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Research-training-action in plans developed by undergraduate biological sciences students

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ABSTRACT

This study aims to analyze the teaching plans of undergraduate students in the 7th phase of the Biological Sciences-Bachelor's Degree course, from the 2022/1 class of a Federal Public University, located in the northwest region of the State of Rio Grande do Sul, in order to highlight the presence of the stages of the ARTTS process and investigative methodologies. The research methodology used was documentary and included content analysis according to three stages: pre-analysis, exploration of the material, and treatment of the results. At first, the undergraduate students' Internship Conclusion Works (TCE) were read, from which it was possible to analyze four categories established a priori, such as series/year, network, hours/class, content/theme, action-research-training model in the teaching of science (ARTTS) stages and investigative methodologies, and, finally, the analysis and inference of the results found were carried out. Thus, from the 19 TCEs read, 45 teaching plans emerged, of which 13 were able to develop the 5 stages described by the self-reflective spiral of the ARTTS: problematization, planning, action, evaluation, and modification. Thus, ARTTS, in addition to enabling the development of investigative methodologies for teaching Science, such as investigative teaching (IT), investigative experimentation (I. Exp.), and educating through research (ER), also develops the critical reflection of the student and the teacher in the teaching and learning processes through the investigative process.

KEYWORDS: Teacher Training; Elementary Education; Learning in a Practical Situation; Learning Methods; Natural Sciences.

A investigação-formação-ação em planejamentos desenvolvidos por licenciandos de ciências biológicas

RESUMO

O presente trabalho busca analisar os planejamentos de ensino dos licenciandos da 7ª fase do curso de Ciências Biológicas-Licenciatura, da turma de 2022/1 de uma Universidade Pública Federal, localizada na região noroeste do Estado do Rio Grande do Sul, com intuito de evidenciar a presença das etapas do processo de investigação-formação-ação para o Ensino de Ciências (IFAEC) e de metodologias investigativas. A metodologia de pesquisa utilizada foi do tipo documental e contou com a análise de conteúdo seguindo as três etapas: pré-análise, exploração do material e tratamento dos resultados. No primeiro momento, foram lidos os Trabalhos de Conclusão de Estágio (TCE) dos licenciandos, dos quais foi possível analisar quatro categorias estabelecidas a priori, como: série/ano, rede, horas/aula, conteúdo/temática, etapas da IFAEC e as metodologias investigativas e, por fim, foi realizada a análise e inferência dos resultados encontrados. Assim, dos 19 TCE lidos, emergiram 45 planos de ensino, dos quais 13 conseguiram desenvolver as 5 etapas descritas pela espiral autorreflexiva da IFAEC: problematização, planificação, ação, avaliação e modificação. Deste modo, a IFAEC, além de possibilitar o desenvolvimento de metodologias investigativas para o ensino de Ciências, como o ensino investigativo (EI), a experimentação investigativa (Exp. I) e o educar pela pesquisa (EP), desenvolve também a reflexão crítica do aluno e do professor nos processos de ensino e de aprendizagem por meio do processo investigativo.

PALAVRAS-CHAVE: Formação de Professores; Ensino Fundamental; Aprendizagem em Situação Prática; Métodos de Aprendizagem; Ciências Naturais.

CONTEXTUALIZING THE INVESTIGATION-TRAINING-ACTION PROCESS IN SCIENCE TEACHING

Teaching Science is to show the world around us, with a sharp and analytical eye, developing literacy and scientific knowledge in students, providing familiarity with scientific knowledge and internalizing scientific language in an investigative and reflective manner.

Scientific Literacy is taken as "a process in constant development; a process that allows students to discuss themes of Science and how they are present and influence their lives and that of society, in addition to potentially bringing consequences to the environment" (Sasseron, 2014, p. 42).

Investigative teaching presents itself as a viable proposition for teaching and training teachers in this area, being essential in the process of investigation-training-action (IFA) (Güllich, 2013) in Science (IFAC) (Radetzke, Güllich & Emmel, 2020; Lunardi & Emmel, 2021) focusing on the use of investigation in the articulation of teaching processes and teacher training in Science through IFA in Science Teaching (IFAEC) (Bervian, 2019; Radetzke et al., 2020; Lima, Güllich & Bremm, 2024).

Thus, the three theoretical-methodological constructions: IFA, IFAC, and IFAEC are based on action research, experiential learning, and a reflective approach (Alarcão, 2010, p. 51), in which

> ... IFA implies both controlled intervention and practical thinking within the self-reflective spiral, which positions itself as an [inter]active intervention program, led by individuals committed not only to understanding the world but also to changing it through practical and critical reflection (Güllich, 2013, p. 289).

This intention that Güllich (2013) advocates, in terms of training and action, is a pedagogical intervention based on critical rationality that is provoked, intended, and aimed, and leads us to defend a proposal for investigative teaching in the Sciences that also has these assumptions. Following this line of defense, we find IFAC (Radetzke et al., 2020; Lunardi & Emmel, 2021) and IFAEC, proposed by Bervian (2019), which focus on the initial training of Science teachers.

These teachers in initial training seek to understand and reflect on their professional practice, including IFA in the process, as a methodology of teaching and learning (at the different levels of education/training that the process may transit), in which IFAEC becomes a modeled process aimed at teachers who teach Sciences in Basic Education. For this reason, it is necessary and "important that your training process provides you with support so that you can put your knowledge and experiences into practice" (Santana & Massena, 2024, p.3).

The proposal to develop Science activities in the classroom, so that Science teaching becomes investigative and formative, found in IFAEC (Bervian, 2019), is positioned as a self-reflective spiral, conceived as a macromethodology that understands and proposes teaching based on investigation-training in the teaching and learning process in Sciences (Lima et al., 2024).

Investigative learning in Sciences enables reflection, hypothesis formulation, problem-solving, the formation and understanding of concepts and scientific work, criticality, as well as argumentation (Batista & Silva, 2018).

> Investigative teaching aims, among other things, for the student to adopt some typical attitudes of scientific practice, such as questioning, reflecting, discussing, observing, exchanging ideas, arguing, explaining, and reporting their discoveries. This makes Investigative Teaching a didactic strategy in which teachers stop simply providing knowledge to students, who become more active, and not mere recipients of information (Batista & Silva, 2018, p. 99).

The role of the teacher in this perspective of teaching is, beyond teaching and producing school knowledge with investigative strategies, "to generate pedagogical knowledge, not just common, spontaneous, or intuitive, it must transform into capacity in action" (Imbernón, 2011, pp. 117-118) so that the teacher reflects not only on their practice but also on interests related to education and social reality (Imbernón, 2011).

IFA is based on critical rationality, from which arises the importance of developing investigative teaching in Sciences, in which reflection and criticality are present throughout the process, making the teacher a transformative agent in the teaching and learning process in Sciences, as by reflecting and questioning their practice, they propose investigative teaching, transforming the student into the protagonist of their learning process (Güllich, 2013).

Teaching Sciences through the investigative-formative lens considering IFAEC as a teaching methodology goes beyond reflection in action in the teaching process, it is to consider and think about the learning process in Sciences and the role of the student in this context.

The self-reflective spiral, proposed as a macromethodology for the development of IFAEC, considers the model of training and teaching based on critical reflection in Science Education (Bervian, 2019; Lima et al., 2024). For this reason, it is understood as an important methodology for the initial training process of future Science teachers, as well as considering the process of training and constituting the teacher through the lens of reflecting on their own practice. That is, in addition to considering investigative practices for teaching Sciences, it also focuses on the student's role in constructing their knowledge.

This study aims to analyze the teaching plans developed by teachers in initial training of the Biological Sciences Course - Licentiate, in the curricular component of Supervised Curricular Internship: Sciences in Elementary Education. The analysis will cover the contents, grades, time, network, and teaching methodologies used in the process, in order to highlight the presence of the stages of the IFAEC process in the teaching plans and investigative methodologies, from which it is believed to be possible to demonstrate the contextualization of the investigation carried out.

PLANNING THE INVESTIGATION ON TEACHING PROCESSES AND SCIENCE PLANNING CONTEXTUALIZING THE INVESTIGATION-TRAINING-ACTION PROCESS IN SCIENCE TEACHING

The research methodology planned for the development of this work was qualitative of the documentary type, developed through Content Analysis (CA) by Bardin (2011), in which the process of developing teaching plans present in the Internship Conclusion Papers (TCE) of students in the 7th phase of the Biological Sciences - Teaching Degree course, enrolled in the curricular component Supervised Internship was analyzed: Sciences in the Elementary Education of a public university located in the northwestern region of the State of Rio Grande do Sul, where teacher trainers of the course decided to propose in their internship classes the elaboration of teaching plans aimed at the practice of IFAEC, in which the component had as its general objective "Plan, execute and analyze the teaching practice through teaching in Sciences, reflecting articulately theory and systematized practical contexts" (Universidade Federal da Fronteira Sul [UFFS], 2018, p. 133).

It is important to highlight that the teachers in initial training were led to plan and develop a block of classes (a set of plans - planning) with teaching processes based on IFAEC, necessarily contemplating the stages of the self-reflective spiral as a macromethodology that models the process. And, for that, classes on this theme were taught in order to contextualize the process of IFA, IFAC, and IFAEC with concepts, theorization, presentation of the IFAEC model, the self-reflective spiral, and examples and teaching experiences.

For the analysis of the plans, the theoretical framework of Bardin (2011) was used, in which the three stages described by the author were followed: pre-analysis, exploration of the material, and treatment of the results. In the first stage, a complete reading of the TCE was carried out, and out of a total of 22 TCE, three were disregarded for analysis in the research as they had already completed the internship in the Pedagogical Residency Program and were only enrolled in the discipline for credit, thus, 19 sets of teaching plans (planning) were analyzed.

In the second stage, the teaching plans were effectively analyzed, with categories established a *priori*, such as: series/year, network, hours/class, content/theme, stages of IFAEC, and investigative methodologies (Table 1).

The third and final stage of analysis, in our qualitative analysis, triggered the inference of results and interpretation of qualitative results, in which the results produced by the data found were organized in discussion with the specific framework of the area and the objective of the research.

The planning and action of investigation presented in this work followed the ethical precepts of research with human beings, having been approved by the institutional ethics committee (Opinion N. 6620148). For that, the teaching plans are referenced from codes established a *priori*, being represented by P1, P2 (plan 1, plan 2) to refer to the theme in question and, TCE1, TCE2 (internship conclusion paper 1, internship conclusion paper 2) to refer to the teaching candidate who developed the lesson plan in question, maintaining confidentiality and anonymity in the analyses and publications.

EVALUATING THE DEVELOPMENT OF TEACHING PLANNING (AND FORMING IN) SCIENCES THROUGH INVESTIGATION

Thinking and planning the processes of teaching and learning through the self-reflective spiral enables the development of investigative teaching and a critical and reflective pedagogical practice, that is, teaching and forming in Sciences through investigation (Güllich, 2013).

Thus, training future Science teachers using IFAEC as a teaching methodology favors the development of an investigative pedagogical practice in the training teacher, presenting a whole theoretical methodological support for this practice, a process that also enables the investigation of action, through critical and reflective analysis of the teacher's own practice.

For better evaluation - analysis of the developed plans, Table 1 was organized in ascending order of the Elementary Education series, also presenting the teaching network, planned hours/class, content/theme of the lesson, the stages of IFAEC, in addition to the present investigative teaching methodologies.

Table 1

Plans that explicitly presented the stages of the self-reflective spiral of IFAEC

Code	Series / year	Rede	Hours / class	Content lesson theme	IFAEC*	Teaching methodologies**
P1 (TCE1)	7th grade	State	12	Machines, Fuels, and Thermodynamics	1, 2, 3, 4, 5	EI, Exp. I
P2 (TCE2)	6th grade	State	5	Synthetic materials	1, 2, 3, 4, 5	EI
P3 (TCE2)	6th grade	State	7	Chemical and physical transformations	1, 2, 3, 4, 5	EI, Exp. I.
P4 (TCE2)	6th grade	State	7	Cytology	1, 2, 3, 4, 5	EI, Exp. I
P6 (TCE3)	6th grade	Municipal	8	Photosynthesis and cellular respiration	1, 2, 3, 4, 5	EI, Exp. I
P9 (TCE4)	7th grade	Municipal	13	Continental Drift and natural phenomena	1, 2, 3, 4, 5	EI, Exp. I
P12 (TCE5)	6th grade	State	10	Cytology	1, 2, 3, 4, 5	Exp. I
P14 (TCE5)	8th grade	State	10	Electricity and consumption	1, 2, 3, 4, 5	EI, EP
P18 (TCE8)	6th grade	State	8 class hours	Cytology	1, 2, 3, 4, 5	EI, Exp. I

Code	Series / year	Rede	Hours / class	Content lesson theme	IFAEC*	Teaching methodologies**
P22 (TCE10)	8th grade	State	18	Electricity, consumption	1, 2, 3, 4, 5	EI, Exp. I
P29 (TCE12)	7th grade	Municipal	9	Public health policies	1, 2, 3, 4, 5	EI, Exp. I
P33 (TCE15)	6th grade	Municipal	6	Cytology	1, 2, 3, 4, 5	EI, Exp. I
P32 (TCE15)	9th grade	Municipal	6	Sustainability and preservation	1, 2, 3, 4, 5	EI
P5 (TCE3)	6th grade	Municipal	10	Cytology	1, 2, 3, 4	EI, Exp. I
P7 (TCE4)	6th grade	Municipal	11	Camadas da Terra	1, 2, 3, 4	EI, Exp. I
P8 (TCE4)	6th grade	Municipal	5	Hydrosphere	1, 2, 3, 4	EI, Exp. I
P10 (TCE4)	8th grade	Municipal	9	Rotation and translation movements	1, 2, 3, 4	EI, Exp. I
P11 (TCE4)	8th grade	Municipal	9	Solar and lunar eclipse	1, 2, 3, 4	EI
P13 (TCE5)	7th grade	State	10	Ecosystems	1, 2, 3, 4	Exp. I
P15 (TCE6)	8th grade	Municipal	10	Electricity and consumption	1, 2, 3, 4	EI, Exp. I
P16 (TCE7)	7th grade	State	18	Machines, Fuels, and Thermodynamics	1, 2, 3, 4	EI, Exp. I
P17 (TCE7)	8th grade	State	10	Electricity and consumption	1, 2, 3, 4	EI, EP, Exp. I
P19 (TCE8)	6th grade	State	8	Nervous system	1, 2, 3, 4	EI
P20 (TCE8)	7th grade	State	8	Machines, Fuels, and Thermodynamics	1, 2, 3, 4	EI, Exp. I
P21 (TCE9)	8th grade	State	18	Human reproduction, sexuality, contraceptive methods, sexually transmitted infections	1, 2, 3, 4	EI, EP
P23 (TCE10)	9th grade	State	7	Physical states of matter	1, 2, 3, 4	EI

Code	Series / year	Rede	Hours / class	Content lesson theme	IFAEC*	Teaching methodologies**
P24 (TCE10)	9th grade	State	11	Structure of matter and electromagnetic waves	1, 2, 3, 4	EI
P25 (TCE11)	6th grade	State	9	Chemical and physical transformations	1, 2, 3, 4	EI, Exp. I
P26 (TCE11)	7th grade	State	18	Machines, Fuels, and Thermodynamics	1, 2, 3, 4	EI, Exp. I, EP
P28 (TCE12)	7th grade	Municipal	4	Ecosystems	1, 2, 3, 4	EI, Exp. I
P27 (TCE12)	7th grade	Municipal	5	Bacteria; fungi; protozoa	1, 2, 3, 4	EI, Exp. I
P30 (TCE13)	9th grade	State	9	Technology and environmental impacts	1, 2, 3, 4	EI
P31 (TCE14)	9th grade	Municipal	2	Biodiversity and ecosystem	1, 2, 3, 4,	EI, Exp. I
P34 (TCE15)	6th grade	Municipal	3	Skeletal system and muscular system	1, 2, 3, 4	EI, Exp. I
P39 (TCE16)	6th grade	State	2	Synthetic materials	1, 2, 3, 4	EI, EP
P40 (TCE16)	6th grade	State	4	Renewable and non-renewable raw materials	1, 2, 3, 4	EI
P38 (TCE16)	6th grade	State	4	Chemical and physical transformations	1, 2, 3, 4	EI, Exp. I, EP
P35 (TCE16)	8th grade	State	4	Electricity, consumption	1, 2, 3, 4	EI, Exp. I
P36 (TCE16)	8th grade	State	2	Sources and types of energy	1, 2, 3, 4	EI, EP
P37 (TCE16)	8th grade	State	4	Renewable and non-renewable sources of electric energy	1, 2, 3, 4	EP
P41 (TCE17)	9th grade	Municipal	17	Colors and light, radiation and electromagnetic	1, 2, 3, 4	EI, EP
P42 (TCE18)	7th grade	State	4	Machines, Fuels, and	1, 2, 3, 4	Exp. I

Code	Series / year	Rede	Hours / class	Content lesson theme	IFAEC*	Teaching methodologies**
				Thermodynamics		
P43 (TCE18)	7th grade	State	6	Ecosystems	1, 2, 3, 4	EI, EP
P45 (TCE19)	8th grade	Municipal	7	Human reproduction, sexuality, contraceptive methods, sexually transmitted infections	1, 2, 3, 4	EP, EI
P44 (TCE19)	8th grade	Municipal	5	Sexual and asexual reproduction	1, 2, 3, 4	EI, EP, Exp. I

Source: Authors (2024). Notes: *Stages of IFAEC: 1- problematization; 2- planning; 3- action; 4- evaluation; 5- modification. **Teaching methodologies: EP – teaching through research; EI – teaching by investigation; Exp. I – investigative experimentation.

The **analysis of the stages of IFAEC** was developed from the reading of the 19 TCE, emerging 45 teaching plans that presented the IFAEC explicitly, which managed to reach the evaluation stage or even the modification stage, completing the entire path described by the self-reflective spiral that was considered in the planning, according to Table 1. Regarding the stages of IFAEC, 32 plans were found that presented only the first four stages (32:45), and 13 plans that managed to carry out the planning following the five stages of the spiral (13:45).

Among the plans that explicitly showed the **5 stages of IFAEC** are the TCE1 – P1 plan, TCE2 – P2, P3 and P4, TCE3- P6, TCE4 – P9, TCE5 – P12 and P14, TCE8 – P18, TCE10 – P 22, TCE12 – P29 and TCE15 – P32 and P33, on which this research dedicated greater attention to the analysis of the stages of IFAEC.

It was noted that for the teacher candidates it was necessary to explicitly state in writing in the plans the meaning/concept of each stage of IFAEC. Here are some conceptualizations, according to the understanding of the teacher candidates:

> **Problematic** Initial - Used for an initial reflection that will guide the lesson block: "How does the advancement of technologies impact the maintenance of life on Earth?" **Planning** - Seeks to answer the initial problem, and for this to be possible, lessons were constructed and thought out based on the problematic question. And it will be developed throughout the lessons. **Action** - Presents itself in the entire development of the planning and the lesson itself. As it refers to all the steps of the planning, being the action, the doing of the activities of development both of investigation, as well as debates, practices, and constructions of critical and social thinking. **Evaluation** - Refers to the analysis of the results in light of the developed lessons. **Modification** - Seeks to have a look at the final result and see the possibility of improvements and modifications that are deemed necessary. It aims to present what could be different and improved from what was done (TCE1-P1, 2022, pp.13-14);
>
> [...] the **Problematic** initial that will guide the lessons: What is the role of food production and its direct relationship with the production of oxygen for life on planet Earth? **Planning**: will be the processes of teaching science through IFAEC, which through dialogue via the posed question, students will start from a writing attempt to express themselves and relate

> why there is a direct relationship with oxygen and why it is so important for life on Earth... **Action**: Relates to the entire planning of the lessons where students will have continuous involvement in dialogue, the experiments developed during the lessons, so that investigative thinking can be included, where the student can raise hypotheses and make inquiries that aim at their learning, works, reflective writings, are the processes that will be carried out throughout the lessons. **Evaluation**: The evaluation of the teaching process through IFAEC will be a constant and ongoing process... **Modification**: To make a general analysis of everything that has been worked on, and gradually see which improvements could be inserted during the process so that what possibly did not have a positive or even desired result can be reviewed and modified. At this stage, it is important to rethink the way of working and seek alternatives that allow for greater learning (TCE3 – P6, 2022, pp. 39-40).

The constituent stages of self-reflective practice stem from the process developed in IFAEC, a perspective that enables teaching and learning processes based on critical reflection-action. Thus, the stages of IFAEC present themselves as a cyclical process initiated by the problematization of practices, followed by planning and action developed in the classroom, and finally, the evaluation and modification of pedagogical practice through continuous observation and reflection that permeate all stages of this process (Güllich, 2013; Bervian, 2019).

Regarding **problematization**, a fundamental stage in the investigative science teaching process, it is

> more strongly related to inter and intrapersonal contextual factors, concerning the development and planning of activities, it is the teachers' understanding of the problem and the problematization. This aspect also considers the guiding question that will trigger the other stages of the IFAEC model ... (Bervian, 2019, p. 171).

The problematization, in the analyzed plans, presented itself as:

> **Initial Problematization that will guide this set of classes**: How do tectonic plates shape the Earth's surface? I will leave some time again for you to try to answer. After the discussions and thoughts expressed, the students will develop a writing (planning and action) of a maximum of two paragraphs in their notebooks depicting points they consider fundamental that were brought up in the video. This writing will provide clues for them to try to respond with their understandings to the **initial problematization**: How do tectonic plates shape the Earth's surface? (TCE4 – P9, 2022, p. 14);

> ... (**initial problematization**): "What do you think these needs would be?" "What should the body of the simplest living being be like, considering its basic need for survival?" These will be written on the board and noted in the respective students' notebooks. Then, I will explain that to answer the questions, we will carry out an activity that will be developed through drawings, in which the class will be divided into groups of 4 to 5 members. (TCE15 – P32, p. 21).

Thus, like the other plans, in TCE1-P1, TCE2-P4, TCE3-P6, TCE4-P9 and P10, TCE5-P14, TCE12 – P29, TCE15-P32, TCE16-P40, issues/problems are mentioned at different stages, following the development in the classes, but always returning to the initial question throughout the knowledge construction process, which allows for reconstructive and continuous questioning that constitutes the problematization and is revisited, permeating other stages of the IFAEC.

The **planning** is the stage in which the explicitness of what was planned occurs. This stage goes hand in hand with the **action**, that is, the moment of development/practice of the planned activities.

> Once the problem is understood, it is urgent to **plan** the attack solution and put it into execution to then observe the results of the experience, conceptualizing results and emerging problems, **to plan or replan**, thus entering a new spiral cycle (Alarcão, 2010, pp. 53-54).

It was noticed that the teacher candidates manifested **action** in their own process of **planning** (developing the teaching plan) and vice versa, so that:

> **Action**: Presents itself in the entire development of the planning and the class itself, as it **refers to all the steps of the planning, with action being the doing of the activities of development** both of investigation, as well as debates, practices, and constructions of critical and social thinking (TCE4- P9, p. 41);

> **Action**: Furthermore, I will explain that at the end of the presentations, we will carry out the systematization of the students' answers, which will be extremely important **because it is only possible to think about doing, planning the action and then seeking the reflection of the work developed with the students** (evaluation stage of the IFAEC) (TCE15 – P32, 2022, p. 21).

Regarding **action**, it is perceived that the teacher candidates understand the investigative question as central, which is the objective of this macromethodology in terms of teaching activities (Bervian, 2019; Lima et al., 2024). On the other hand, it is also possible to notice the concern of the teacher in initial training with the formation of the investigative, critical, and social thinking of the students, as "practice, thought, and action (theory and practice) present a dialectical relationship, they are mutually constitutive, in a process through which thought and action constantly reconstruct themselves" (Carr & Kemmis, 1988, p. 51, own translation).

In developing their practice, the teacher candidate reflects on their performance and exercises their role as a citizen educator, in which "the IFAEC is directed towards the need to provide teachers with recognition of investigative practices and to guide the planning and development process of classes for students" (Lima et al., 2024, p. 3). Thus, reflection in action presents itself as the action in progress, in which one reflects on the reflection of one's own action, reformulating what one is doing while doing (Alarcão, 2010).

The investigative processes about action, present in the educational process, seek not only to solve the problems of education but to problematize, question, and interrogate practice and (re)orient it, in such a way that teaching is (re)constructed through the interaction between teacher and student in order to promote critical reflection (Contreras, 1994).

In the **evaluation**, a stage in which the student's learning is analyzed and reflected upon, through pre-established criteria, instruments, and evaluative records, as well as evaluating the teacher's practice, it was possible to perceive the evaluative process as a construction of knowledge that occurs through reflection. For, in this process, teaching and learning are thought of through the self-reflective spiral, which subscribes to a process of action investigation. Thus,

Proposing an investigative teaching approach to contribute to learning in the Sciences also means establishing evaluative criteria consistent with the content taught. It is very important for the teacher to establish the criteria to be evaluated, so that the evaluation is characterized as "a process that requires the skill to observe, (re)plan, guide, and monitor the path of reformulating the school

curriculum in action" (Krüger & Uhmann, 2021, p. 3), allowing for thinking and proposing the evaluation of learning to promote changes and meanings in learning.

Among the various evaluative criteria found in the TCE, those understood include those aimed at establishing a weight/grade for each activity (TCE15), others aimed at a final value considering students' understanding in the learning process (TCE14), even alluding to written memories in notebooks that recall the important element of IFA, reflective writings (Güllich, 2013), or only concerned with the punctual understanding of what had been studied (TCE2), as follows:

> The **evaluation** will be conducted during the classes; we will give 20% of the **grade** for participation in classes, 50% for completing the work, and 30% for the presentation. The evaluation of the planning will be considered satisfactory if students perceive how our actions affect the environment and can reflect on this thinking about their city and later globally (TCE15 – P32, 2022, p. 14);

> Evaluation: To systematize the discussion of this block, students will be asked to respond on a sheet of paper to the initial problematization "What should the body of the simplest living being be like, considering its basic survival needs?", writing what they learned about the subject; after this, the sheets will be collected to identify the knowledge that students acquired about Cells (TCE2- P4, 2022, pp. 26-27).

The evaluation needs to consider the whole, the process, all stages, and it is the teacher's understandings that guide the teaching and evaluation process.

The **modification** is a part of the IFAEC that can be thought of as a moment when "students together with the teacher in initial training were able to think and analyze which factors could be improved in the learning process, and how this could be addressed" (Lima et al., 2024, p. 4). Thus, the modification appears in the last stage of a turn in the self-reflective spiral, this in the first turn, as from the reflection on the action (retrospective), which results in the modification, a new stage/turn or a new spiral in the teaching and learning of Sciences begins, projecting itself as a reflection also for action (prospective). These two dimensions of reflection, retrospective and prospective, that permeate the IFA processes are outlined by Alarcão (2010) as indispensable to a cyclical and developmental characteristic of learning, which in teaching (IFAEC) we also outline as indispensable (Lima et al., 2024). It is important to emphasize that this stage was present in 13:45 analyzed plans, as in:

> **Modification** - Aims to look at the final result and see the possibility **of improvements and modifications that are deemed necessary**, which seeks to present what could be different and improved from what was done (TCE12 – P29, 2022, p. 44);

> **Modification** - this stage is focused on analyzing the final result, through which there is the possibility of **tracing modifications and improvements in the teaching process and pedagogical practice** (TCE5 – P14, 2022, p. 40);

Modification is adding something more to the evaluation, it is investigation of action, it is observation of the final result, it is verifying how the knowledge of students and teachers was consolidated. Therefore,

> ... when we implement training in an interactive process directly related to a teaching model, we are able to advance in responding to concrete professional needs, articulating theoretical references in overcoming the issue, still very present, of the distance between what is learned at university and what is taught in school. Therefore, the IFAEC model is fruitful and powerful, due to the collaboration among teacher subjects, in reflective movement, with investigative deepening to be appropriated by those involved, aiming at

> the learning of Basic Education students and undergraduate students in Sciences in Higher Education (Bervian, 2019, p. 169).

Thus, IFAEC is configured as an important methodology to be used from initial and continuing teacher training courses in Sciences to teaching practice in Sciences, as it allows for the development of reflection in an educational context.

It is important to emphasize that the self-reflective spiral is a macromethodology that was used for the development of these plans and, in this case, for the analysis of the IFAEC process, which considers five important stages for planning and action in teaching Sciences, namely *problematic, planning, action, evaluation, and modification* (Lima et al., 2024), which concern the teaching process and teacher training.

Among the **investigative teaching methodologies** presented in the 45 plans, the following stages of **planning** and **action** stood out, particularly the Investigative Teaching (EI) present in 41 of the 45 plans, the Investigative Experimentation (Exp. I) (29:45) and Educating through Research (EP) (11:45), of which only 13 managed to develop the 5 stages described by the self-reflective spiral. Thus, the investigative methodologies present in the 13 plans were:

I (10:13) and EP (1:13), in the most complete plans regarding IFAEC. EI (12:13), Exp. In the remaining 32 plans, the investigative methodologies appeared with the following frequency: I (20:32) and EP (11:32). EI (30:32), Exp. This shows that the teaching plans that managed to develop the 5 stages of the self-reflective spiral developed the investigation-training-action based on the content to be studied; however, EP could have been better explored. Regarding the 32 plans, there is a greater diversity of investigative methodologies used, which demonstrates the influence of IFAEC as an investigative methodology starting from the problematic and questioning about the themes related to the teaching of Sciences. Therefore, the prevalence of the choice of **Teaching by Investigation** for the plans in which IFAEC was developed, as, based on the guiding questions, the classes were organized and the path to be taken was better known by the undergraduates in their initial training process as interns, because from the teaching of Sciences through investigation, in which the "proposed by EnCI, students must understand, in addition to the conceptual content of science, the processes of 'doing' and 'talking' science in the classroom and engage in such processes" (Ferreira & Franco, 2021, p. 1228), these processes of EI contribute to the teaching and learning process in Sciences and scientific knowledge.

EI is the strategy that most presents itself among the chosen investigative teaching methodologies to work in Sciences, as they start from guiding questions/issues/problems of the theme to be studied, permeating and being present in all stages of the learning process, manifesting itself throughout the learning through problematic, as can be evidenced in the works where the "**Initial Problematic that will guide this set of classes**:

I will **leave again some time for them to try to answer**" (TCE4-P9, 2022, p.14), or the "Problematic: How do tectonic plates shape the Earth's surface? How do you believe the format of a cell is? **making them launch their answers orally and voluntarily to start the contextualization of the content**" (TCE2-P4, 2022 p. 25), still as the "initial Problematic - Aimed at provoking **initially a reflection that will guide the block of classes**: "Do you think it is possible to light a bulb using

potatoes, wires, and clips? If so, how does this happen?" (TCE16-P40, 2022, p. 12). In the teaching of Sciences through EI, there are also those problems that already present the entire path to be taken in that content/theme in question and, thus, other guiding and problematizing questions appear as introductory and investigative in the entry of the themes or, even, as a return of the studied content and the learnings being consolidated, such as, "At the first moment of the class, I will work on the theme Chemical Transformations, right at the beginning, on the board, I will write the following sentence:

Have you ever observed in your homes that sometimes fruits like bananas and strawberries rot?" (TCE2-P2, 2022 p. 17), or "Through this documentary, classes, slides, and texts provided, students will seek support to answer the initial question: How can the unconscious use of electrical energy lead to an environmental and energy crisis?" (TCE5-P14, 2022, p. 44).

Among the investigative strategies, there is also **Investigative Experimentation**, which presents itself as a differentiated methodology, providing students with different ways of learning, thus aiming to provide education for all students, in addition to promoting discussions and problematizations based on the results obtained, expanding scientific knowledge and also developing critical and reflective thinking about Science education. Thus, among the activities Exp. I that appeared in the teaching plans of the teacher trainees were:

> At the end of the activity and as a form of closure, I will ask them to write in their notebooks about the activity, the construction of the composter, how they believe it can help prevent diseases and problems to the environment, always emphasizing and reminding the problematizing question in their writings" (TCE12-P29, 2022, p. 48);
>
> After the roll call, **we will go to the school cafeteria to develop the bread dough experiment** (the main action of this class), with the students lining up to head to the cafeteria. Upon arriving at the location, we will make a **question** as a problematization of the class: what is fermentation and how does it occur? which will be redone in the **analysis and description of the practice**... Before the end of the **execution of the action - experimental class - a moment will be dedicated to the writing (reflection and evaluation) of the group about their understanding of the practice carried out by answering the following questions** (TCE3- P6, 2022, pp. 43-44);
>
> The fourth and final station will work with the function of body support, for this, there will be **two bones, one that was left in vinegar for five days** on the bench, the instructions are present in (Annex 4), and the **other normal**... It will be requested that **the students gather in their groups again and discuss the results they reached and relate them to their hypotheses discussed in the first stage of the class, then each group will present their conclusion, we will guide them so that everyone arrives at the correct answer** (TCE15-P34, p. 24).

It is important to emphasize that, for Exp. I to be successfully developed in the teaching and learning processes in Sciences, it is necessary for Science teachers to identify the potential of these activities from their planning and qualify "the experimentation processes that are present in the school curriculum and all its educational dimension" (Lopes; Hermel & Leite, 2023, p. 282).

The **Educate through Research**, methodology that was present in only 11 works, being: TCE5-P14; TCE9-P21; TCE16-P36, P37, P38 and P39; TCE17-P41; TCE18-P43 and; TCE19-P44 and 45, also demonstrated the use of this investigative strategy by few teacher trainees, as it showed the fragility regarding the little use and development of this investigative methodology, being used only four times by

the trainee author of TCE16, and two times by the author of TCE19, appearing in the lesson plans of the others only once, which shows that only six trainees made use of this methodology in question. This fact shows a certain fragility in the use of EP as a teaching methodology, as we can see when, for example:

> In the fourth class composed of two hours, the planning stage will occur, which we will address through a text (form16108591.pdf (eventoanap.org.br)) about the energy crisis, actions to save electricity, and **how the unconscious use of energy impacts the environment, through this and the data collected from research in materials selected by the students and also provided by me, the students will gather in groups and create posters** (or slides and mind maps, if they have access to the internet and a notebook) (TCE5-P14, 2022, p. 44);
>
> At the end of the class, I will give an activity to be done at home, the activity consists of: **conducting research on ways to minimize energy consumption in homes**, and what are the environmental impacts of energy generation in hydroelectric plants, I will indicate that **they conduct research on reliable websites on the internet** (TCE16 – P36, 2022, p. 19);
>
> The following **question will be used as a starting point to stimulate the students' work** - What reproductive characteristics will allow vertebrate animals to conquer the terrestrial environment?. When thinking about this question, they will create groups of 4 students to **develop a Lapbook** on certain animals, **for this they will conduct research on the animal that will be assigned to the group**. (The animal will be drawn) For the development of the Lapbook, **they will use the main research topics**: Reproduction; Life cycle, Ecological niche (environmental conditions, resources, and interactions that allow the survival of a species); Habitat; Curiosities (TCE19-p45, 2022, p. 26).

In this way, it can be seen that the questions, the production of arguments, and the systematization/communication of learning, considered as central elements of the EP, were developed in the analyzed classes. The EP "is not easily understood by teachers and students" (Galiazzi & Moraes, 2002, p. 238), as "... assuming education through research implies taking investigation as a daily practice in teaching activities." Research becomes a daily methodological principle of the class" (Galiazzi & Moraes, 2002, p. 238).

It is understood, then, that to propose teaching through research, the teacher needs to be/become a researcher as well, as this will provide a greater foundation to guide teaching based on the EP, since working with "the reconstructive questioning must become a daily attitude of the teacher, mediated by reflection, which also implies problematizing" (Kierepka, 2017, p. 68).

Moreover, the use of commercial films was also verified, as they encompass investigative teaching strategies, making students reflect and research the referred themes, with the films in question being: Confessions of a teenager; Precious: a story of hope; and Enigma: a steam turbine (TCE9-P21, TCE11-P26, TCE19-P45). The "use of films in the classroom can be a pedagogical methodology capable of promoting differentiated teaching through discussion, reflection, analysis, and interpretation of the film presented to students" (Günzel, Marsango, Both & Santos, 2019, p. 2), expanding the student's repertoire and enabling a broader worldview, as the films address various topics that are sometimes taboos in society, especially those related to sexuality and adolescence. Thus, films contribute to different methodological approaches in the classroom.

Although the investigative methodologies present in the teaching plans of the interns were not diversified, it is known that there are several, such as: problem-solving, conceptual maps, didactic sequences, pedagogical workshops,

photographic and audiovisual records, discussion forums, socio-scientific questions, letters, and pedagogical interviews (Marin & Güllich, 2024).

Investigative activities can be developed to teach science, as "teaching science through investigation allows for greater interaction of students in solving a problem, constructing questions, formulating hypotheses, analyzing evidence, drawing conclusions, and considering results" (Melo, 2012, p. 9). These strategies contribute to the diversification of activities that the teacher can use in their classes, in order to contribute to the development of their students "with activities that promote the development of autonomy and the ability to make decisions, solving and evaluating problems through concepts and theories of natural sciences" (Melo, 2012, p. 9). By using diversified strategies, the teacher will also be promoting group work, greater socialization of the class, investigation, development of critical-reflective capacity, and moments of interaction and exchanges among peers, as practical activities provide a greater understanding of concepts, considering the students' prior knowledge, in addition to making them more participative. (Melo, 2012).

Regarding the **teaching contents**, the themes that presented the highest number of teaching plans were: cytology (5:45); machines, fuels, and thermodynamics (5:45); electricity and consumption (5:45); chemical and physical transformations (3:45); ecosystems (3:45); synthetic materials (2:45); and human reproduction, sexuality, contraceptive methods, sexually transmitted infections (2:45). The contents that appeared only once in each teaching plan (1:45) were: renewable and non-renewable raw materials; photosynthesis and cellular respiration; layers of the earth; hydrosphere; nervous system; skeletal and muscular system; continental drift and natural phenomena; bacteria, fungi, and protozoa; public health policies; sources and types of energy; renewable and non-renewable sources of electric energy; sexual and asexual reproduction; rotation and translation movements; solar and lunar eclipses; physical states of matter; structure of matter and electromagnetic waves; technology and environmental impacts; biodiversity and ecosystem; sustainability and preservation; colors and light, radiation and electromagnetic.

The contents align with what was proposed by the National Common Curricular Base (BNCC), which is organized into thematic units that recur throughout Elementary Education, namely: Matter and energy; Life and evolution; and Earth and Universe (Brasil, 2018). Thus,

> The thematic unit **Matter and energy** encompasses the study of materials and their transformations, sources and types of energy used in everyday life, with the perspective of building knowledge about the nature of matter and the different uses of energy (Brasil, 2018, p. 325);
>
> The thematic unit **Life and evolution** proposes the study of issues related to living beings (including humans), their characteristics and needs, and life as a natural and social phenomenon, the essential elements for their maintenance and understanding of the evolutionary processes that generate the diversity of life forms on the planet (Brasil, 2018, p. 326);
>
> In the thematic unit **Earth and Universe**, the aim is to understand the characteristics of the Earth, the Sun, the Moon, and other celestial bodies – their dimensions, composition, locations, movements, and forces acting between them. Experiences of observing the sky, the planet Earth, particularly the areas inhabited by humans and other living beings, as well as observing the main celestial phenomena are expanded (Brasil, 2018, p. 328).

In this way, one can see the presence not only of the study of animals and plants in the 7th grade Sciences, for example, and not only the study of "*biologies*", specifically from 6th to 8th grade, in addition to chemistry and physics being present only in the 9th grade of elementary education, but it is understood, on the other hand, the implementation of the study of chemical and physical concepts and theories present in the Sciences content from 6th to 9th grade of elementary education, content that previously was not even included in the Sciences curriculum.

Changing the paradigm or the way Sciences classes have been conceived over the years, that is, altering the (re)organization of the Sciences curriculum content is something that needs to be perceived, analyzed, and discussed with the teachers who are in training. Even because these teachers, when carrying out supervised internships, may still be connected to the teaching methods of Sciences that they experienced when they were students in the school grades in question.

Therefore, it is worth remembering that the teachers in training have a certain experience and conception of the school reality, which can interfere and bring dilemmas to these teachers when a curricular reformulation is presented, sometimes destabilizing all those involved, directly or indirectly.

In this sense, the supervised curricular internship in Sciences presents itself as an important formative stage for the future teachers, as it is at this moment that they are being prepared for their future professional performance, through interaction and exchanges with their guiding teachers, since it is clear "the need for a practice of initiation to teaching accompanied by much reflection and investigation based on the guidance of qualified trainers during the training" (Garda, Wirzbicki & Lima, 2023, p. 2). Thus, the importance of developing an investigative teaching in Sciences is evidenced, through the self-reflective spiral proposed by IFAEC (Bervian, 2019).

In the analysis of the teaching plans, it can also be highlighted that the most presented contents followed the thematic units highlighted by the BNCC (2017), as well as followed the organization of the contents presented in the Sciences textbooks, which, being linked to this base, also follow these changes.

It was also possible to perceive in each year of Elementary School the quantity of plans related to each theme, as well as the choice or availability of classes by the schools where the internships were developed. Thus, the supervised internship is characterized as a "pedagogical didactic activity of a social order, which provides the student with participation in real situations, where they will have the opportunity to develop work related to their future profession" (Linhares et al., 2014, p. 123), which aligns with the syllabus of the CCR under analysis,

> The role of the internship in teacher training. Articulation of theory and practice through proximity to the school reality. Knowledge, diagnosis, and analysis of the school context. Internship planning. Theoretical foundation of the internship proposal. Integration of theory and practice through experiences, experiences, and knowledge production. Teaching practice in Sciences in Elementary School. Development of the Internship proposal. Execution of internship activities, investigation, reflection, and analysis of the situations experienced during the internship, theoretically grounded. Preparation of the internship completion work and production of experience reports (UFFS, 2018, p. 1).

As can be seen, the **grade** that presented the highest number of teaching plans was the sixth grade (16:45), followed by the eighth grade (12:45), the seventh

grade (11:45), and lastly, the ninth grade (6:45). While the **education network** that was present in these teaching plans was the Municipal (27:45), followed by the State (18:45). The increase in the supply of education in the municipal public network is due to the transfer from the State to the municipalities, through the Fund for the Development of Basic Education and the Valuation of Education Professionals (FUNDEB). Furthermore, according to the Law of Guidelines and Bases of National Education (LDBEN, Law No. 9,394, 1996), the State, together with the municipalities, must offer Elementary Education close to the homes of children and adolescents, thus expanding the municipal public education networks.

The **hours/classes** are directly related to the classes in which the internships were carried out, that is, if a student teacher developed their activities in two sixth-grade classes, their classes are concentrated in those classes and, in greater quantity, while other student teachers developed their internship in several classes, which generated a variety of plans, but with a lower workload.

These choices of student teachers also align with the time to develop the internships, taking into account the weekly hours/classes of each class. Thus, we notice the number of plans developed by the interns, where TCE16 presented the highest number of plans, six plans, followed by TCE4, with five plans, hence the diversity of themes and the total number of plans analyzed (45).

Moreover, it is worth noting that the teaching of Sciences based on the self-reflective spiral proposed by IFAEC, in addition to guiding the use of activities aimed at developing investigative teaching, allows for reflection in practice, for practice, and for learning in Sciences.

UNDERSTANDING THE PROCESS IS TO PROPOSE MODIFICATIONS: THE CONTEXTUALIZATION AS A PROPOSITION

IFAEC presents itself as an important methodology for the Teaching of Sciences, as it contributes to the teaching and learning process, where the student is encouraged to think and engage with the subject studied, in addition to the teacher questioning the teaching and learning process, as well as their own training in Sciences.

In this IFAC process, *modification* is found as a privileged stage of the self-reflective spiral, where the teacher reflects on their action to modify it, noting that this was the stage least achieved by the plans evaluated in the study. At this moment, it is important to write about and for practice, so that their performance/teaching transforms into an investigation, at this stage the teacher becomes an actor and author of their lesson and thus: a researcher/investigator of their own practice, re-elaborating knowledge and thus also developing their self-formation.

It is understood and interpreted in this process that ***contextualization*** is an innovation and, therefore, the proposition/modification emerges from this scenario, which can be part of the context of a class or research, whether from a theme and problem that emerged from the classroom or research context, or even starting from the institutional context that may follow guidelines such as those of the BNCC or its maintainer, or still, the context of the teacher's training that is made available for the research process of their own practice.

It is important to emphasize that contextualization here presents itself as a proposition that emerges from this and other teaching and research experiences with IFA and encompasses: observation, problematization, and reflection, contained in an initial and procedural moment.

It is also important to advocate for IFAEC as a teaching proposal to be disseminated/used in initial and continuing training courses for Science teachers and in teaching practice in Sciences, as it allows for the development of reflection on practice, in practice, and for practice with the subjects involved.

Therefore, turning to the understanding of the teaching process, and stimulating student learning through IFAEC, improves the study experience, both for students and for teachers, placing both parties involved to experience the stages of the self-reflective spiral.

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