



# Characterization of didactic planning regarding interdisciplinarity in the initial training of teachers of Natural and Mathematical Sciences

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**Abstract:** This study discusses the challenges faced by teachers in initial training in the area of Natural Sciences and Mathematics, in the task of developing interdisciplinary planning. The methodology used was a document analysis of the didactic plans. The objective was to identify the levels of interdisciplinarity achieved in the didactic plans developed by the groups. To classify the plans of the six participating groups, three levels of classification were used regarding interdisciplinarity: level 1, juxtaposition, level 2, integration and level 3, overcoming barriers. The analysis of the results indicates that of the six groups, one group is closer to level 1, three are at level 2, and two groups are close to level 3. The study reinforces the need for greater inclusion of interdisciplinary approaches in initial training courses so that future teachers can implement them in their professional performance, expanding their didactic-pedagogical repertoire in Basic Education.


**Keywords:** Natural and Mathematics Sciences. Initial Teacher Education. Interdisciplinary Planning.


## Caracterización de planeamientos didácticos cuanto a la interdisciplinarietà en la formación inicial de profesores de Ciencias de la Naturaleza y Matemáticas

**Resumen:** Este estudio discute los desafíos enfrentados por los docentes en formación inicial en el área de las Ciencias de la Naturaleza y Matemáticas, en la tarea de elaborar planeamientos interdisciplinarios. La metodología utilizada fue del análisis documental de los planeamientos didácticos. El objetivo fue identificar los niveles de interdisciplinarietà alcanzados en los planeamientos didácticos elaborados por los grupos. Para clasificar los planes de los seis grupos participantes, fueron utilizados tres niveles de clasificación cuanto a la interdisciplinarietà, siendo ellos: nivel 1, de yuxtaposición, nivel 2, de integración y nivel, y 3, de superación de barreras. El análisis de los resultados indica que de los seis grupos, un grupo está más próximo del nivel 1, tres se encuentran en el nivel 2 y dos grupos están próximos al nivel 3. El estudio refuerza la necesidad de mayor inclusión de abordajes interdisciplinarios en los cursos de formación inicial, para que los futuros profesores puedan implementarlos en su actuación profesional, ampliando su repertorio didáctico-pedagógico en la Educación Básica.

**Palabras-clave:** Ciencias de la Naturaleza y Matemáticas. Formación Inicial de Profesores. Planeamientos Interdisciplinarios.

## Caracterização de planejamentos didáticos quanto à interdisciplinarietà na formação inicial de professores de

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## Ciências da Natureza e de Matemática

**Resumo:** Este estudo discute os desafios enfrentados pelos docentes em formação inicial na área das Ciências da Natureza e Matemática, na tarefa de elaborar planejamentos interdisciplinares. A metodologia utilizada foi a de análise documental dos planejamentos didáticos. O objetivo foi identificar os níveis de interdisciplinaridade alcançados nos planejamentos didáticos elaborados pelos grupos. Para classificar os planos dos seis grupos participantes, foram utilizados três níveis de classificação quanto à interdisciplinaridade, sendo eles: nível 1, de justaposição, nível 2, de integração e nível, de 3 de superação de barreiras. A análise dos resultados indica que dos seis grupos, um grupo está mais próximo do nível 1, três encontram-se do nível 2 e dois grupos próximos ao nível 3. O estudo reforça a necessidade de maior inclusão de abordagens interdisciplinares nos cursos de formação inicial, para que os futuros professores possam implementá-las em sua atuação profissional, ampliando o seu repertório didático-pedagógico na Educação Básica.

**Palavras-chave:** Ciências da Natureza e Matemática. Formação Inicial de Professores. Planejamentos Interdisciplinares.

### 1 Introduction<sup>3</sup>

Initial education, predominantly, is marked by fragmentation and over-specialization of the specific contents, not occurring or occurring, in a very timid manner, the integration among the disciplines. The fragmented visions of knowledge show the lack of dialogue between the curricular components, which hinders the interdisciplinary process. However, when this newly graduated teacher finds himself in the job market, he is sometimes faced with schools that require a broader and more integrated view of the contents and demand a teacher who works in an interdisciplinary way.

Official documents suggest an interdisciplinary approach through the areas of knowledge, fulfilling the requirements of documents such as the Parâmetros Curriculares Nacionais (PCN) (BRASIL, 1999, 2006), the Lei de Diretrizes e Bases da Educação Nacional (LDB) (BRASIL, 1996), the Exame Nacional do Ensino Médio (BRASIL, 2009; 2013a), the Diretrizes Curriculares Nacionais da Educação Básica (DCN) (BRASIL, 2013b), and the Base Nacional Comum Curricular (BNCC) (BRASIL, 2018). The Diretrizes Curriculares Nacionais da Educação Básica (BRASIL, 2013b) guide the organization of the curriculum in areas of knowledge, the document also emphasizes that the methodological treatment should highlight the interdisciplinary

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<sup>3</sup> This article is an excerpt from a doctoral thesis defended in the Programa de Pós-Graduação em Educação em Ciências from Universidade Federal de Santa Maria written by the first author and supervised by the second author.

and contextualization.

Furthermore, other official documents such as the LDB (BRASIL, 1996), PCNs for High School (BRASIL, 1999), ENEM reference matrix (BRASIL, 2009, 2013a), DCNs for Basic Education (2013b), and BNCC (2018) indicate that teaching should occur through the areas of knowledge in a contextualized and interdisciplinary way. DCNs indicate that teachers should transpose the specific knowledge and development of their knowledge areas, planning, implementing, and monitoring curricular activities (BRASIL, 2013b). Fernandes and Silveira (2019) point out that even though the country documents and curricula encourage interdisciplinarity, little implementation occurs in practice.

In this context, interdisciplinarity is little evidenced in the different levels of education. Thus, we highlight that teachers end up not receiving the necessary training to approach teaching from a systemic point of view, and this is reflected in Basic Education. Researchers Feistel and Maestrelli (2012, p. 166) point out that:

Teachers who develop their teaching activities in Basic Education are required to develop a contextualized and interdisciplinary teaching, as the official documents propose to be followed in the school environment. However, teachers are generally not trained in interdisciplinarity, which makes it difficult for them to develop teaching from this perspective in their teaching practice.

Given the above, it is essential to look at teacher training regarding the need for an interdisciplinary approach to the educational process. Fazenda (2002) points out that teachers have not been prepared in universities to work in an interdisciplinary way and feel insecure to perform this task, this is one of the difficulties encountered. Thus, the importance of initial training that thinks about the interdisciplinarity process is justified, thus integrating their teaching practices. From this perspective, Pierson *et al.* (2008) point out that teaching education in educational institutions has a disciplinary bias that guarantees specificities of a particular area of knowledge. The authors also indicate that it is the educators' essential function to instigate their students to analyze and criticize reality and, for this, the integration of different knowledge is indispensable.

The construction of interdisciplinary work has the function of integrating the different knowledge of the curricular components while preserving their specificities. According to Araújo (2003), interdisciplinarity should make the disciplines communicative with each other, in which exchanges and cooperation should occur

between the professionals and areas involved, allowing a sharing of ideas and opinions between two or more disciplines. Interdisciplinary teaching should act in a critical and contextualized way, in which knowledge transcends the memorization of terms and decontextualized processes so that the knowledge of the different curricular components integrates the process of joint construction of interdisciplinary knowledge.

Besides the Basic Education documents mentioned above, the Diretrizes Curriculares Nacionais for teacher education (BRASIL, 2015)<sup>4</sup> present guidelines about teacher education as "the principles that guide the national common base for initial and continued education, such as solid theoretical and interdisciplinary training; [...] collective and interdisciplinary work (BRASIL, 2015, p. 2). Thus, it is possible to observe that the official documents guide interdisciplinary teaching, so that it occurs teaching with this perspective, it is essential to insert since the initial training so that the teachers in training activities in school environments within this interdisciplinary approach. However, there is still a gap between the indications given in the documents and what occurs in practice in most of the undergraduate courses in our country. Thus,

in order for the technical-pedagogical guidelines contained in official documents not to seem like theoretical recipes, with no connection to school reality, but to be effectively understood by teachers, it is essential that they have a growing repertoire of knowledge and actions, based on the perspective of interdisciplinarity. Thus, we understand that the educational processes need to involve the theoretical and methodological foundations of this perspective associated with a systematized reflection on their experience in the classroom, in the most varied educational spaces, in order to promote the constitution of new knowledge from the encounter of theory and teaching practice, in a process of redefinition of the practice itself. (AZEVEDO *et al.*, 2009, p. 2)

To carry out teacher training with the re-signification of the different knowledge with an interdisciplinary bias, from close up, is not an easy task, it provokes feelings of fear and refusal initially, besides involving many subjects in this process, such as the teacher trainers and the students in training. This fear and reluctance are by what Japiassú (2006, p. 2) states: "This is why interdisciplinarity provokes attitudes of fear and refusal. Because it constitutes an innovation. Every new is bothersome. Because it questions what has already been acquired, established, fixed, and accepted. In the

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<sup>4</sup> The research for this paper took place in the year 2018, the new National Curriculum Directive for teacher training was homologated in December 2019 (BRASIL, 2019), as well as the Base Nacional Comum Curricular (BRASIL, 2018) for high school was implemented only in December 2018, in this way, we justify the use of previous documents.

same way, Lück (1995, p. 88) also points out that: "the orientation by the interdisciplinary approach to guide the pedagogical practice implies breaking habits and accommodations, implies seeking something new and unknown". Faced with the difficulties, insecurities, and resistance to interdisciplinary teaching, it is essential to invest in teacher training in an attempt to change this panorama. In this sense,

Initial training courses (undergraduate) are strategic points to be focused on if we want to enable changes in the desired direction. Rethinking this training from an interdisciplinary perspective invites us to promote the confrontation of the future teacher with points of view of specialties different from his own, to enable a change in his relationship with scientific knowledge, in order to promote the exchange of knowledge with specialists from other areas to build a more integrated perception of science and a willingness to develop and implement interdisciplinary projects in his field of work. Initial training courses seem to us, then, a good scenario to stimulate these exchanges of knowledge, since they outline the profiles of future teachers (PIERSON and NEVES, 2001, p. 122)

The discussion about the need to modify teacher education is evidenced by several researchers (PIERSON and NEVES, 2001; FAZENDA, 2002; THIESEN, 2008; LEITE *et al.*, 2010; FEISTEL and MAESTRELLI, 2012; SHAW, ROCHA e FOLMER, 2017; DREHMER-MARQUES, EPÍNDOLA and SAUERWEIN, 2020) because initial teacher education is considered a very fertile field to initiate changes so that these will impact successively on the work done in Basic Education. Therefore, the transformations must leave the merely theoretical field, and practical actions of interdisciplinary implementations are carried out, as well as curricular changes in the degrees. Shaw (2020) points out that it is necessary to insert interdisciplinarity in teacher training today, enabling integration between knowledge and the search for solutions to problems. The researcher encourages the need to rethink the formative structure so that interdisciplinary practices are developed and evaluations are consistent in an integrative manner.

Still related to this situation of necessary modifications in educational institutions, Pombo (2005) emphasizes that it is essential to create mechanisms and circumstances that favor the understanding of interdisciplinarity in universities. Among the possibilities to assist in these mechanisms, raised by the author, we highlight two: promote the development of attitudes, habits, and forms of interdisciplinary work; and encourage the practice of teaching that promotes an ever deeper integration of knowledge (POMBO, 2005, p. 12).

This study aims to present the results obtained in the implementation of interdisciplinary practices, through a teaching project with teachers in initial training in the area of Ciências da Natureza e de Matemática (CNM), from a federal university in the interior of Rio Grande do Sul (RS). In this sense, we worked with interdisciplinary practices that contemplated the two aspects highlighted in the previous paragraph: (I) the development of attitudes necessary to carry out interdisciplinary work; and, (II) the integration of different knowledge.

In an attempt to contribute to the educational context and develop interdisciplinary experiences in initial teacher training, this article will discuss the development of interdisciplinary teaching plans, one of the activities developed in the Projeto Interlicenciaturas<sup>5</sup>. The objective of this study was to identify the levels of interdisciplinarity achieved in the teaching plans developed by the groups, according to the classification of Pombo (2005).

## 2 Methodological procedures

The research presented in this article is characterized by the qualitative approach, being used in the procedure of documentary analysis of teaching plans (LUDKE and ANDRÉ, 2015). The data sources of the present study are the plans prepared by the participants in the initial training of CNMs. In this research, six teaching plans built by teachers in initial training, participants of the project, were analyzed.

Therefore, a planning structure was elaborated to guide the participants, among the items that were present in the plan: subjects involved, teaching level, theme, contents, articulation among subjects, school year, time, objective, resources, teaching strategies, competencies, didactic action, conclusion, evaluation, and references. Some elements were divided, as in the didactic action, in which the groups should explain the introduction, the development, and the conclusion. Another divided item was related to "evaluation", the sub-items indicated were: criteria and instruments.

The option to prepare a structure as a model for the construction of the plans is justified by the fact that there were participants from different semesters of the

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<sup>5</sup>The Projeto Interlicenciaturas was conceived to develop interdisciplinary practices in initial teacher education. It aimed to discuss and implement, through a theoretical and practical approach, interdisciplinary didactic activities with undergraduate students in the areas of Natural Sciences and Mathematics. The name of the project is explained by the desired integration between the undergraduate courses (Interlicenciaturas). The Interlicenciaturas had as research subjects, undergraduate students of Biological Sciences, Physics, Mathematics, and Chemistry from a federal university in the interior of RS, in 2018.

undergraduate course. However, it is worth mentioning that the structure was only a model to guide the groups in the production of the interdisciplinary activity, they were free to include new elements they deemed necessary.

The interdisciplinary planning was built collectively, that is, carried out by the six work groups that remained until the end of the InterLacenciatura Project. The construction of the plans began in one of the face-to-face meetings of the project when the activity was presented. On this day, the groups started to discuss possibilities and draft proposals to compose the plan. The other moments of elaboration occurred virtually and in person, according to the availability of the participants.

In the first face-to-face meetings of each group, the researcher and creator of the project participated in these moments with the groups, guiding them and helping to organize the ideas in the construction of the planning. The orientations followed, after the face-to-face meetings, in a virtual way. The time dedicated to the elaboration of the plans was, approximately, two months. The orientations that occurred to help the groups in the elaboration were very fruitful, as some undergraduate students did not have the experience of teaching yet. The moments of orientation were constructive and fostered exchanges between the research subjects and the researcher, and among the undergraduate students belonging to the same group.

The undergraduate groups had the autonomy to choose the theme, year, content, and teaching strategies, among other items requested in the proposal. In the last face-to-face meeting of the Projeto Interlicenciaturas, the students presented their planning proposals orally to the other participants, and then there were moments of dialogue with questioning by the researcher and the other project colleagues.

For the analysis of the teaching plans prepared by the participants, a detailed reading was made, identifying the elements that were incorporated and the relations established among these elements. To systematize the data, they were summarized and grouped in tables throughout the text. In the analysis of the planning, we will investigate the level of interdisciplinarity achieved by the groups. We will use, in this study, the classification of the levels of interdisciplinarity of Pombo (2005).

The researcher Olga Pombo (2005) presents in the text "Interdisciplinarity and integration of knowledge", a classification of levels/degrees of interdisciplinarity that seek to overcome the disciplinary specificity, "an attempt to break the tight character

of the disciplines. But this attempt can be made at different levels, to different degrees" (POMBO, 2005, p. 5). The author characterizes three levels of interdisciplinarity to overcome the disciplinary approach, achieving integration of knowledge, namely: juxtaposition, interaction, and overcoming barriers (Table 1).

Table 1: Levels of interdisciplinarity proposed by Pombo (2005)

Levels of interdisciplinarity	Description
<b>Level 1: juxtaposition</b>	The disciplines are side by side but do not really "touch" each other, they do not establish interaction between them.
<b>Level 2: Integration</b>	There is communication between the disciplines, establishing integration to a greater or lesser extent. The disciplines keep their specificities, but interaction occurs between them, in certain moments and situations.
<b>Level 3: overcoming barriers</b>	In the third level "the barriers that separate the disciplines are overcome, they merge into something else that transcends them all". A deeper integration occurs, something close to a fusion or unification.

Source: Adapted from Pombo (2005)

To guide the analyses, the following elements were observed: starting point, development, and articulations between the curricular components listed by the groups. The details of the interdisciplinary planning developed in the Inter-Licenciatura Project and their respective analyses are presented in the next section, in the results and discussions.

### 3 Results and discussions

This study focused on the analysis of the last task performed of the Interlicenciatura Project, which consisted of the elaboration of an interdisciplinary plan. We emphasize that the plans were not implemented in the classroom, the task consisted of thinking of a proposal for interdisciplinary planning. At this point, we will investigate some elements present in the plans, aiming to investigate the levels of interdisciplinarity achieved by the groups.

In this section, we discuss the interdisciplinary planning developed by the groups. To understand the analysis made, we present Table 2, which summarizes the productions of the participants, highlighting the constituent elements of each planning.

Table 2: Summary of interdisciplinary plans

Grupo / Tema	Ponto de partida e desenvolvimento
<b>Group 1 (G1):</b> Seed germination	<b>Starting point:</b> Problem situation:



and plant development	<p>-Under what circumstances does a plant grow best and fastest?</p> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-Perform experiments, testing a variable in seed germination and development of the plant;</li> <li>-Notes in a logbook such as characteristics, size, color, questions, hypotheses, results, other information, and explanations;</li> <li>-Discussion of the data collected with the teachers of the disciplines involved about the factors that are altering the development of the plant; and</li> <li>-Final elaboration of conceptual maps, individual and collective, and preparation of a final report.</li> </ul>
<p><b>Group 2 (G2):</b> Food - diet</p>	<p><b>Starting point:</b></p> <ul style="list-style-type: none"> <li>-Observation of everyday food issues; and</li> <li>-Recording food and physical activities performed over the course of a week.</li> </ul> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-Introduction of concepts with lectures by subjects;</li> <li>- Calculation of calories from food and amount of exercise needed to spend them;</li> <li>- Proposal to calculate the total calorie intake of a day and the energy expenditure needed to consume it;</li> <li>-Production of a video with a healthy recipe, talking about: composition, calories of a portion, physical activity, and time needed to spend the calories in the recipe;</li> <li>-Presentation of the documentary "Super Size Me - The Clown's Diet";</li> <li>-Production of posters about unhealthy eating, based on the documentary; and</li> <li>-Final problem situation: the students will receive a supposed diet of a physically active young person and another of a sedentary adult. The challenge will be to analyze the diets and see if they are by the lifestyles presented. The groups will have to write a report addressing several criteria to justify the resolution of the problem with advice on health, spending and consumption, and food composition, and propose improvements for the individuals in question.</li> </ul>
<p><b>Group 3 (G3):</b> Yerba mate path</p>	<p><b>Starting point:</b></p> <ul style="list-style-type: none"> <li>-Introduction of the theme with video "Erva Mate - Scientists discover new properties of mate"</li> </ul> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-Group research on the production stages of yerba mate;</li> <li>-Each group will keep one of the production stages; later, the groups will present it to the rest of the class in the form of seminars;</li> <li>-A didactic game with the stages of production and processing of yerba mate;</li> <li>-An experimental practical activity to identify the cations of different brands of yerba mate;</li> <li>-an expository class on the physiological effects of consumption and a Kahoot game related to the concepts discussed in the class; and</li> <li>-Workshop on how to make a mate.</li> </ul>
<p><b>Group 4 (G4):</b> Radiation</p>	<p><b>Starting Point:</b></p> <ul style="list-style-type: none"> <li>-Expository-dialogued class on the concept of radiation, the history and discovery of radioactivity, as well as the scientific evolution and positive</li> </ul>

	<p>and negative applications of radiation.</p> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-Screening of the movie Pandora, in the sequence, discussion about the fiction and reality addressed in the video, entailing research for debate;</li> <li>-Mock jury on positive and negative aspects of radiation;</li> <li>-Expository lessons that will cover topics that were not covered in the previous classes. The classes will be for closing the activity with the use of videos;</li> </ul> <p>Problem situation:</p> <p>"You live in a city where the power comes from a nuclear power plant. Unfortunately, an accident has occurred, the plant starts emitting high levels of radiation, and the government warns everyone to stay indoors. Based on the interdisciplinary knowledge presented in the quarter argue about the main problems that can happen for the people of this city if they are exposed to high levels of radiation."</p>
<p><b>Group 5 (G5):</b> Collective versus individual transport</p>	<p><b>Starting point:</b></p> <p>Everyday problematizing questions involving the theme of transportation modes.</p> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-Selection of printed images of means of transportation, so that in groups students separate and classify the images using some criteria. The groups should write down in text form the criteria that were used and present them to the rest of the class;</li> <li>-Research on different countries and their energy matrices, as well as the relationship of this information with the most common means of transportation in these regions. Each work group will receive a different country to research;</li> <li>-Problematizing questions to begin the discussion of the energy problem in a more regional context;</li> </ul> <p>What is the most used form of energy in our city?</p> <p>From your perspective, what is the form of energy most used by your family?</p> <ul style="list-style-type: none"> <li>-From these questions, the problem related to the rice husk waste in the Santa Maria region should be discussed, as well as projects that explore the possibility of using this waste as an energy source;</li> <li>-Approach scientific concepts from their areas related to the theme; and</li> <li>-Performing a simulated jury, entitled "Urban Crossing Work, the city of Santa Maria and the culture of cycling" with problematizing questions to guide the debates.</li> </ul>
<p><b>Group 6 (G6):</b> Greenhouse effect</p>	<p><b>Starting point:</b></p> <ul style="list-style-type: none"> <li>-Performing a demonstration experiment on the greenhouse effect with questioning for discussion.</li> </ul> <p><b>Development:</b></p> <ul style="list-style-type: none"> <li>-After the introduction of the theme, the organization of knowledge that consists of teaching the physical, chemical, biological and mathematical concepts necessary to understand the phenomenon Greenhouse Effect, through expository classes with the use of videos, news, scientific dissemination texts and problematizing questions; and</li> </ul> <p>Preparation of seminars in groups about the socio-environmental impacts, prevention measures, and alternatives to stop the problems. What alternatives can be used to change these problems?</p>

Source: Prepared by the Authors, with data extracted from the plans, in 2022.

We can observe, based on Table 2, that the groups chose very varied themes, as well as their approaches. Of the six groups, only group 1 did not indicate in the planning the presence of an expository lecture, all the others, at some point, resort to this didactic. This result is similar to that obtained in the work of Azevedo *et al.* (2009), in which the authors analyzed the elements that constituted a collective planning process, prepared by undergraduates in an extension course on the interdisciplinary theme. This fact, perhaps, is due to the structure of initial training courses in Higher Education and Basic Education that have, for the most part, expository strategies, appearing in five of the six plans. We can think of collective strategies with an interdisciplinary approach, even with dialogical lectures, using the strategy of shared teaching<sup>6</sup>.

Sensitivity is needed to understand that the process of building interdisciplinary planning is not instantaneous, much less a simple task, it requires involvement and consists of a gradual process of action-reflection-action (SCHÖN, 1992). Therefore, it requires patience and time, it is not coherent to "demand" that teachers in initial training propose a "perfect" plan, interdisciplinary constructions are a continuous process, the subjects are eternal learners, and it is always possible to look over what has already been planned and visualize new possibilities.

Therefore, the proposal to develop interdisciplinary planning and reflect on it, at each newly constructed planning new possibilities and perceptions are glimpsed, based on previous experiences. In the same way, in the initial training process, even without implementing it, it would be possible to develop interdisciplinary planning, critically discuss and reflect on it and, at other times during the course, develop new planning, discussing and improving each new development, this is an eternally unfinishable process.

The problem situation was another didactic resource used by five of the six groups. The functions attributed to it were diverse, such as a way to start discussions (G6, G5, G1), development throughout the planning (G5, G4) or to close (G5, G4, G2), as a synthesis of the subject addressed, all with an investigative character. In interdisciplinary approaches, it is interesting that the problems "transit in more than

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<sup>6</sup> Shared teaching consists of more than one teacher in the classroom to promote educational activities. Shared teaching emerges as a possibility to be affected, to take part and participate with the other professional in a joint training that confers a teaching quality to the act of educating (HOCHNADEL and CONTE, 2019, p. 84)

one area of knowledge, and that their solution requires critical and systematic thinking, and, mainly, permeating all disciplines of the chosen set" (FERNANDES and SILVEIRA, 2019, p.118).

Regarding the strategy of problem situations, the document of the Orientações Educacionais Complementares aos Parâmetros Curriculares - Ciências da Natureza, Matemática e suas Tecnologias Nacionais (BRASIL, 2006) indicates the development of strategies for facing problem situations.

In this process, one must provoke the student's motivation, that is, create unbalanced situations to arouse interest. For this to happen, the teacher must invariably propose problem situations, challenges and instigating questions. (BRASIL, 2006, p. 55)

Still, about the analysis of the plans, we observed that three groups, G2, G3, and G5, presented in their proposals everyday life issues, which were, respectively, food and diets, consumption of yerba mate, and the use of public versus individual transportation. The didactic strategy that addresses the student's daily life, i.e., that considers their previous knowledge to approach specific concepts, provides a contextualized and more interesting teaching to the students because it is linked to the living reality of the subject (KATO and KAWASAKI, 2007).

In any case, the groups were concerned about creating situations close to the everyday life of the students as a way to contextualize the conceptual contents, giving meaning to their study. This characteristic is present in the documents PCNEM (BRASIL, 1999) and PCN+ (BRASIL, 2002) when expressing the need to give meaning to the scientific content taught. Other teaching resources were used by the groups, such as example, simulated jury (G4 and G5), experimentation (G1, G3, and G6), and videos (G2, G3, and G4).

The presented plans were classified into levels of interdisciplinarity (Chart 3), based on the ideas of Pombo (2005). To classify them, we analyzed the teaching plans in their entirety, focusing mainly on the starting point items, the development, and the articulations presented by the groups. We remind you that some groups ended their participation in the project with the absence of representative (s) from one of the curricular components.

Table 3: Classification of the level of interdisciplinarity in the planning

Grupo / Tema	Níveis de interdisciplinaridade
Group 1: Seed germination and plant development.	Level 3
Group 2: Food – diet.	Level 2
Group 3: Yerba mate path.	Level 1
Group 4: Radiation.	Level 2
Group 5: Collective versus individual transportation.	Level 3
Group 6: The greenhouse effect.	Level 2

Legend: Level 1- juxtaposition; Level 2- integration; Level 3- overcoming barriers.

Source: Prepared by the Authors, 2021.

The level 1 classification, juxtaposition, was attributed to G3, because in this plan the undergraduates listed a theme "Caminho da erva-mate" and there was no real interaction between the curricular components, they only discussed a common theme. In the planning it is not described how the dialog between the disciplines would occur, lacking details and integration. The group suggests activities without detailing them; by the analysis, we identified only one theme that links the curricular components. In the element of the plan "articulation among disciplines", the group described:

*During the industrialization of yerba mate, the processes of drying, sap drying, involve knowledge about heat, temperature, proportion of water loss, functions of temperature variation. In the experimentation it is necessary to know concepts about the periodic table, the issue of proportionality between substances. When presenting the physiological effects, the integration between the human body systems and the chemical composition of the yerba mate is perceived. In the workshop, the knowledge about temperature related to health and the measurements used in the making of mate is resumed. (G3).*

For the analysis of the plans located at level 1, it is important to highlight that there is no identification of the necessary concepts in each curricular component, but the group did not make explicit how they could be transferred across disciplines for the study of the chosen theme. For this reason, this planning was located at level 1 on Pombo's scale.

Groups G2, G4 and G6 were classified in level 2, in which there are moments of communication that enable the integration among disciplines. In the three groups mentioned above, it is possible to verify in the planning that integration among curriculum components occurs in certain moments, and moments in which the subjects maintain their specificities. Analyzing the plan of interdisciplinary activities and the item "articulation of the disciplines", we were able to identify elements that propitiate the

classification in level 2 of interdisciplinarity. In the plan, the item "articulation between disciplines", we exemplify the response listed by Group 4 in their planning.

*The chosen theme helps to complement the knowledge, because it is possible to integrate the knowledge of physics and chemistry in relation to the nature of the radiation effect, as well as its propagation in space and in nature. In relation to nature, the environmental effects of the action of radiation can be worked on, as well as the beneficial effects of its application to cure diseases. All of this information can be handled by mathematics with data processing and other auxiliary calculations. (G4)*

The groups listed at level 2 show a concern with the integration of the curricular components, but throughout the planning, it is possible to verify disciplinary moments. The groups managed to highlight the curricular contents and the possible dialogues that can be held between the different disciplines. We emphasize that all the constructions of the plans, in their different levels of interdisciplinarity, have their contributions and the passage from one level to another is a gradual process, differing mainly in the degree of articulation and integration between curriculum components. Japiassú (1976, p. 74) points out that "interdisciplinarity is characterized by the intensity of the exchanges between specialists and by the degree of real integration of the disciplines within a specific research project".

Groups G1 and G5 were classified in level 3 of interdisciplinarity, these groups performed planning with deeper integration between the curricular components. In these plans, the disciplines complement each other in such a way that a single curricular component does not explain the whole, only a part, requiring, then, the knowledge from other curricular components to explain the whole process. According to Thiesen (2008, p. 552),

There will only be interdisciplinarity in the work and attitude of the educator if he/she is able to share the domain of knowledge, if he/she has the necessary courage to leave the comfort of a strictly technical language and venture into a domain that belongs to all and of which, therefore, no one is the exclusive owner.

G1 proposed an experimental activity with an investigative character about the process of seed germination and plant development. The proposed activity would be extracurricular and the students would have to test through variable experiments and follow the process of germination and plant development. The group with the proposal intended that the interdisciplinary knowledge would be applied and explained as the

experiment was carried out. G5 built the interdisciplinary planning proposal with the theme of public versus individual transportation, involving energy and environmental issues. The disciplines are articulated throughout the various proposed activities. The two groups (G1 and G5), reached a plan with deeper integration, something close to a fusion. In the point of the element "articulation among disciplines", we can observe, in the fragment taken from G1's plan, the evidence of a greater articulation among the curricular components, described by the group.

*The articulation of the disciplines will occur through the application of an experimental extracurricular and interdisciplinary project, guided by an initial problem, in which physical, biological, and mathematical concepts will be applied and tested in a practical way. The integration of the disciplines will help in the understanding of the processes that involve plant germination and development. From a biological point of view, the approach to the subject requires concepts of plant physiology and morphology, as well as cellular metabolism. In physics, electromagnetic radiation and principles of thermodynamics, while in mathematics, concepts of functions, graphics, and statistics will be required. The articulation between disciplines will occur as the experiment is developed, since it aims to test different variables, stipulated by the students, that will affect the development of the plant. (G1)*

We emphasize that the interdisciplinary plan, as well as the perception of articulation between the disciplines, of groups G1 and G5, differs from the others, presenting a higher level of integration and articulation between the curricular components. Interdisciplinarity provides a way to approach processes and phenomena in their completeness, that is, under different aspects. A biological phenomenon does not present knowledge restricted to biology; it presents concepts and knowledge from several curricular components, thus making it possible to understand the phenomenon in its entirety. In this way, the interdisciplinary approach in the area of Natural Sciences and Mathematics propitiates analyzing the same phenomenon through the look and concepts of biology, physics, mathematics, and chemistry. In this sense:

We can say that we are faced with an interdisciplinary undertaking whenever it manages to incorporate the results of various specialties, borrowing from other disciplines certain methodological tools and techniques, making use of conceptual schemes and analyses found in the various branches of knowledge, in order to make them integrate and converge, after they have been compared and judged. Hence, we can say that the specific role of interdisciplinary activity consists, primarily, in building a bridge to connect the frontiers [...] (JAPIASSÚ, 1976, p. 75)

Given the foregoing, we envision interdisciplinarity as a bridge to connect borders, thus integrating the different fields of knowledge within their specialties, in the perspective of overcoming fragmentation and aiming at understanding phenomena

and processes in their entirety. We support the idea advocated by Fernandes and Silveira (2019, p. 120):

the use of interdisciplinarity for the approximation of learning through the rupture, even if temporary and punctual, of the limits created by the disciplines, providing processes of knowledge construction that are broader and more adherent to reality. However, we know that didactically, there are still obstacles regarding strategies and methodologies for the application of interdisciplinarity.

Among the obstacles that hinder interdisciplinary planning and implementation, we highlight how laborious is the development of plans and other activities with an interdisciplinary approach because they are often unprecedented constructions, with various challenges. When we think of planning groups with other colleagues, we must reflect on the challenges of time involvement and even the lack of teacher training with an interdisciplinary approach.

In this perspective, Rodrigues (2011, p. 126) emphasizes among the limits "the difficulty of thinking and acting as an area, in contrast to disciplinary training [...] the shortage of time for planning, difficulty in establishing a dialogue with other areas". Similar to the result obtained in this research, in which the groups participating in the Inter-Licenciatura project highlighted that it was difficult to develop interdisciplinary activities, the study conducted by Shaw (2020) pointed out that the undergraduate students reported difficulties in developing interdisciplinary practices in the planning of a workshop. These results are within expectations, since developing interdisciplinary practices is a complex task.

Therefore, it is possible to state that level 3 of interdisciplinarity is defined as that in which it is possible to overcome disciplinary barriers, where integration occurs close to unification. This level is the most complex and difficult to reach, we point out that at this level it is possible to occur sub-levels of different degrees of articulation such as initial, intermediate, and advanced. The advances in these sub-levels are obtained through readings, practices, time, and reflections, among others. Contributing to the discussion about the degree of integration of curricular components, Santomé (1998, p. 61) highlights:

In any case, it is important not to forget that, for interdisciplinarity to exist, there must be disciplines. The interdisciplinary proposals arise and develop by relying on the disciplines; the very richness of interdisciplinarity depends on



the degree of development reached by the disciplines and these, in turn, will be positively affected by their contacts and interdisciplinary collaborations.

As we have presented and discussed in this text, "the richness of interdisciplinarity itself depends on the degree of development reached by the disciplines" (SANTOMÉ, 1998, p. 61), the different degrees of articulation between the disciplines constitute the interdisciplinary approaches at its various levels. We reaffirm how laborious and complex the task of performing practices is with an interdisciplinary bias. Added to this is the idea expressed by Japiassú (1976, p. 82), who stresses how "truly interdisciplinary work is very arduous and its realization extremely difficult".

Given the above, we reiterate that teacher training with an interdisciplinary perspective should begin from initial training, for such is the complexity, the involvement, and the willingness to develop interdisciplinary planning, therefore, the such task involves different challenges, such as the issue of human relations, i.e., the difficulty of working in groups. We also highlight the difficulty regarding the availability of time to plan, since it is a major challenge, which is to overcome the barrier of specific training, i.e., to accept to leave their area and see beyond, to give in and glimpse the possibilities of integration between the conceptual knowledge of other curricular components.

Therefore, it is of substantial importance to have, from the beginning of teacher training, interdisciplinary approaches. These first experiences are of great value so that in the institutions of professional activity, whether in Basic Education or in Higher Education, the subjects can advance between the levels of interdisciplinarity. It is important to point out that:

interdisciplinary methodological experiences, in approach to the multiple educational realities, must be on the pedagogical projects of the teacher training courses, especially in the initial training courses held by the Higher Education Institutions. (AZEVEDO *et al.*, 2009, p. 2)

Thus, we reinforce the importance of approaches to interdisciplinary practices through the different stages of teacher training. Starting the first actions in the initial training, working on theoretical and practical aspects of interdisciplinarity, conducting projects, planning, and interventions in schools, through workshops, and throughout the curricular internships. Throughout the process of permanent teacher training, interdisciplinary activities can be planned and developed in the school where teachers

work.

As previously mentioned, we understand that developing interdisciplinary practices requires great involvement and commitment from a group of people willing to integrate their different knowledge. According to Azevedo et al. (2009), the development of interdisciplinary practices is justified as a necessary component of teacher training, since teachers will possibly, at some point, need the repertoire of knowledge and skills to develop interdisciplinary practices.

With the data obtained in this study, we emphasize that it is possible to plan activities with an interdisciplinary bias, the proposals presented great diversity regarding methodological conceptions and development. The different levels of interdisciplinarity reached in the graduates' plans demonstrate the relevance of stimulating the development of interdisciplinary practices from the beginning of education.

#### **4 Final considerations**

Based on what was exposed in this study, it is of substantial importance to reflect on the formative processes of teachers. The activities developed during the Interlicenciaturas Project stimulated the interdisciplinary approach, providing dialogues and articulations between the different knowledge. The interdisciplinary experience did not aim to annul the disciplines but to enable integrations between them, so that knowledge was approached broadly.

The proposed activity of building interdisciplinary plans allowed the students to experience the challenges practically. The six groups that remained throughout the project developed the interdisciplinary plans, proposing various activities throughout the development. This study analyzed the constructed plans and the levels of interdisciplinarity achieved. Only one group was classified in level 1, juxtaposition, in which there is no evident dialog between the disciplines, there is only one common theme. Three groups were classified as level 2, in which there is a more evident integration between the curricular components, and, finally, two groups were categorized as level 3, in which there is a deeper integration, something close to the unification of knowledge.

We point out, therefore, that to go from a level of less integration to a higher one

there is no ready answer, no recipe or formula. It is necessary to seek the development of interdisciplinary attitudes through reading, reflection, and the development of interdisciplinary work, with the support of the teacher Educators, and to promote practices that increasingly enable the integration of knowledge.

It is necessary to think about teacher training processes that help in the development of interdisciplinary practices. This study reports on the implementation of a teaching project, in which undergraduate students in the areas of Natural Sciences and Mathematics, from a federal university in the interior of Rio Grande do Sul, were invited to participate. However, this project occurred punctually, contributing only to the formation of the participating undergraduates.

However, we highlight the need for institutional changes, to rethink the curricula of the courses. We suggest, thus, the insertion of subjects focused on interdisciplinary practices in teaching, with theoretical and practical approaches. Furthermore, we point out the possibilities of addressing interdisciplinarity in the already existing courses, but the syllabuses need to be restructured to contemplate this bias. However, for there to be curricular changes, it is essential that the teacher educators have the support and preparation to carry out interdisciplinary practices, and also, that they believe in this type of proposal. The formation of the teacher educators, for the most part, comes from a specific disciplinary formation, making it difficult to act in an interdisciplinary way, therefore, the need to think, initially, about the formation of the teachers. Otherwise, just a curricular change would be a theoretical and not a practical modification.

Besides, it is essential to organize pedagogical strategies that enable the realization of interdisciplinary practices in undergraduate courses. The inclusion of interdisciplinary proposals in initial education is a constant challenge and involves the participation of the teacher educators, the undergraduate students, who also come from a disciplinary background, who need to solve the challenging task of reintegrating the knowledge from different curricular components and develop interdisciplinary practices.

We consider, therefore, that the results obtained in this work contribute to studies related to teacher education from an interdisciplinary perspective. We also indicate the potentiality of interdisciplinary practices in initial teacher education, such as the challenge of developing interdisciplinary planning with subjects from different

undergraduate courses (biology, physics, Chemistry, and mathematics). The authenticity of the plans and the levels of interdisciplinarity achieved by the teachers in training were perceptible. The results show us the relevance of similar research, which elucidates the challenges and the importance of the interdisciplinary approach in initial training, providing an interlocution of different knowledge, aiming at an understanding in its entirety.

Finally, we emphasize that this study pointed out possibilities of developing interdisciplinary practices in the initial training of future teachers. Moreover, the data obtained in this research must serve for future reflections on the training of students in the area of Natural Sciences and Mathematics, still marked by fragmentation and high specificity. We hope that the results will make it possible to rethink course curricula and the training of teacher educators. Thus, we reiterate the need for research that discusses the interdisciplinary approach in teacher education, fostering debates about interdisciplinary practices at different levels of education.

## References

ARAÚJO, U. F. **Temas transversais e a estratégia de projetos**. São Paulo: Moderna, 2003.

AZEVEDO, H. B.; LIMA, K. S.; BASTOS, H. F. B.; TENÓRIO, A. C. Interdisciplinaridade escolar: análise do processo de planejamento interdisciplinar de licenciandos em um espaço educativo alternativo. In: VII ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 2009, Florianópolis. **Anais do VII Encontro Nacional de Pesquisa em Educação em Ciências**, Florianópolis, Universidade Federal de Santa Catarina, 2009, 1-10.

BRASIL. **Lei nº. 9.394, de 20 de dezembro de 1996**. Lei de Diretrizes e Bases da Educação Nacional. Brasília: MEC, 20 de dezembro de 1996.

BRASIL. Ministério da Educação. **Diretrizes Curriculares Nacionais da Educação Básica**. Brasília: MEC, 2013b.

BRASIL. Ministério da Educação. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. **Matriz de Referência para o ENEM 2009**. Brasília: MEC/INEP, 2009.

BRASIL. Ministério da Educação. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. **Matriz de Referência para o Enem 2013**. Brasília: MEC/INEP, 2013a.

BRASIL. Ministério da Educação. Secretaria da Educação Básica. **Orientações Curriculares para o Ensino Médio: Ciências da Natureza, Matemática e suas Tecnologias**. Brasília: MEC/SEB, 2006.

BRASIL. Ministério da Educação. Secretaria de Educação Básica. **Base Nacional Comum Curricular: Ensino Médio**. Brasília: MEC/SEB, 2018.

BRASIL. Ministério da Educação. Secretaria de Educação Média e Tecnológica. **Parâmetros Curriculares Nacionais para o Ensino Médio**. Brasília: MEC/Semtec, 1999.

BRASIL. **Resolução MEC/CNE nº 2, de 1º de julho de 2015**. Define as Diretrizes Curriculares Nacionais para a formação inicial em nível superior (cursos de licenciatura, cursos de formação pedagógica para graduados e cursos de segunda licenciatura) e para a formação continuada. Brasília, 2015.

DREHMER-MARQUES, K. C.; ESPÍNDOLA, I. S.; SAUERWEIN, I. P. S. Teias interdisciplinares: a infindável construção dos fios da interdisciplinaridade na formação inicial de professores de Ciências da Natureza e Matemática. **Revista de Ensino de Ciências e Matemática**, v. 11, n. 7, p. 379-398, 2020.

FAZENDA, I. C. A. **Interdisciplinaridade: História, Teoria e Pesquisa**. 10 ed. Campinas: Papirus, 2002.

FEISTEL, R. A. B.; MAESTRELLI, S. R. P. Interdisciplinaridade na Formação Inicial de Professores: um olhar sobre as pesquisas em Educação em Ciências. **Alexandria Revista de Educação em Ciência e Tecnologia**, v. 5, n.1, p.155-176, 2012.

FERNANDES, J. C. N; SILVEIRA, I. F. Jogos digitais educacionais, práticas interdisciplinares e pensamento computacional: relações possíveis. **Revista de Ensino de Ciências e Matemática**, v. 10, n. 4, p. 116-136, 2019.

HOCHNADEL, S. B.; CONTE, E. Docência Compartilhada: possibilidade de inovação e ressignificação da atuação profissional? In: CASAGRANDE, C. A.; JUNG, H. S.; FOSSATTI, P. (Org.). **Desafios e Práticas Docentes na Contemporaneidade: as séries iniciais em foco**. Canoas: Unilasalle, 2019, p. 84-98.

JAPIASSÚ, H. **Interdisciplinaridade e Patologia do Saber**. Rio de Janeiro: Imago Editora LTDA., 1976.

KATO, D. S.; KAWASAKI, C. S. O significado da Contextualização no ensino de Ciências: análise dos documentos curriculares oficiais e de professores. In: VI ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 2007, Florianópolis. **Anais do VI Encontro Nacional de Pesquisa em Educação em Ciências**. Florianópolis, Universidade Federal de Santa Catarina, 2007, p. 1-12.

LEITE, V. C.; MESQUITA, N. A. S.; ALVARENGA, K. B.; BARBOSA, C. J. V.; FERREIRA, A. M. A Prática da Interdisciplinaridade na Formação Inicial de Professores de Ciências e Matemática: do Discurso à Prática. **Revista Anhanguera**, v. 11, n. 1, p. 35-62, 2010.

LÜCK, H. **Pedagogia interdisciplinar: fundamentos teórico-metodológicos**. 3. ed. Petrópolis: Vozes, 1995.

LÜDKE, M.; ANDRÉ, M. E. D. A. **Pesquisa em educação: Abordagens Qualitativas**.

2a Ed, Rio de Janeiro, EPU, 2015.

PIERSON, A. H. C.; FREITAS, D.; VILLANI, A.; FRANZONI, M. Uma experiência interdisciplinar na formação inicial de professores. **Revista Interacções**, Braga, Portugal, v. 4, n. 9, p. 113-28, 2008.

PIERSON, A. H. C.; NEVES, M. R. Interdisciplinaridade na formação de professores de ciências: conhecendo obstáculos. **Revista Brasileira de Pesquisa em Educação em Ciências**, v. 1, n. 2, p. 120-131, 2001.

POMBO, O. Interdisciplinaridade e integração dos saberes. **Liinc em Revista**, v. 1, n. 1, p. 3-15, 2005.

RODRIGUES, R. Reflexões sobre a organização curricular por área do conhecimento. In: MOLINA, M. C.; SÁ, L. M. (Org.). **Licenciaturas em Educação do Campo**, Belo Horizonte: Autêntica Editora, 2011. p. 123-147.

SANTOMÉ, J. T. **Globalização e interdisciplinaridade**: o currículo integrado. Porto Alegre, RS: Artmed, 1998.

SCHÖN, D. Formar professores como profissionais reflexivos. In: NÓVOA, A. **Os professores e a sua formação**. Lisboa: Dom Quixote, 1992, p. 79-92

SHAW, G. S. L. Formação interdisciplinar docente no Ensino Superior: uma proposta de avaliação. **Meta: Avaliação**, v. 12, n. 34, p. 181-210, 2020.

SHAW, G. S. L.; FOLMER, V.; ROCHA, J. B. T. Uma revisão sobre a interdisciplinaridade no ensino e a formação de professores. **Revista Ciências & Ideias**, v. 8, n.1, p. 202-226, 2017.

THIESEN, J. S. A interdisciplinaridade como um movimento articulador no processo ensino-aprendizagem. **Revista Brasileira de Educação**, v. 13, n. 39, p. 545-554, 2008.