DEVELOPMENT OF EFFECTIVE TEACHING PRACTICES IN HIGHER EDUCATION IN SOIL SCIENCE

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ABSTRACT

Higher education in soil sciences needs to adapt to contemporary demands, using innovative and interactive pedagogical practices to promote students' autonomy and critical thinking. Teaching should involve the practical application of knowledge, such as the diagnosis of agricultural inputs, to connect theory and market reality.

Keywords: Higher education. Active methodologies.

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INTRODUCTION

We live in an educational scenario in constant transformation, where pedagogical innovation is naturally the great challenge of today's higher education. A relevant aspect of higher education didactics is its ability to adapt to the contemporary demands of education, incorporating technologies, active learning methodologies, and interdisciplinary approaches (Silva et al., 2024). According to the same authors, this didactics of higher education should be converted into pedagogical practice that focuses on the formation and development of effective teaching methods in higher education institutions. Through these innovative pedagogical practices adapted to the needs of students, higher education didactics will promote autonomy, critical thinking, and problem-solving skills (Silva et al., 2024).

Within the aforementioned context, the teaching of soil science, considering its different disciplines, is mostly aimed at a small slice of society, notably the one that reaches the university (Diniz, 2005), in undergraduate courses, for example, in geology, agricultural sciences, biology, environmental engineering, ... and so on. During the school period, the performance of mechanical literature review work during the courses, presented later in the classroom, only to obtain grades and approval, does not seem to be the way to build a more dynamic and effective educational environment. Higher education in soils needs to be bold in its teaching practices, providing quality education, capable of forming critical, creative citizens prepared for the professional challenges of the future (Silva et al., 2024).

Teaching in soil science, as it is an important subject as a natural resource, cannot be neglected in the training of undergraduates, as their knowledge is what governs the internal and external modifications of planet earth, directly influencing human life. Thus, it is worrying to note the difficulty that students have in relating certain theoretical knowledge acquired during the course of the disciplines with their technical, practical and economic applications during their training process. For example, in the disciplines of Soil Fertility and Plant Mineral Nutrition, the fact that students do not know the correctives and fertilizers, their nutrients and their market realities, hinder the relationship between theoretical knowledge and practice, causing discouragement in teaching and learning.

Therefore, there is a great challenge for teachers in soil education, which is to seek to break with the traditional teaching model, in which the teacher is the holder of knowledge and the student is a mere passive receiver (Silva et al., 2024). Students learn best when they are actively involved in the learning process, where they are protagonists of their own educational process. In this way, effective teaching practices in higher education in soil science promoted via research and/or extension will be presented below. Teachers need to find inspiration and resources to transform their lessons into dynamic and engaging

learning environments, through pedagogical approaches that are able to prepare students for an ever-changing world.

DEVELOPMENT

TEACHING PRACTICE I: "DIAGNOSIS OF THE TRADE OF CORRECTIVES AND FERTILIZERS: A NECESSARY PRACTICE TO STIMULATE THE TEACHING OF SOIL FERTILITY AND MINERAL NUTRITION OF PLANTS"

Based on the principles discussed in Freire (1996), when he states that no one teaches anyone, but we learn from each other, it is clear that students needed to maintain social and market relations in their learning process. In this way, some practices began to be adopted experimentally in soil education, notably in the disciplines of Soil Fertility and Plant Mineral Nutrition, initially at the Parauapebas Campus and later at the Capanema Campus of the Federal Rural University of the Amazon - UFRA, in an attempt to contribute to the teaching and learning process in soil science.

Theoretical work passed on by the professors at the beginning of the semester was done in a hurry, practically in the last week of class, and usually only one or two students on the team really worked in a committed way. Practically the only students interested were those who still needed a grade for their approvals. Thus, in place of this inadequate practice, the students have been carrying out a diagnosis of the agricultural houses in the region, where they are put in contact with the local trade of agricultural inputs, to get to know the reality up close and understand what the real technical and economic difficulties are encountered by most producers when investing resources in the purchase of limestone and fertilizers.

When the student experiences the market relations of the rural man through a continuous process of dialogue with society, the transformation of his knowledge happens in real time. In turn, the student is encouraged to be the protagonist of their own learning, developing autonomy, critical thinking, and problem-solving skills (Silva et al., 2024). The use of active methodologies, such as project-based learning that goes beyond the classroom, seeks to involve students in a more direct and participatory way, promoting deeper and more lasting learning.

Methodology

At the beginning of each academic semester, the Soil Fertility and Plant Mineral Nutrition class is divided into several teams, which must carry out a diagnosis of the trade of chemical correctives and fertilizers in the region of the municipality where the UFRA Campus is located, notably in Parauapebas or Capanema in the state of Pará. The students

conducted interviews with the agricultural houses in the municipality, that is, a team for each different commercial establishment (Figure 1).

Figure 1. Facade of some agricultural houses diagnosed as to the sale of correctives and fertilizers.

Source: Prepared by the authors.

The work begins with a discussion in the classroom with the teacher about what correctives and fertilizers are, reaching the elaboration of a questionnaire based on some basic questions (Chart 1).

Table 1. Main questions made (script) by the Soil Fertility and Plant Mineral Nutrition classes that participated in the diagnoses of the agricultural houses.

a) For the Corrective:
▪ Do you sell any kind of limestone?
▪ Which one or which?
▪ Is there always for immediate delivery or should I place an order?
▪ Is it sold in bulk, in bags (how many kg?) or only closed trailer?
▪ Where does your limestone come from?
▪ What are the main specifications (PRNT and PN) of the product?
▪ What is the current price? and What is the cost of freight to deliver to the property?
▪ When is the peak season?
b) For fertilizers as isolated sources of N, P and K:
▪ What are the fertilizers as isolated sources of N, P and K do you have to sell under prompt delivery?
▪ Which ones need to be ordered?
▪ What are the best sellers?
▪ What are the current prices?
▪ Are they in granulated or powdered form?
▪ What is the form of sale? (in bulk and/or in a bag of how many kg?)
▪ Where do fertilizers come from? (see which manufacturer company)
▪ Delivery to the property? and What is the cost?
▪ When is the peak season?
c) For NPK formulations:
▪ What are the best-selling formulations and which are available for immediate delivery? (he had tried to find out why)
▪ Which ones are still sold, but only by order?
▪ What are the current prices?
▪ Are they in granulated or powdered form?
▪ Where do fertilizers come from? (see which manufacturer company)
▪ Delivery to the property? and What is the cost?
▪ When is the peak season?
(d) additional information or information on other fertilisers:

Source: The authors.

Subsequently, each team goes to a different commercial establishment in the region to carry out the interviews, apply the questionnaire and other surveys (Figure 2). By having the opportunity to see, touch and handle the stored inputs, students begin to visually recognize each input, linking them to their technical characteristics and forms of action in the soil, without losing sight of the economic aspects of commercialization (Figure 3). On the return to the University, the data are discussed within the teams and presented in the classroom in the form of an expository, with the democratization of the acquired knowledge and the technical and academic debate, already giving direction in the final considerations of what are the procedures for the second teaching practice, presenting this information to the rural producers.

Figure 2. A team of students from the disciplines of Soil Fertility and Plant Mineral Nutrition applying questionnaires to diagnose the market for correctives and fertilizers.

Source: The authors.

Figure 3. Teams of students from the discipline of Soil Fertility and Child Plant Nutrition in the warehouse of commercial establishments identifying available correctives and fertilizers, as well as the storage and marketing conditions.

Source: The authors.

Results and Discussion

Prior to this teaching practice, more specifically when addressing in the classroom the content of interpretation of soil fertility analysis and the mineral nutrients essential to the life of a plant, a certain difficulty in understanding was perceived by most students. The question did not cause a collective lack of interest in the subject, but it caused some frustration or even discouragement in the learning process. Much of this was due to the fact that many students did not know, if not visually, the fertilizers to be worked on, nor whether or not they were sold in the region and what nutrients they provided. It is of fundamental importance that the university leaves its "walls" and places its students closer to the real world and at the disposal of the basic interests of society (Lima et al., 2021).

It is impressive how a simple practice such as having students diagnose local commerce allows them to cross the limits of the University, enriches their experience and knowledge. The student stimulus is latent for everything that is to come in the discipline of Soil Fertility and Plant Mineral Nutrition. During the semester, as soon as the discussions about fertilizers and fertilizers begin, the students will really know which are the most common inputs in the region, which ones need to be ordered in advance, what are the prices of inputs and freight and the technical parameters related to plant nutrition. Therefore, not only technical knowledge about correctives and fertilizers are necessary for the interpretation of soil analyses and fertilization calculations, but also economic knowledge of the market for these inputs, especially regarding the local trade of dolomitic limestone and NPK fertilizers available to technicians and producers (Alcarde; Guidolin; Lopes, 2014). In this way, the student will be able to put into practice the knowledge acquired in the academy, developing the ability to dialogue with society, exchanging knowledge, articulating academic knowledge with reality (Lima et al., 2021).

All the aforementioned context facilitates the learning process throughout the disciplines, from the interpretation of soil fertility analysis, to liming and fertilization calculations, reaching plant nutrition to its production. The student begins to realize that fertilizing is not only the act of "throwing" fertilizer on the soil, but that fertilizing is effectively understanding soil fertility and plant nutrition, applying inputs in a technical, economical, and sustainable way. This adopted methodology encourages student participation through practical, collaborative and reflective activities. They also encourage the development of socio-emotional skills, which are fundamental for professional and personal success. All of this not only improves knowledge retention but also develops critical and problem-solving skills (Silva et al., 2024).

A finding, specific to the Amazon region, that students usually detect, is that the high cost of correctives and fertilizers is evident, mainly due to the value of freight. This ends up affecting the supply of traders and the demand by producers, considering the high cost of logistics for production and transport, as well as for commercialization in a regionalized way. In the field of research, the importance of establishing a participatory research linked to the area of soil science has already been demonstrated, aiming at the exchange between the academic environment and the rural environment, in order to consolidate teaching and extension within the research action. Thus, there is a challenge for higher education educators to rethink their academic practices, and to adopt strategies that value the personalization of learning in soil science and its interdisciplinarity.

The teaching practice reported so far helps in the training of future professionals in Agricultural Sciences and other related areas, so that they can make technical and economic decisions about which correctives and fertilizers should be used. With this, year after year, the study of Soil Fertility and Plant Mineral Nutrition has been boosted, with regard to the teaching of content about fertilizers and fertilizers, allowing the evolution of knowledge in line with the reality of the local market of correctives and fertilizers. This preparation of the student to work with the community from the time he is in the academic environment is a way to encourage the student's protagonism and make available to the job market more complete professionals in their training (Paula et al., 2023). This should contribute significantly to the change in the training of the professional profile, especially of students trained in the agricultural sciences courses at UFRA (Santana et al., 2003).

TEACHING PRACTICE II: "PRESENTATION OF WORKS BY HIGHER EDUCATION STUDENTS TO RURAL PRODUCERS DEVELOPED IN DISCIPLINES RELATED TO SOIL SCIENCE"

It is another effective teaching practice, also with the extension bias, which stimulates students, aiming at their commitment and application in the preparation and execution of their academic work, where at the end of them the presentations will be made to rural producers, sharing their knowledge in a responsible and real way, while society lends and transmits its values, desires and culture. The participation of rural producers is of the utmost importance in the generation of knowledge for themselves and in the training of students, having, as a perspective, the intervention in the social, economic and environmental reality. Therefore, practices such as these in higher education play a key role in the training of students, as it goes beyond the transmission of content and involves the creation of meaningful learning environments.

Papers presented in the form of seminars, only in the classroom for the teacher, tend to generate a very small sharing of knowledge between the teacher and the team that did that work. In general, the other teams do not make an effort to attend and participate in the discussions of the work of other colleagues. Each one is only interested in his merely mechanical evaluation to obtain a grade. In this way, the new practice adopted contributes to the integral development of individuals, preparing them not only for the job market, but also for conscious citizen participation in society (Silva et al., 2024).

The theme of education in soils should not be neglected, and in this conception, dialogue cannot be reduced to the act of the teacher depositing ideas in the student subject, nor to the simple exchange of ideas within the classroom (Muggler et al., 2006). It is necessary for students to approach reality, in a protagonist way, through a two-way street between academia and society. This is nothing more than a pedagogical process of extension, which is not a novelty in the higher education environment, where currently, through the so-called "curricularization of university extension", it has been established as a mandatory curricular component in the academic training of students and as a transformative contribution to society (Paula et al., 2023). The extension disciplinary activities practiced are potential mechanisms to make classroom learning be applied in practice, which will make the content learned more participatory and meaningful for students (Vieira, 2020).

Methodology

At the beginning of the semester, based on the different works that were planned in the preparation of the teaching plan of the disciplines of Soil Fertility and Plant Mineral Nutrition, among them the "Diagnosis of the trade of correctives and fertilizers", it was implemented, as a form of culmination, the presentation of the works to rural producers in the municipality, with the protagonist performance of the students effectively evaluated, generating participation in its final grade.

The class, already divided into teams, based on the realization of their previous practices, was responsible for preparing a practical presentation in the form of interactive stands, indicating the main correctives and fertilizers for the region, in the specific case of the work of "Diagnosis of the trade of correctives and fertilizers". Thus, together with the producers, their needs were characterized in terms of soil fertility and plant mineral nutrition. The main purpose was to relate the proper management of soil fertility with the mineral nutrition of the species used, aiming to move towards a better environmental, economic and productive sustainability of the region, concomitantly with the practical academic learning of undergraduate students.

The great differential for the students of the two extension teaching practices mentioned above, carried out in an integrated way, was the responsibility that at the end they would have to present their work to rural producers. The teams had to prepare a true portfolio of information, as the presentation would no longer be only for the teacher in the classroom. The students would have to make themselves understood in the dialogue that would take place between the academic environment and the rural environment.

Usually, the presentations are made to small producers in the municipality and region, often indicated by people linked to university extension and rural extension. All logistics made with resources from the university, but also being able to count on partnerships, such as the transportation of students and teachers to the producers' association, the municipality provided a school bus (Figure 4). Thus, the teacher is seen not only as a transmitter of knowledge, but as a facilitator and mediator of learning, as an environment conducive to the construction of knowledge has been created (Silva et al., 2024).

Figure 4. Displacement of professors and students to present the works, developed as part of the evaluation of the disciplines of Soil Fertility and Mineral Nutrition of Plants to rural producers.

Source: The authors.

Results and Discussion

At the end of the semester, the presentation, for example, of the work "Diagnosis of the trade of correctives and fertilizers", caused a lot of anxiety on the part of the students. They were aware of the responsibility of interacting with a community of rural producers and their association, when they had to present their work. For the producers, it is usually a real event, and they mobilize to organize the meeting in the form of a beautiful event, even if in a simple way in a shed covered with straw (Figure 5). It should be recognized that the learning process is the result of the interaction of the student subject, with the environment and with all its social and cultural conditions where his professional performance will occur (Rosa, 1997).

On the day set by the producers, the work of all the Soil Fertility and Plant Mineral Nutrition teams is presented, as well as other disciplines of the same semester (Figure 6). It is noteworthy that in addition to the teachers of these subjects, teachers from other disciplines also participate, and they, in a multidisciplinary way, are also responsible for evaluating each team. The average of the evaluations of the teachers involved generates the final grade of the students. Dialogue should be the best way to teach, because, in this way, there is no imposition of knowledge, but an exchange that results in benefits for both the student and the rural producer, regardless of who is passive or active in this process of interaction (Freire, 1996).

Figure 5. The presentation of the students' work was organized by the community of small rural producers in the form of a beautiful event.

Source: The authors.

Figure 6. Presentation of the works to rural producers in a community within an Association of Rural Producers.

Source: The authors.

The impact of the action is so great that it generates a mobilization in the municipality as a whole, as authorities linked to the rural environment are also present to participate, such as: the secretary of agriculture, the head of IBAMA and representatives of private companies (Figure 5). There is a true exchange of experiences, demonstrating that the University really must go beyond its walls and act effectively with its community. This allows the full development of the student in the professional and social spheres, that is, the student learns at the same time as he teaches. The educational process must reach all the actors involved; students and producers, because there is an interaction in the dialectic in the teaching and learning process, where both have become subjects of knowledge, constituting a two-way street in the search for a coherence between theory and practice.

The responsibility of the students and the seriousness of having to face, perhaps for the first time, an audience eager for information, makes all the students engage, taking to the producers in addition to oral and merely expository communication, different visual resources, such as: posters, flip chart, folders, booklets, realhas, collection of fertilizers, seed samples, tools, augers used for soil collection and plants developed in pots (Figure 6). The reported extension teaching practices, observed from the point of view of "emancipatory intentionality", will have a positive impact on the broad training of new professionals, as it is being offered the opportunity for undergraduate students to experience their academic theories in the practice of society, strengthening their citizenship education (Lima et al., 2021).

In this way, after the implementation of the two integrated extension teaching practices discussed so far, students are able to understand more broadly what is the true role of the study of soil fertility and plant mineral nutrition, as they begin to have the perception of analyzing, together with the producer, how and why the soil has certain attributes. Thus, the student will be able to solve the problem technically after interpreting the soil, explaining the reason for the problem to himself and effectively solving the producer's problem. Know the inputs, correctives and fertilizers, dialogue with the producer and, after recommendations, know if the problem will return; This is the broadest sense of understanding soil fertility and plant mineral nutrition.

The establishment of extension teaching practices such as those reported here or in their different configurations, should now occur more frequently in higher education institutions with the advent of the "extension curricularization", which by the National Education Plan (PNE), mandatorily provides for the inclusion of at least 10% of the total curricular credits required for graduation in extension actions (Paula et al., 2023). In this sense, through extension actions, teaching practices that transform society can be

provided, in view of their characteristics of socialization, integration, cooperation, and participation, which lead the knowledge and professional practices generated and learned at the university to society (Lins et al., 2016).

University extension actions are powerful instruments to put teaching in the classroom into practice, which will make the content to be learned more meaningful to the student, making them able to translate theoretical concepts into responsible practices towards the community (Vieira, 2020). The protagonist participation of the students from the planning of actions in the classroom to the presentation to the producer was a fundamental experience not only for technical and scientific training, but also for allowing them, from an early age, to maintain important social relations with the farmer and to experience market relations. Therefore, university extension is a powerful tool, meeting the demands of social relevance, allowing it to also reach its pedagogical dimension in the training of undergraduate students.

TEACHING PRACTICE III: "IMPLEMENTATION OF EXPERIMENTS RELATED TO SOIL SCIENCE IN AREAS OF RURAL PRODUCERS: A CONTINUOUS DIALOGUE BETWEEN COMMUNITY AND UNIVERSITY"

The soil theme, even though it is an essential component of the environment, is neglected since basic education and, several times, it is disregarded and devalued, not receiving the attention and care necessary for its protection and conservation (Jesus et al., 2013). In addition, didactics in higher education is also related to building a closer relationship between professors and students, favoring effective communication, constructive feedback, and encouraging the active engagement of students in their own learning process (Silva et al., 2024).

In universities that offer courses related to the teaching of soil science, regardless of the importance and relevance of the disciplines, a large part of academic research is carried out through scientific experiments carried out in laboratories and greenhouses. Classical statistical designs are usually used in agronomic research, which considers small plots in homogeneous areas (Silva, 2013).

The research carried out in the field is often implemented within the university's premises or even in experimental units belonging to them. Thus, only at the end of the research, after some presentations of partial results at scientific congresses, or even in the form of a full article published in a journal of a recognized editorial board, the information is disclosed in a restricted way. It is unlikely that, after all the effort generated before, during and after the conduct of the experiments, the final result of a research will reach the knowledge of rural producers.

The distance between research, extension and producer is historically an obstacle in rural development programs (Silva, 2013). It is logical that, in order to minimize the

distortions previously reported, some research bodies have their technology diffusion centers. Research cannot have, as its sole principle, the generation of specific knowledge to be transmitted vertically to those served by its results. Thus, the very transfer of technology has been questioned in its conception and efficiency. In addition, one cannot forget the pedagogical role of research in the training of students.

Most teaching and research institutions have developed work based on the linear model of technology transfer, in which research generates knowledge, extension transfers and the farmer adopts. This approach has been questioned due to the low appropriation by farmers. This is mainly due to the little weight given to the local values of these workers, to the detriment of global ones.

Producers, in the same territory and productive arrangement, react differently to the incentives received (Lima; Gomes, 2014). Several projects are doomed to failure because they are standardized, so that the uniformity of the information pointed out to the producers does not correspond to the diversity of the situations they experience (Dufumier, 2007).

With research restricted to the walls of universities, a great opportunity to disseminate knowledge in the field, in a natural way and in real time, is lost. A research conducted in the area of a producer becomes a true demonstrative unit, in addition to achieving the objectives preconceived by the teacher-researcher. It is believed that the implementation of research in areas of rural producers allows, in addition to obtaining its final result, that several stages of knowledge are made available, also enabling the action of teaching and extension.

Using Haguete (1987), participatory research is a good alternative for the generation of scientific knowledge, in a concomitant process on the part of the research center and the researched center (rural community) [...]. Participatory research also allows for an educational process, which seeks the "intertransmission" and "sharing" of the knowledge already existing in each pole, provoking immediate changes that go beyond the scope and temporality of the research.

Still in relation to participatory research, Uhde et al. (2014) clarify that participatory research has the emancipatory and transformative purpose of discourse, conducts and social relations, that is, a modality of social research, in which there is a dialogue between the researcher and the researched who are involved in the solution of a problem detected in order to, then, set up strategies aimed at solving the detected issue.

Thus, it is important to implement scientific experiments related to soil science in the areas of rural producers, aiming at the exchange between the academic environment and the rural environment, through a continuous dialogue, in order to establish teaching and extension, in addition to the final result of the research.

Methodology

Considering and recognizing the responsibility and social relevance of the University, as well as the potential of university extension in its dialogical conception of social intervention, below is the report of a proposal for the construction of solutions for development with sustainability applied by the Federal Rural University of the Amazon - UFRA in rural communities.

The first practice of connection between teaching, research and extension emerged in 2003 from a need, from the advanced campus of UFRA in Parauapebas (PA), at the time newly created. Being a new campus, with a structure still under construction to serve teaching, research and extension, it was decided to establish the first field experiments related to soil sciences in the areas of rural producers. The purpose was that, in addition to the research itself, it would be possible to establish partnership ties, taking, directly and indirectly, teaching and extension, with interaction between the academic environment and the rural environment, in the form of participatory research.

The idea of participation involves the active presence of professors/researchers, undergraduate students and a certain part of the population in a common research project that is at the same time presents an educational process, produced within the action of research/extension (Haguete, 1987). Therefore, the present study was carried out considering the intentions of participatory research, according to Chart 2.

At first (diagnosis of the community), the Association of Rural Producers of the APA of Igarapé Gelado (APROAPA) was sought, through its president, which led to the holding of a first meeting with the associated producers (Figure 7). Initially, the main problems of its agricultural production were discussed, defining that the university would act in the recovery of degraded pasture areas (determination of problems and hypotheses). Then, the possibility was launched for the rural producers present to make areas available for the development of experiments that would provide solutions for the recovery of degraded pastures (characterization of the actors involved). It was defined by the use of three properties, in which the university would implement experiments related to the recovery of worn pasture areas, focusing on topics such as: soil fertility, no-tillage, crop-livestock integration, forage, pasture management, entomology (study and control of mound termites

and pasture leafhoppers) and application of steel slag (a by-product of the pig iron industry that can be used as fertilizer and soil corrective alternative).

Table 2. Main procedures in participatory research (limitations and potentials).

Procedimentos	Limitações	Potenciais
Diagnóstico das comunidades	Impossibilidade de um completo diagnóstico da realidade e pretensões das comunidades.	Permitir ao pesquisador inteirar-se dos problemas da comunidade, conhecer a sua evolução histórica, social e cultural.
Caracterização dos atores envolvidos	Desconhecimento do nível de comprometimento com o trabalho de cada participante, bem como diferentes objetivos individuais.	Escolher membros da comunidade para desenvolver o trabalho, os quais irão difundir os resultados obtidos.
Determinação dos problemas e hipóteses	Os problemas levantados podem ser casos extremamente particulares que dificultam o trabalho grupo	Escolha de problemas de interesse comum, os quais estimulem os atores na busca de soluções.
Proposição de alternativas aos problemas e hipóteses	As alternativas levantadas podem ser adaptadas a pequenos grupos e não a toda comunidade.	Utilizar o conhecimento local, junto com o conhecimento científico disponível, buscando alternativas de interesse da comunidade
Elaboração do projeto	Dificuldades na adequação científica do projeto	O conhecimento científico disponível e as alternativas propostas podem ser mesclados, construindo novas perspectivas
Condução dos trabalhos	Os atores podem não estar suficientemente estimulados a participar do projeto originando falhas na sua condução	Os atores, adquirirão o conhecimento prático das alternativas, as quais podem ser difundidas aos demais membros da comunidade economizando esforços da extensão rural
Avaliação final	Em função da condução inadequada podem inferir em conclusões equivocadas ou levadas a super valorização de uma determinada alternativa.	Estimular os participantes, construindo resultados a partir de sua própria experimentação, despertando para novos estudos e elaboração de conclusões adaptadas localmente

Fonte: Silva (2013)

Figure 7. First meeting of UFRA (Campus de Parauapebas - PA) with rural producers belonging to APROAP to enable the implementation of experiments on their lands.

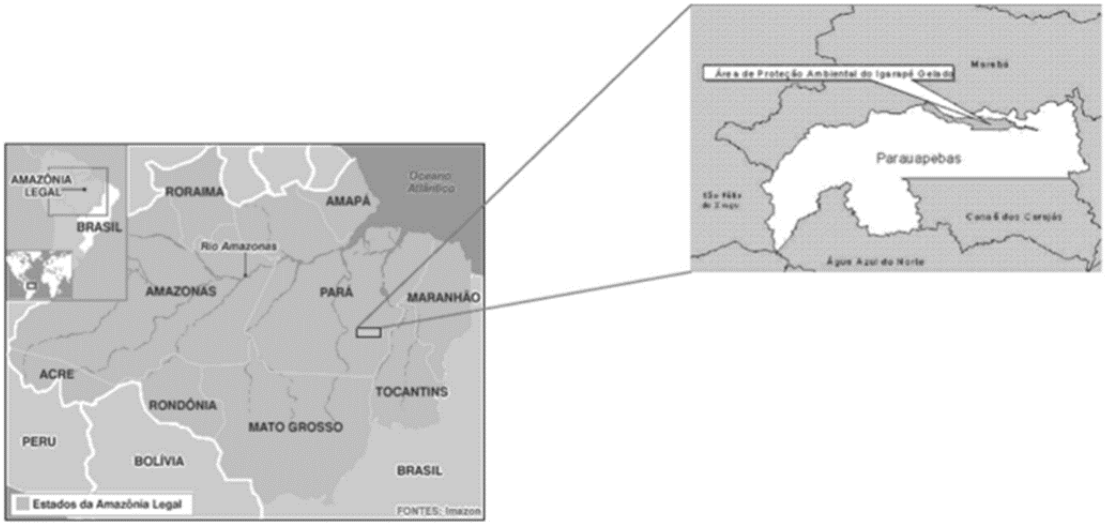
Source: The authors.

The awakening to the elaboration of participatory research projects took place, mainly, through meetings between the actors, in which each participant had the freedom to

question and launch proposals, establishing goals of common interest, without losing methodological rigor and not always reaching a consensus. This practice of participatory research was also used as an effective and active methodological tool for learning, showing itself as an innovative approach in the higher education process, centered on the student as the protagonist of his own education.

Regarding the conduction of the work, the experiments were implemented and conducted in rural properties in the Environmental Protection Area (APA) of Igarapé Gelado, from 2006 to 2010 (first phase of the project). The experimental areas were located at the intersection of the Igarapé Gelado and the Carajás Railroad (Figure 8).

Figure 8. Location of the Igarapé Gelado Environmental Protection Area. Parauapebas - PA.



Fonte: Imazon (2011).

As a reference, we have latitude 06°00'10"S and longitude 49°57'43"W, 30 km from the municipality of Parauapebas, Pará. The average annual temperatures, in general, are higher than 23°C, average rainfall of 1,700 to 2,000 mm $^{year-1}$ and average relative humidity of approximately 70% in the dry season. The APA of the Igarapé Gelado has most of its relief classified as flat to smooth undulating (up to 8%), in which a large extension is formed by Ultisols (Embrapa, 2006).

The selected properties represent the reality of the municipality (lots with a maximum of 75ha), a former agrarian reform settlement, with *Brachiaria brizantha* pastures, formed more than fifteen years after the primary forest was cut down. These properties have, as their main activity, dairy farming, a predominant characteristic in the region.

Prior to the installation of the experiments, the renewal of pastures in the selected experimental areas occurred through soil preparation, which included raking, using a crawler tractor with blade (D6R-XL), and the removal of stumps, tree weeds and termite

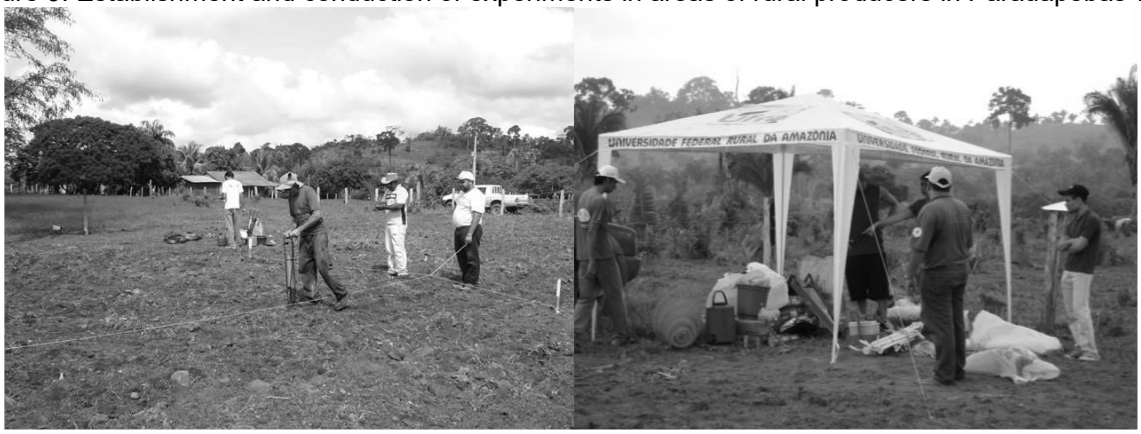
mounds. Subsequently, the tire tractor with a harrow was used, with the intention of eliminating the smaller vegetation. Then, the second harrowing was carried out in the area, with the use of the tire tractor only with the drag harrow, aiming at leveling. Beaconing, staking and the installation of rain gauges were carried out in the various experimental areas.

Results and Discussion

Naturally, at first, there was some distrust of rural producers, as some resisted and were not willing to make areas of their properties available for the installation of experiments. In subsequent meetings, it can be detected that the reason for the aforementioned problem was the fact that experiences of previous partnerships between researchers and rural producers were not successful. According to the producers, researchers from other institutions had already worked there, however, as reported: " they collected what they wanted, left and left us nothing as a teaching in favor of the development of the community ". This is a strong indication of the decadence of traditional research, in which researchers often do not return the results of their research to their objects of study. This is more difficult to occur in research carried out in a participatory way.

Once the first obstacle was overcome, it should be emphasized that all the activities of implementation and establishment of the experiments were, day after day, actively monitored by all the producers in the region, with the democratization of everything that was happening in the ordinary meetings of the association. From a scientific point of view, any participatory research can be carried out in a coherent way, as long as all participants are engaged in the objective of the work and that correct analysis alternatives are used, based on available scientific knowledge and local contributions, in the preposition of new alternatives and results (Silva, 2013). Therefore, the work was implemented and conducted, with a large flow of professors, students and producers in all stages of the execution of the experiments (Figure 9).

Figure 9. Establishment and conduction of experiments in areas of rural producers in Parauapebas-PA.



Source: The authors.

The students exercised teaching and training, in which teaching and research took on an emancipatory sense, as research is done to know what is not yet known, and to communicate or announce the novelty (Freire, 1996). The participation of the students in the experiments was a fundamental experience not only for technical and scientific training, but also for allowing them, from an early age, to maintain important social relations with the countryside and to experience market relations. Several students did internships recognized by the university, others obtained scholarships from the Institutional Program for Scientific Initiation Scholarships (PIBIC/CNPq), and even a master's thesis was developed from experimental areas (Pinheiro, 2010).

This experience report allowed us to better understand some principles discussed by Silva et al. (2024), where learning becomes more meaningful and applicable to everyday situations, contributing to the promotion of autonomy and intrinsic motivation of students, essential factors for effective and lasting learning. Returning to Haguete (1987), we emphasize that, at certain moments of the research (and our experience shows this), the educational process reached the team involved and researchers and participants interacted in the dialectic of the teaching/learning process (they all became subjects of knowledge) constituting a two-way street in the search for praxis.

With the same importance as they were for academic training, the experiments linked to soil science in rural areas made it possible for all producers in the region in question to have the opportunity to follow the entire process of knowledge construction. The rural environment was actively involved in the teaching process, with significant learning in soil science, in which teaching was not only the transfer of knowledge, but the creation of possibilities for its production or construction (Freire, 1996).

The producers were able to analyze new techniques, follow the data collection and discuss among themselves and with the research professors, drawing their own

conclusions. Taking into account the components of participatory research – investigation, education and action – Haguete (1987) defined participation as an action reflected in an organic process of change, whose protagonists are the researchers and the population interested in change.

Another interesting fact observed was the report of some producers that if a few years ago they had had access to the information acquired today, their properties would not have so many degraded pastures or those in the process of degradation. Thus, the need to make knowledge about soil reach all spheres of society for an awareness of sustainability became evident.

During the construction of new knowledge, following the experiments and in direct contact with the academic environment, the producers realized that, from now on, they could carry out some low-cost practices of soil management, phytotechniques and animals, to avoid the degradation of their pasture and soil. This reinforces that in participatory research, the researcher usually returns the data to the community studied for possible interventions (Demo, 2000). This type of research cultivates scientific neutrality and presents a double challenge: to research and to participate, with the concern of returning the information collected to the population, with coherence between theory and practice (Thiollent, 2002).

In subsequent meetings, to evaluate the projects in progress and the partial results of some experiments, several producers who were initially reluctant made their areas available for the development of new participatory academic research projects. An important communication channel between the community and the University was opened, and could be expanded in a more expressive way, thanks to the development of the idea of dialogue between researchers and producers and not about them.

Freire (1996) believes that dialogue is the best way to teach, because, in this way, there is no imposition of knowledge, but an exchange that results in benefits for both the educator (researcher) and the learner (rural producer). In this context, the subject (learner/rural producer) is neither active nor passive, he is interactive; and, from this interaction of the subject with the environment, with language as the main mediating agent, learning occurs (Muggler, 2006).

In short, participatory research, as an excellent alternative, refers to the need not only for the insertion of the researcher in the environment, but also for an effective participation of the researched population (through dialogue) in the process of knowledge generation, fundamentally conceived as a process of collective education, in order to minimize social inequalities in their most varied shades (inequality of power, to know,...

etc.) (Haguete, 1987), because education promotes the opportunity for the individual to build a critical consciousness, promoting the transformation of the subject (Freire, 1996). Therefore, the participation of rural producers is of the utmost importance in the formation and execution of research projects developed in rural areas (Lima; Gomes, 2014).

TEACHING PRACTICE IV: "AN EXPERIENCE IN THE TEACHING OF SOILS OF THE DEGREE COURSE IN NATURAL SCIENCES – UFRA/PARFOR DOM ELISEU, PARÁ"

PARFOR is the result of a set of actions by the Ministry of Education - MEC, in collaboration with the state and municipal education departments and public institutions of higher education, to provide free and quality higher education courses to teachers working in public schools without adequate training (Ufra, 2014). In the state of Pará, the Federal Rural University of the Amazon is present in the municipality of Dom Eliseu with the Degree in Natural Sciences, and the discipline of Geosciences aims to provide knowledge about the geological phenomena that govern the internal and external modifications of the Earth and understand their influences on human life, however, no focus has been given to soil science in the context of the discipline (Ufra, 2014). And the soil, as it is an important subject as a natural resource, cannot be neglected in teacher training.

Thus, this work reports the actions that were carried out in the municipality of Dom Eliseu, southeast region of the state of Pará, using as teaching practice the material "Experimentoteca em solos" as a way to provide basic knowledge about soil science in the training of basic education teachers.

Methodology

From January 6 to 11, 2014, Geosciences classes were taught to students of the undergraduate course in Natural Sciences in the municipality of Dom Eliseu, southeast region of the State of Pará. The undergraduate course in Natural Sciences is part of the National Teacher Training Program (PARFOR), and in the municipality of Dom Eliseu the Federal Rural University of the Amazon is the institution responsible for the execution of the program.

During the elaboration of the teaching plan of the discipline of Geosciences, it was detected that the syllabus of the discipline described in the Pedagogical Plan of the Degree Course (PPC) in Natural Sciences, did not address contents about the teaching of soil science. And the objective of the Geosciences discipline was only to provide information for the knowledge of the internal and external geological phenomena of the earth and to understand their influences on human life. Thus, the following subjects were included: Weathering in soil formation; The ecological function of soil and; the soils of the Amazon,

and a didactic activity with soil samples in the classroom. The students of the Licentiate Degree in Natural Sciences are predominantly teachers of basic education in the municipality, average age group of 30-35 years old and most with more than 15 years of experience in basic education. It was proposed to include the new subjects in the course syllabus, as it would complement the study of the process of earth formation with the formation of rocks and their weathering, and the formation of soil as an essential component of the ecological relations of the earth and humanity.

As for the subject "The soils of the Amazon", the objective was to provide information on the main physical and chemical characteristics of the soils of the Amazon and their aptitudes and limitations. Relating them to the economic, social and environmental reality. The current situation of the municipality of Dom Eliseu was used, as its main economic activity is agriculture and livestock, and to a lesser extent forest production. To carry out the didactic activities, the materials created by the team of the Soils at School Project of the Department of Soils in Agricultural Engineering of the Federal University of Paraná, called "Experimentoteca em solos" (Ufpr, 2005), were used. In the didactic activity, the students were organized into four groups, and each group was responsible for carrying out the didactic experiments and explaining the theoretical foundations during the conduction of the experiments. For this, previously the didactic class, printed materials were passed on to the teams to study.

The didactic experiments carried out were: 1 – soil texture, 2 – soil consistency, 3 – soil porosity and 4 – water and wind soil erosion. After the presentation of the didactic experiments, questions were asked to the other students in the class about the activity presented, following the questions suggested in the printed material of the "Experimentoteca em solos" (Ufpr, 2005).

Results and Discussion

The students did not encounter difficulties in carrying out the didactic experiments. Due to the versatility in the acquisition of materials and the ease of conducting the experiments, the students reported that they would carry out the Experimentoteca in the disciplines that are responsible for teaching classes in basic education.

In the didactic activity regarding soil texture (Figure 10), the first team presented two soil samples: sandy soil and clay soil. Through touch analysis, they were able to demonstrate the feeling of roughness of the sandy soil and silkiness of the dry clay soil. With this information, the students emphasized that in the field, it is possible to have general information on the predominance of soil texture, and that only by laboratory

analysis is it possible to identify and classify with greater precision the granulometric composition and textural classification of the soil. In addition, they found that different proportions of sandy and clayey materials modify the soil texture, and consequently, each type of soil has intrinsic characteristics due to the presence of water, sand, clay that vary in proportion to the constitution of each soil.

The second team was able to discuss what soil consistency is (hardness, friability, stickiness, plasticity) (Figure 11). The practical aspects of consistency, which were easily observed by the students, were the hardness that certain soils present when dry, or the stickiness that some present when wet, especially clay soils. They were also able to argue that consistency can vary along the soil profile, in its different horizons.

The third team achieved the objective of the experiment on soil porosity (Figure 12), demonstrating the existence of pores with the undisturbed samples collected, the infiltration of water in the soil occupying the porous spaces and demonstrated that in the porous spaces of the soil there is the presence of air. And that in these small empty spaces called soil pores, the air and water that the roots of plants and other organisms need for their hydration and respiration are stored.

The fourth team, when exposing soil erosion, demonstrated wind and water erosion outside the classroom (Figure 13). He was able to discuss that erosion is the dragging of particles that make up the soil, by the action of moving water, resulting from rainfall, or by the action of winds and waves. And that the two main agents of erosion are rainfall (water erosion) and wind (wind erosion). And that the action of rainwater is what causes the greatest damage, as it removes the surface layer of the soil, and promotes siltation of rivers and lakes. The process tends to accelerate, as more land is deforested for logging and/or agricultural production, since the soils are unprotected from vegetation cover and, consequently, the rains fall directly on the surface of the land.

Figure 10. Presentation of team 1 on soil texture.

Source: The authors

Figure 11. Presentation of team 2 on soil consistency.

Source: The authors

Figure 12. Presentation of team 3 on soil porosity.

Source: The authors

Figure 13. Presentation of team 4 on soil erosion.

Source: The authors

Regarding erosion, the other students reported the effects that agriculture with intensive soil mobilization and absence of effective soil cover, in the municipality of Dom Eliseu has caused serious environmental damage over the years, such as the silting of the rivers of the municipality. As a proposal to solve the problems, they indicated the use of conservation practices that reduce the problem of soil erosion and siltation of water sources.

Finally, regarding the characteristics of the Amazonian soils studied, they reported that some geography books generalize by commenting that Amazonian soils are unproductive and have serious limitations to agriculture. They found that the main limitations are chemical, but most soils have physical properties favorable to mechanization, as they do not have limitations regarding physical impediment such as shallowness, rockiness or stony in the soil profile, and that they are soils that have good capacity for infiltration and storage of water in the soil profile.

FINAL CONSIDERATIONS

The teaching practices reported can and should be adopted in an integrated way, helping in the training of future professionals, as demonstrated. The significant impact of active methodologies employed on the motivation and engagement of students in higher education in soil science was evident. However, the implementation of the teaching practices presented here requires a decisive change in the teaching methodology regarding the planning and structuring of classes.

The first two teaching practices developed were carried out in an integrated way, being clearly promoted through extension. Thus, the students, by maintaining direct contact with the market and with the rural producer, developed the security so that they can make technical and economic decisions in the future about which correctives and fertilizers should

be used. This dynamization of the teaching of Soil Fertility and Plant Mineral Nutrition, notably with regard to the teaching of content on correctives, fertilizers, fertilizers and nutrition, allows the evolution of knowledge in line with the reality of the local market and the reality of the rural producer's field.

Not only issues related to Soil Fertility and Plant Mineral Nutrition, but also any and all information generated within the academic environment can and should be shared with those who are of interest, strengthening higher education and social relations between students and rural producers, for example. Regardless of the discipline or content, the form of evaluation suggested here, with the presentation of the works to a certain target audience within society, can perfectly be employed, developing the student's applied skill and obtaining a broad and quality learning.

In the third teaching practice, the research presents its pedagogical facet, where all actors (teacher, student and rural producer) are involved on an equal footing in the teaching and learning process. When a partnership of trust is established between the University, through the research professors and their students (academic environment) with the rural producer (rural environment), the fruits of a participatory research work are harvested daily during its execution, in a continuous process of dialogue in which the producer sees, in real time, the transformation of his knowledge and the research also has its pedagogical role in the training of students.

With the approximation of the producer to the condition of subject of the process of generation and production of knowledge, participatory research reveals its political component, which makes it possible to discuss and dialogue about the importance of the investigation process, having, as a perspective, the intervention in the social, economic and environmental reality, without, therefore, necessarily losing methodological rigor, in addition to providing opportunities for the protagonist participation of students.

In the fourth teaching practice, all students of the Degree in Natural Sciences approved the "Experimentoteca" as a didactic resource for their future classes in basic education, which can be used in science fairs and also in higher education in disciplines related to the teaching of soil science. The "Experimentoteca" achieved its objective of contributing with basic education information on soils in teacher training and dissemination in the teaching of soil science for basic education. And after this case study report, it was proposed that the subjects presented here about soil science be discussed and definitively inserted in the syllabus of the Geosciences discipline of the Degree in Natural Sciences at PARFOR-UFRA, via "Experimentoteca".

Constant reflection on pedagogical practices for teaching in higher education in soil science should be valued. The updating of practices should be constant, always through a collaborative dialogue between teachers and students, aiming to promote a possible transformative education that is aligned with the demands of the current century.

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