to explore the axes of analysis of institutional contexts in their full depth. The researcher may even adapt these axes according to the adopted theoretical and methodological perspective, expanding or modifying them to meet the research objectives better. In the discussions on pedagogical innovation encouraged here, the valuation of the knowledge involved in the proposal must be understood critically and within its historical context, while simultaneously recognizing its social relevance and the limits and tensions that arise in relation to other forms of knowledge.

We recognize that every institution has its own unique circumstances, with distinct challenges, expectations, and culture. However, our analytical frameworks can be used to assess the need for change and to guide the implementation of pedagogical innovations, taking into account factors that may act as barriers or enablers in the context under analysis.

This model may have provided a valuable contribution to guiding the analysis of researchers and educators interested in pedagogical innovations. Furthermore, we believe that this study has contributed by offering insights into the feasibility of implementing pedagogical innovations in educational institutions.

For future research, we suggest conducting case studies to evaluate the model's application across different educational contexts. This could provide a deeper understanding of how pedagogical innovations are implemented in educational institutions and offer insights into improving educational quality. Furthermore, investigating the relationships between institutional characteristics and the implementation of pedagogical innovations could be a

fruitful area for future research. Similarly, developing strategies to overcome barriers and facilitate the implementation of pedagogical innovations in educational institutions could be an important objective for future research.

Evaluating the proposed analytical frameworks from the perspective of practitioners across different educational contexts could help validate and refine the presented model. This could enable the model to be used more effectively to guide the analysis of researchers and educators interested in pedagogical innovations. Finally, we acknowledge the limitations of this study. In particular, the adoption of the model by practicing teachers may require training and time to adapt. In this regard, we consider the development of supporting materials and tools—such as guides or analytical roadmaps—that assist teachers in applying the model in their contexts to be promising for future research.

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