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Engineering Education: Interdisciplinary Pedagogical Practices in Civil Engineering

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ABSTRACT

Background: Interdisciplinary pedagogical practices can enhance dialogues, including knowledge and possibilities to produce some impact on society and the labour world. **Objectives**: In general, students need practical activities involving their professional training area, and interdisciplinary pedagogical practices are described from a theoretical and practical perspective**. Design**: This research is based on studying documents produced by the students during ten semesters while studying physics in a civil engineering course. It is educational research of a qualitative nature with descriptive data. **Setting and Participants**: It presents the results of interdisciplinary pedagogical practices developed by students of the second and third semesters of the civil engineering course from 2015 to 2019 at the University of the State of Mato Grosso (UNEMAT). **Data collection and analysis**: The documents analysed were final reports, banners, photos, bulletin boards, teacher's diaries, course plans, videos, and electronic mail. Among more than one hundred reports and banners, 24 reports were selected for this analysis. **Results**: When analysing the documents, it was possible to perceive that the students were involved in interdisciplinary pedagogical practices. **Conclusions**: After this analysis, we concluded that it is essential to bring together professors who teach classes in an undergraduate engineering course to involve students in interdisciplinary actions and reflect on this practice.

Keywords: Engineering education; interdisciplinary pedagogical practices; Civil engineering; Pervious concrete; Physics teaching.

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Educação em Engenharia: práticas pedagógicas interdisciplinares na Engenharia Civil

RESUMO

Contexto: Práticas pedagógicas interdisciplinares podem potencializar os diálogos, incluindo os saberes e possibilidades de produzir algum impacto na sociedade e no mundo do trabalho. **Objetivos**: Descrever e analisar as práticas pedagógicas interdisciplinares realizadas pelos grupos constituídos por alunos da Engenharia Civil matriculados nas disciplinas de Física I, Física II e Laboratório de Física II de 2015 a 2019. **Design**: Essa pesquisa é baseada no estudo de documentos produzidos pelos alunos durante dez semestres enquanto cursavam as disciplinas de Física na graduação em Engenharia Civil. É uma pesquisa educacional de natureza qualitativa com dados descritivos. **Ambiente e participantes**: Apresenta os resultados das práticas pedagógicas interdisciplinares desenvolvidos pelos alunos do segundo e terceiro semestre do curso de Engenharia Civil de 2015 a 2019 na Universidade do Estado de Mato Grosso (UNEMAT). **Coleta e análise de dados**: Os documentos analisados foram relatórios finais, *banners*, fotos, jornal mural, diários do professor, plano de curso, vídeos, correspondências eletrônicas. Dentre mais de 100 relatórios e *banners*, foram selecionados para essa análise 24 relatórios que tratavam de uma temática. **Resultados:** Ao analisar os documentos foi possível perceber que os alunos se envolveram nas práticas pedagógicas interdisciplinares. **Conclusões**: Após esta análise, conclui-se que é importante a aproximação entre os professores que ministram aula em um curso de graduação em engenharia para envolver os alunos em ações interdisciplinares e refletir sobre essa prática.

Palavras-chave: Educação em engenharia; práticas pedagógicas interdisciplinares; Engenharia civil; concreto permeável; ensino de Física.

INTRODUCTION

In the current context, it is central to think about the pedagogical practices developed in the scope of basic sciences and mathematics present in engineering education from a perspective that reflects a commitment to environmental guidelines, quality of life, and citizenship in economically and socially unequal societies.

Basic sciences and mathematics form a set of subjects for engineering courses usually offered in the first school terms (semesters). Engineering departments generally offer few subjects in the first two years of graduation. The current engineering courses curricula in Brazil, structured in a watertight way, with knowledge compartmentalised in isolated subjects, do not correspond to the demands of the market and society to the graduate since their

training does not support the multidisciplinarity required from professionals today (Manrique; Dirani & Campos, 2010).

On the other hand, researchers such as Barbosa, Mezzomo, and Loder (2011) point out that engineering courses are among those with high dropout and retention rates among undergraduate courses in Brazil. As in other countries, in Brazil, engineering students take longer than expected to complete their courses. Among other difficulties is understanding the basic contents. However, engineering students need basic sciences and mathematics knowledge to complete the undergraduate course successfully. According to Camarena (2002), for engineering courses, mathematics is a tool, while physics and chemistry are cognitive science bases.

Several studies in the area show that students have difficulties in basic sciences and mathematics and need this knowledge as future professionals. So, how to overcome these difficulties? Among the investigations involving these areas, studies on teaching and learning in the area of physics in engineering courses stand out (COBENGE/21: Alvares, 2021; Antunes dos Santos, Cargnin-Stieler & Camargo, 2021; Lima, Neves, & Angelim, 2021; Neves, 2021; Stem & Mattasoglio Neto, Cutri, 2021; Silva, Salvador, & Leão 2021).

In most cases presented in those surveys, we noted that students manifested the need for practical activities involving their area of professional training. Based on this, how to work from a theoretical and practical perspective that can respond to the wishes of the students, the prospective engineers?

To contribute to engineering teaching with methodologies that favour learning from a theoretical and practical perspective, this article presents the results of a practice implemented in a Brazilian public university through a pedagogical-methodological approach to learning based on interdisciplinary pedagogical practices. The practices were developed with an extensionist bias in the initial semesters of the Civil Engineering course at the University of the State of Mato Grosso (UNEMAT) in Tangará da Serra, focusing on those practices so that students engage more, are at the centre of the teaching-learning process, and have a hands-on experience.

One of the objectives of the actions developed through interdisciplinary pedagogical practices was to provide students with situations in which they had to think about what to do, for what, how, and for whom they would be carrying out the activities, since each action developed has direct and indirect implications in the lives of human beings. These actions (practices) developed by students and accompanied (guided) by the teacher are usually a social

demand, usually linked to sustainability and deal with thinking (projects), doing (executions), and rethinking (reflecting) to modify the "reality" of the community. In this sense, the teacher's gaze was focused from a Freirian perspective (Freire, 2019b).

Therefore, this research seeks to show that teaching and learning experiences inspired by a teaching methodology based on interdisciplinary pedagogical practices can enhance discussions about students' know-how and the possibilities that dialogues with such knowledge present to produce some impact in the daily life of society and labour work. For Freire (2019b), "teaching requires respect for students' know-how", taking advantage of the social experience they have as individuals to work on pedagogical practices.

Given the above, we ask: How to develop interdisciplinary pedagogical practices in the initial semesters from a theoretical-practical perspective that involves interdisciplinary knowledge in civil engineering?

Therefore, the objective of this investigation is to analyse and describe the interdisciplinary pedagogical practices carried out by groups made up of civil engineering students enrolled in Physics I, Physics II, and Physics Laboratory II from 2015 to 2019. The interdisciplinary pedagogical practices defined here are based on Paulo Freire's theoretical-methodological references, interdisciplinarity being established as a requirement for a social vision of reality (Costa, 2017). From this perspective, the educators recognise the contents being addressed and resignify their knowledge seeing that at the time of teaching, their pedagogical practice encourages students to carry out the attitude of knowing. In this sense, according to Freire (2019a), the role of the dialogical educators is, by working the thematic set gathered in the investigation in an interdisciplinary team, to return it as a problem, not as a dissertation, to the subjects from whom they received it. Thus, as they are encouraged to carry out activities to reflect on their reality, the subjects can begin to understand it, raising hypotheses about its problems and seeking solutions.

This article is divided into six parts. The first presents the objectives, the second, a brief literature review, the third provides the context of the study, the fourth explains the methodology, and the fifth explains the analysis and discussion. Finally, the sixth brings the final considerations.

THEORETICAL BACKGROUND

Thinking about changing pedagogical practices, the National Curriculum Guidelines (DCNs) for engineering courses emerge with teachers and professional transformation commitment. The 2019 Engineering DCNs (Brazil, 2019) point out that engineering education focuses on competencies and a student-centred pedagogical approach with an emphasis on interdisciplinarity and transdisciplinarity, interest in valuing the human being and preserving the environment, social integration, and the link between theory and practice.

This document (Brasil, 2019) also signals attention to pedagogical practices replacing content-oriented teaching with developing competencies and skills (Sarmento, 2020). General and specific competencies can be developed throughout the course. However, the earlier they are developed, the greater the chances of being improved throughout the undergraduate course.

The DCNs point out that future engineers receive an education that facilitates collective construction, project management, and proactive, collaborative, critical, reflective, creative, cooperative, and ethical leadership (Brasil, 2019). They conceive engineering solutions, understanding that people perceive their needs in their contexts.

Items IV and V of the guidelines bring some characteristics of the engineering graduates' profile: "IV – adopting multidisciplinary and transdisciplinary perspectives in their practice; V - consider global, political, economic, social, environmental, cultural and occupational safety and health aspects" (DCNs, 2019, p. 1). However, this will happen when teachers adopt practices beyond traditional education. In this sense, it is necessary to get out of the 'grids', the comfort zone and embrace a multidisciplinary and transdisciplinary action in practice. For the teacher to interact in interdisciplinary and transdisciplinary groups, it is necessary to seek theoretical-practical knowledge in the engineering area that intends to develop interdisciplinary projects.

In 2001, an agreement was formalised between the sciences academies from Brazil and France, with the creation of the ABC Programme in Scientific Education – Hands-on (USP, 2012; Hamburger, 2004), which, according to the author, is a pilot project to assess how science teaching with experimentation needs to be put into practice in Brazilian schools. This pilot project is based on the French project *La main à la Pâte* (Lamap), created in 1996 by Georges Charpak, aimed at improving the teaching of natural sciences in the first school

grades. The historical-cultural conception developed and defended by the Russian psychologist Lev Vygotsky is defined by Mello (2004) as follows:

> Human beings are not born human but learn to be human with other people – with adult generations and older children – with the situations they experience, the historical moment in which they live and with the culture to which they have access. The human being is, therefore, a historical-cultural being. Some of the human skills, abilities, and aptitudes were developed and necessary for life in prehistory, some others in the Middle Ages, and others at the beginning of the Industrial Revolution. Some others are still currently needed. And each human being, in their time, appropriates those human qualities available and necessary to live in their time (Mello, 2004, p. 136-137).

Human beings learn from the situations they experience and the culture they can access. The author also argues that the human being is a historical-social being because it appropriates the qualities available and necessary to live in their context and time. For example, we can cite the Covid-19 pandemic period, when people seized the knowledge they could access and learned from other human beings and their pre-acquired knowledge. In this sense, human beings are free to learn and resemble others.

Carvalho (2018), when dealing with students' freedom in his investigations, argues that:

> [...] the main guideline of an investigative activity is the teacher's care with the intellectual freedom degree given to the student and with the elaboration of the problem. These two items are very important because it is the proposed problem that will trigger the academics' reasoning, and without intellectual freedom, they will not have the courage to expose their thoughts, their reasoning and their arguments. (Carvalho, 2018, p. 767)

Thus, Freire (2014; 2019b) states that teaching and learning are related to the teacher's critical dedication to understanding how students learn, i.e., a difficulty and a beauty, according to the author. In Freire's (2019a) conception, praxis means that the students perform action and reflection at the same time. Reflection modifies its action; therefore, it can go from theory to practice and from its practice to a new theory, and thus theory and practice go together (Madureira & Torres, 2021). The teaching and learning beauty is related to the

teacher's actions in which students are also committed to their learning and the actions taken.

In this sense, it is possible to seek active learning, in which learning is centred on the student. One way to keep students active is with interdisciplinary pedagogical practices involving reality in solutions search to problems. Active learning involves several challenges, in addition to the technical mastery of the subject, such as planning, teamwork, economic viability, production process, and marketing, which are beyond the work in isolated subjects in the course (Santos, Carvalho, & Cargnin-Stieler, 2016).

According to Dwek (2011), engineering problems have become increasingly complex and require sustainable socio-environmental solutions. It is no longer possible to have only the technique as a concern but also the results of its impacts on society. The proposed concepts, methodologies, models, and tools built in the techno-scientific training of the engineer no longer respond to current heuristic diversities, calling into question the currently existing separation between the practice required of engineers and what their training gives them.

When proposing critical education in engineering, this author states that the engineer's formation reaches its maximum potential when associated with contextualised practice, focused on real situations, with social repercussions involving activities of multidisciplinary projects and extension groups as a critical practice.

Working with interdisciplinary pedagogical practices from an extensionist perspective, involving students, allows the production and sharing of knowledge. It allows the students to establish closer communication with their communities and diverse subjects and, in this contact, to carry out exchanges and experiences. Learning is simultaneous and integrated. The critical and plural formation provided by the practice of university extension originates from an epistemological conflict that students (professors and administrative technicians) often experience: the reality is more complex than what academic curricular structures assume, transcending the possibilities analysis of traditional learning dynamics restricted to classrooms and laboratories.

Throughout the history of education, researchers have focused on this theme, highlighted, and described the methodology projects as a way of motivating students to learn; in this direction, Sáinz (1958) stands out. The teacher gathers the students, and his/her role is to facilitate the execution of the

project and the contents to be covered. The teacher suggests strategies for students to progress in their work and focuses on the students' team (Powell, 2004).

STUDY CONTEXT

Tangará da Serra is 230 km from the capital Cuiabá, northwest of Mato Grosso, with a population of just over one hundred thousand inhabitants, being the fifth most populous city in the state.

The civil engineering course at UNEMAT, campus of Tangará da Serra, began its activities in 2013. Admission is biannual, and the maximum number of enrollments per class in the classroom modality is 48. In the course curriculum, the first three semesters are dominated by basic sciences and mathematics subjects, as in most curriculum matrices of the courses offered. This campus only offers civil engineering.

Few professors are tenured; most are contract professors. On this campus, physics professors work on a full-time basis. Since 2014, monthly pedagogical meetings have taken place, in which teachers actively participated, discussing actions to be carried out in the course, such as academic events. Most students come from small towns in the countryside of Mato Grosso and Rondônia states, intending to complete their graduation and return to their origin cities. The distances separating some university students from their families are almost a thousand kilometres, even for those from Mato Grosso.

These practical actions began in 2015 (Unemat, 2015; Santos, Carvalho & Cargnin-Stieler, 2016). The practices focus on the problems and possible solutions discussed previously, i.e., an orientation of the gaze and a search for better environmental conditions. This guiding gaze with intentionality, a search for a deeper understanding of scientific issues, of studying the property of the materials, permeates all the activities proposed for the students, seeking for active participation to interfere in the reality of those involved and improve it from the constituted know-hows (Freire, 2019).

Guided by the teacher, the students gathered into small groups to plan and execute the practices: the idea, the pre-project, the project, the activities, i.e., the actions and executions of the project, and finally, the presentation of the results, including a report on what was developed. The groups were monitored by the professor(s), and during the activities, they were interviewed

by research professors through a semi-structured script. Interviews were audio recorded.

Each semester, the constituted knowledge, the pedagogical, philosophical, and the epistemological reflections of the faculty and students improved, enhancing the professors' way of monitoring and guiding the actions and instigating the students to seek a theoretical and scientific foundation to develop or better useful and lasting products (Miranda, 2006), involving knowledge of civil engineering and social welfare in favour of the engineers' professional education.

METHODOLOGY

This educational research of qualitative nature with descriptive data sought to describe the situations and events experienced in the planning, execution, and students' reports, which lasted from one to two semesters while they were studying physics in the civil engineering course. As a professor/researcher, I had to pay attention to the speeches and changes in the perception of those involved during the practices.

The documents analysed were final reports, banners, photos, bulletin boards, teacher's diaries, course plans, videos, and electronic mail. Among approximately 100 reports and banners (Chart 1), we selected 24 reports that dealt with pervious concrete (Chart 2). This excerpt was a visualisation to detail the analysis in a comparative way. The theme was chosen because it directly involved the subjects of the civil engineering course, interdisciplinarity, practical actions that contributed to the extension either in the community or in the infrastructure of the campus, and actions in the laboratory, besides being present in all semesters analysed. The students produced the documents during the interdisciplinary pedagogical practices in the second and third semesters of Physics I and II and Physics Laboratory II in the civil engineering course at UNEMAT/Tangará da Serra. This study followed the students enrolled in those subjects during ten semesters, from 2015 to 2019.

Table 1

Number of reports per year and main themes

Year/semester	Number	Main themes

2015	14*	Pervious concrete/different traits
2016	22	Pervious concrete/double layer, ecological filters, soil cement, ...
2017	22	Cooling, compaction, Newton's laws, eco kiosk, green curtain, mini square, wood moisture content, bamboo...
2018	31	Bamboo, drainage, mini square, recreational space, electric sieve, vibrating table, ecological square, drainage plates, cement soil,...
2019	28	Kiosk, bamboo, draining floor drinking fountains, ecological ink, arbolite blocks, ...
Total	**117**	

* In 2015 academics produced banners instead of reports.

Table 2
Number of reports per year involving pervious concretes

Year/semester	Number of reports on pervious concrete
2015	*00*
2016	03
2017	04
2018	07
2019	10
Total	**24**

The interdisciplinary practices started every semester. For that purpose, groups of around eight students were formed to develop all the activities related to their project from the beginning to the end of the semester. The student groups were formed based on the teacher's guidance at the beginning of each semester. The reports present abstracts, references, and citations according to academic standards. An example is a report that dealt with the theme of forest revitalisation (not analysed in the clippings of this work), published as a book

chapter by a group (Jesus Júnior, Oliveira, Paz, Frasson, Leite, Pereira, Souza, Garcia & Santos, 2021)

For the qualitative analysis procedures, we overviewed the documents. As there were 117 documents, we opted for a cut involving a theme that was addressed in the ten semesters. The texts of the reports until 2017 were technical, with no discussions beyond the issues involving the technical execution processes. Besides, the groups had fewer students and carried out particular interventions. As of 2018, based on the reflections of the professors' team, the knowledge acquired on the subject, and the popularisation of the works, the students received guidelines for report writing so that the group could write its reflections on interventions, coexistence, interdisciplinarity, creativity, and difficulties encountered, among others. The interventions had a significant impact and a higher level of technical difficulty.

RESULTS AND ANALYSES

This article approaches a description of interdisciplinary pedagogical practices developed in the civil engineering course with students of the second and third semesters.

The interdisciplinary practice

Among other activities, in the first school week, we presented the work done by the students of the previous semesters for the students of the 2nd and 3rd semesters. At this stage, videos, photos, report parts, publications, results of technical visits, and projects in progress were presented and discussed as a way of temporally situating and locating the actions previously developed. We noticed that the students could visualise what was expected of the practices with these discussions. It was also a moment of dialogue that allowed the teacher to get to know the students and bring them closer to the practices that would be developed in the academic semester. In this phase, the professor focused on the students' practical competencies and skills related to attitudes and gave the first guidelines to the groups that would build their projects.

Usually, six groups of around eight students each were formed. It is not a fixed number, depending on the difficulties of the project to be developed. Teamwork can strengthen professional and human bonds between those involved, a relevant factor for the inclusion of students still in the first year of academic life and encouraging learning through research.

These works developed in groups are not of scientific initiation; the intention is for students to develop general skills and abilities, collective relationships, and sustainable actions involving the local community through practical activities.

When monitoring the work, the professor's posture is that of a facilitator. With the look of a researcher, one can think of a new awareness in the engineer's education since the initial semesters. Students looked for possible problems to be developed. These problems are part of the students' context and could be solved. The proposal was to implement an action that could make life easier for everyone and that included the contents of the subjects as a support to develop it.

When the group of students chooses a problem and seeks to solve it (project), at that moment, the professor's gaze needs to focus on keeping the student's intellectual freedom so that he/she can express their thoughts, logical reasoning, and knowledge to be built. In this sense, the guidelines of Carvalho (2018) are fulfilled. The professor also should be attentive to the abilities of each one, giving relevant instructions. In addition, the professor needs to be informed to facilitate student learning and follow the guidelines and questions.

The actions analysis and reports evidenced the dedication to the teams' practical activities and creativity in developing interdisciplinary practices. As we analysed the documents from 2015 to 2019, we realised the students' understanding of the work carried out, such as sidewalks, the floor of drinking fountains, the techniques used, and the production and improvement of tools to work and perform work with pervious concrete. For example, one can understand the dedication and creativity of the student who returns to their public high school institution to implement an extension action to improve that place.

In the reports, we could perceive the knowledge of basic sciences and mathematics and specifics that help decision-making in the planned action (Chassot, 2003). In this analysis, the focus was on practice, dialogues, critical thinking, action-reflection-action (Schön, 1992; 2000), training for work, citizenship, and professional development.

When analysing the acknowledgements, the groups listed UNEMAT, the course coordination, and the professor of the semester. They also mentioned the learning gained from interdisciplinary projects. Through this reading, we realised the interaction of the groups with colleagues from other groups in the same semester, students from other semesters, teachers and the external

community, especially business people in the field. To exemplify: "*The group thanks all coursemates, as all opinions, thoughts, and shared experiences contributed to the realisation of the project*" (Report 7, 2018).

Among other perceptions, it was possible to see that the students presented creative and dynamic proposals. The students visualised the solution and proposed to seek knowledge in continuous dialogue with the teacher. Among the first practices is the execution of a project involving pervious flooring near a drinking fountain at the university. Students write: "*And from this simple and small experimental test of pervious concrete and its functionality, new horizons are opened for practice aimed at promoting this innovative technique for civil construction*" *(*Report 1, 2016, p. 13). You can see the difference in writing and guidelines, that is, the path taken. They are more technical reports in which anguish, difficulties or reports of the acquired knowledge or the subjects that were used were not often found.

In the reports analysed from 2015 to 2019, we noticed that the writing and the action developed were improved by the maturation of those involved. The guiding teacher focused on the pervious concrete theme so that students could carry out projects with a higher level of difficulty and creativity (Freire, 2019a). In the first works, they made pervious plates; later, they applied the pervious concrete *in loco* after creating and perfecting tools for projects and execution with draining concrete on larger scales, for example, draining sidewalks. This gaze was also directed to better involve students in the group according to their skills with the theme. The reports are registers of the actions developed, they received a look beyond the technical issues to report the reflections of the actions developed in the semesters during the practices. This action leads us to reflective practice, the reflective professional, according to Schön (1992; 2020) and Freire (2019a, 2019b, 2014).

The first practices in the course in 2015 involved special concrete with a sustainable appeal (Santos, Carvalho & Cargnin-Stieler, 2016). At this stage, the work involved all students in a class working in groups seeking to produce draining floors, in partnership with a company. On the same theme, Santos, Cargnin-Stieler, and Weber (2018) focus, with a more technical emphasis, on practices with students that show some of the technical aspects of design and execution involving concrete *in loco* for pervious pavements. Another topic of study is the production of soil-cement bricks, which deals with the production process and execution of this type of material, which deal with soil collection, sieving, trace, pressing, curing and construction method. These actions also had

the partnership and support of a company in the sector (Santos, Cargnin-Stieler & Damasceno, 2018).

Among the documents selected for analysis in this article, we searched for evidence between theory and practice. The reports involving practices with pervious concrete were some actions developed in the course with the students' participation.

Regarding the importance of those works as future civil engineers for the practice they managed to integrate, for the contents viewed, Report 3 (2018) stands out. The experience in the execution of the projects led them to realise that the stages, from the project to the execution, *were a construction site*.

This excerpt refers us to the results of a study by Guimarães (2019), who tried to create alternative methodological practices. Among the answers obtained through a form, the students claim: "to have a space like a construction site on the university's Campus". This request from the students surveyed is in line with the practices carried out at UNEMAT since 2015. The view was that at another university, students in the initial semesters of the civil engineering course showed the same perceptions. Another issue that caught our attention was the request for "practice of what is learned in theory in the classroom" (Guimarães, 2019). The students' request in the research has been contemplated in the practices carried out in the context under study. When analysing the reports, we noticed that the students felt comfortable with such practices related to engineering professional education. Some of the works had an extensionist bias and the student felt the joy of contributing in some way.

One of the practices was carried out in the external community, in a free public space where some attended high school. The students in the group report that they were flattered to carry out this work, to be able to contribute to the community, improve the life quality of other people (Report 8, 2019). They also mentioned achieving greater visibility with the execution of the work, as it is another reality, "*including the visibility of the civil engineering course*". This group, formed by second-semester students, had the support of the professors, including the indication of scientific articles.

> *To create the concrete, we had to consult some people, such as professors, to have an idea of how it would be done, which process we should follow and some tips and advice that were very important. The group talked to two professors, […] presented a study on the same subject, and with it, we got tips on how to implant and prepare the concrete. Both professors*

> *provided us with articles and works presented as theoretical reference* (Report 8, 2019, p. 12).

Students cited the teachers' experience, works and publications. These works remind us of the actions taken. These theoretical and practical actions are at the university; they realise what has been accomplished and everyone can enjoy, from the parking space, drinking fountains, and living spaces, among others. As mentioned above, these memories are presented in the first classes, including participation in events and incentives for publications.

Justification of the group to execute the work, this excerpt is part of the constitution process of the project. Only after passing these phases will the work be implemented.

> *On 09/26, the members of the group and the theme to be followed were defined. The group's idea is to apply a permeable sidewalk to the Institute's drinking fountains [...]. The idea was elaborated after analysing the dirt in the proposed place, due to the constant fall of water and the intense people flow, with that there is dirt and as a result of these factors, the need arises to implant a floor to be able to drain the water and alleviate the problem. The group is composed of the students:* (Electronic mail, Group 8, 2019).

As for the group's communication with the subject professor: some students preferred to talk personally with him. Communication through e-mail or print is also part of the responsible teacher's reflections. We noticed that verbal communication is difficult to register. It happens in classes, indoor living areas, and during breaks when the student looks for the teacher individually. In this process, some information went unnoticed. From some reflections, the orientation was that the students tried to synthesise the information, doubts, and project progress through written communication. This orientation was also so that the report could record some reflections on the entire course of the project to the execution of the practice.

Most of the works focused more intensely on the technical part, the knowledge, and how they did it. Mainly in 2019, some reflections were found in the reports, and due to the richness of the arguments, parts were transcribed. We observed that this group was able to execute the work after the third attempt.

> At the beginning it was quite complex, as there were several ideas that went from a bus stop for university students to an

> accessibility ramp in the bathroom corridor next to the [...], but all ideas had some obstacle because what they already had there was a pilot project behind everyone, so after a situation encountered by one of the members of the group, it was observed the excess of pond water in the Institute halls [...]. (Report 8, 2019, p. 13)

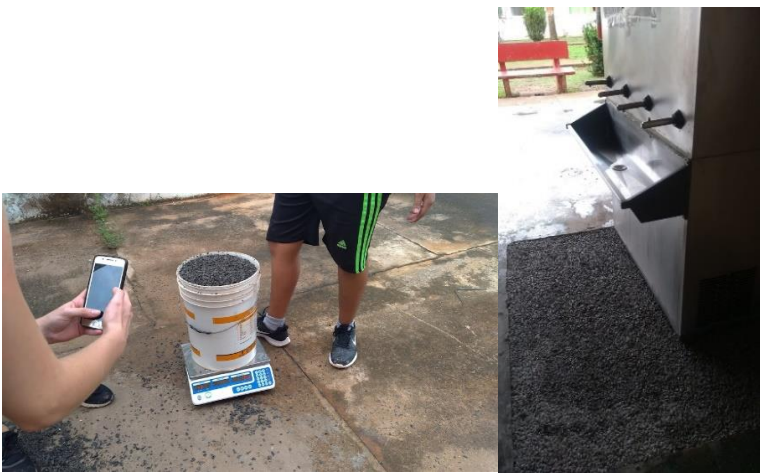
In some reports, we found evidence of group work. This report had the subtitle "experience and coexistence of the group", part of which we transcribe below:

> One of the difficulties encountered by the group was the issue of logistics, as two of the five members of the group are from another city, so both members helped as they could, until the group reached a consensus that two teams would stay, one for the practical and the other for the theoretical part. Decision that was successfully complied with (Report 8, 2019, p. 13)

As we requested the students to register the actions, we noticed that a student usually kept the registers, the photos, the videos, and the notes. We understand that carrying out both actions is a little complicated (Figure 1).

Figure 1

Collaborative work, a shot of the mass of concrete and another student capturing the moment. Next to the water fountain on the draining floor. (



These divisions appear in student registers as well when a student claimed to be responsible for the report. The students themselves divided the tasks based on the teacher's guidance, based on skills and competencies. Usually, all students engaged in the actions. Nevertheless, one would be responsible, for example, for the records that would compose the final report, for the engineering project (design, topography, budget, search for resources, and execution of certain stages, among others). This organisation was already pre-established and others were guided by the professor. The students sometimes did not know each other and the professor tried to integrate them, including according to the skills and competencies for that project. In the course, the subjects are offered per credit. The physics professor teaches more than one subject and thus gets to know the students and their skills, whether in informal conversations or other actions and work carried out.

In some reports, they visualised the learning and writing. Some groups noticed the division of tasks, including monitoring and writing. In other words, students were instructed to record all activities carried out "I followed all the steps, as I am the group's rapporteur" (Report 2, 2018).

The division of tasks was perceived by the records. Some were more involved in the execution and others were recording what happened. This guidance came from the professor when he realised the success of FOCCO (UNEMAT), a project based on solidary cooperative learning in which each participant has a task in the group (Carvalho & Andrade Neto, 2019), in which some civil engineering students participated.

Among the documents, we searched for the electronic mail received, and we found report on the difficulties encountered in starting to carry out the work, and asking about the possible replacement of materials (electronic mail, Group 8, 2019).

> Good afternoon professor […]! We got in touch with [...] about the subject of the vibrating plate, in which the municipality informed us that the machine, due to the long period of non-use, is damaged and there is no maintenance forecast, therefore, the use of the vibrating plate. So, [...] offered a frog hammer, a soil compactor, to replace it, so our group wants to know whether […] (Group 8, 2019)

In this clipping, we see the connections that the process helps develop and, on the other hand, we perceive that the student understands that the

professor helps link the stages and technical aspects of execution in the theme. At that moment, the professor can take the opportunity to make the student's life easier simply by answering or making him think and reflect on the whole context. These are possibilities listed by Freire and Faundez (2021), in which the professor helps learning when proposing questions.

As for knowledge, they report that they managed to add various kinds of knowledge and cite the execution methods, the constructive techniques they used and applied, and what they learned in the classroom for the execution (Report 2, 2018).

Records of learning were also found. In recent years, they reported: "With the practical part performed, we can answer some questions, such as 'What was the result absorbed by the group?', 'What is the importance of the work for the students' learning?'" […] (Report 8, 2019)

We cut out some of the answers reported about the result for the group.

> The activity was very important for the absorption of learning, as it puts into practice several artefacts that are not commonly used both in practice and theory since all the members of the group have never had the experience of digging a hole of this size and for the theoretical part, that we have never studied anything of this type … (Report 8, 2019, p. 12)

Below is an excerpt about learning for students.

> For students' learning, this type of work is excellent, as it places the student within the world of engineering, with the student learning in practice, the fixation of the content is much more solid, as the student absorbs the required content better (Report 8, 2019, p. 12)

Part of the answer about the implementation of work for student learning is transcribed: "The work was essential for learning and for the insertion of all members in the field of engineering" (Report 8, 2019, p. 12).

Among the observed reports, it is possible to select four words (with the variations) that are repeated with greater frequency. Like, see, do, first. The relationship between these four signifiers (Orlandi, 2009; Saussure, 2012) and the meaning manifested after the interdisciplinary pedagogical practices is described below:

Like – they show a taste for practices, for action, for the activities carried out, as they realised what an engineer's life on a construction site is like, how what they learned or are still going to learn is related to action. In some reports, they highlighted the contents studied. They listed a taste for doing, for having the opportunity to choose the action, and being happy with how they were learning.

See – they report that all stages were observed, as they want report readers to perceive all stages they experienced. They want readers to understand that they visualised the work and sometimes needed to modify some things. See and feel the joy of having managed to accomplish, seeing as one of the senses.

Do – doing was present in the reports and for various actions, what they did, how the action was, the steps followed, the difficulties with doing.

First – is related to the first work performed, the first action, the order of tasks and actions to successfully achieve the objectives.

In the year 2019, the last works were developed to solve a real problem in the students' context, since during the following two years, the classes were in the remote modality due to the Covid-19 pandemic. However, when resuming practical activities, in the first classes, in which articles, reports, videos, photos of projects, and previous executions are made available along with the guidelines to be followed, we suggested the model of the 2019 articles, as they also list the lived experiences and technical issues of execution. In other words, the conflicts, the difficulties, the coexistence, and the experiences of the group, in short, it is richer, so it is serving as a subsidy for this research as educators who seek to reflect on the action. Socialisation of knowledge, knowledge domain, student perspective.

According to the exposed arguments and the practices carried out, it is necessary to plan and implement proposals that involve the so-called active methodologies that take into account in the social, cultural, and technical context in the spaces of the university and society. Bringing teachers of basic sciences and mathematics closer to teachers of specific areas through practical activities would be a constant search, mainly because teachers still experience turnover in both specific subjects and basic sciences and mathematics.

We realised the importance of approximations between professors who teach classes in the most diverse areas of the course. To involve students in

interdisciplinary actions, we must involve and even strengthen studies and research on the faculty's actions. It is necessary to go further, to create an investigation group on the pedagogical practice of the course. What is society's demand for engineering courses? The challenge is to think about what kind of engineer one intends to qualify and from that thinking, create actions that favour this critical, conscious education focused on the social well-being. We agree with Camarena (2002) that the professors of basic sciences and mathematics must be prepared in the areas of engineering where they work, and the professors of specific areas need more solid preparation than those they have at the beginning of their career in subjects they address. In light of the DCNs (2019), both need to be aware to build integrated practices aimed at educating students from the beginning of the engineering course. Among the dreams is joint planning, a space that ventilates and articulates the new DCNs (2019) in engineering, companies, and universities.

In this analyses, we tried to highlight the results of a subjectivity attributed to learnin. There are several subjective meanings produced by the students during the semester, which can be noticed through their speeches and behaviours in relation to the team when working on their project that can result in a creative and less memoristic understanding compared to the traditional way.

As for the assumed theoretical understanding, the contents do not constitute an end in itself. We believe that students learn to learn from those experiences. As for the contents, the ideal would be for students to revisit these practices at different levels of difficulty and maturity in the course. Usually, the subjects of basic sciences and mathematics are offered in the first semesters and then, students and the professors do not meet again over the next few years. A "spiral" offer could better involve professors and students throughout the course and not just in the initial semesters of graduation.

When reflecting on the reports from 2015 to 2017, we perceived that those reports were more technical because of the professor's position during the period. This means that the professor's focus was centred on the execution of the work itself, and wanted the students to deliver the finished work, the executed project by the end of the semester. Due to the actions worked, during this period, the reports focused on technical aspects and theories read in bibliography related to the subject. They carried out small tests in the laboratories, establishing a partnership with a company, seeking to make the work feasible. We believe that this is why the students wrote the reports focusing on the technical aspects of the project. From the reflections, the need

to write and publicise the practices, the participation in the COBENGE, in particular the Working Group on Basic Sciences and Mathematics in Engineering (GT-CbME), and the readings and analysis of the reports, we felt the need to see the registers that reported students' difficulties, ease, logistics, sponsorship, the problem of the act of constituting, the groups' gathering, the conflicts that arose during this journey, the contacts with the students of most advanced courses, faculty, and the outside community. As of 2018, the challenge was to carry out actions with greater impact and level of difficulty, involving a larger budget. For example, the pervious sidewalk involved the knowledge acquired in previous semesters, including the participation of the UNEMAT/Tangará da Serra campus and a group of experienced students and newcomers. In report 8 (2019) on the draining floor, the students could write about the problem and therefore the reflections were more linked to the reflection of the practice.

Over the course of the practices carried out, we noticed that interdisciplinary pedagogical practices can help students understand the university and the responsibility of having advanced from secondary education to higher education.

Reflecting on one's own action was what moved the changes in the way of guiding practices; this takes us to a reflection on the action (Schön, 1992; 2000) of the professor involved in it. For example, about knowledge in action, in know-how-to-do, knowledge involved both in planning, action, and reflection for re-planning. For example, reflection on the best concrete, how to make it, what is the best kiosk. For this to happen, a journey as a professor was necessary. Among the different trends, there is a tendency to reflect the practice as a whole, as a teaching goal, thinking about the process of transforming the practice. Reflect on what one is doing, a reflection on action, reflect on action after developing action, reflect on experiences to find a new way of teaching and learning. We must lead the student to reflect on action and in action, which are different epistemologies. Reflecting in action is closer to action, which is why Freire says that all education is political. Education is not repetition, it is reflection, reflecting the meaning of each action, forming people who care about each other, an evolving process.

CONCLUSIONS

With the selected documents, we could analyse the interdisciplinary pedagogical practices carried out by the groups made up of civil engineering

students enrolled in Physics I and Physics II, and Physics Laboratory II from 2015 to 2019.

When analysing the documents, we perceived that the students were involved in interdisciplinary pedagogical practices. The latest reports presented the technical aspects and reflections on the group and on the action, such as the section "Co-working and experiences of the group".

In this sense, in the analyses, we tried to highlight results of a subjectivity attributed to learning. There are different subjective meanings produced by the students during each semester. This was perceived through the reports when describing the memories of the professors involved who, when rereading the documents, remembered the speeches, and attitudes towards the group when developing their practice, which can result in a creative understanding.

As for the assumed theoretical understanding, the contents do not constitute an end in itself. We believe that students learn to learn from those experiences. As for the contents, the ideal would be for students to revisit these practices at different levels of difficulty and maturity in the course. Usually, the subjects of basic sciences and mathematics are offered in the first semesters and then, students and the professors do not meet again over the next few years. A "spiral" offer could better involve professors and students throughout the course and not just in the initial semesters of graduation.

We conclude that it is important to bring together professors who teach classes in an undergraduate engineering course to involve students in interdisciplinary actions and reflect on this practice. The challenge is to think about what kind of engineer one intends to qualify and from that thinking, create actions that favour this critical, conscious education focused on the social well-being.

AUTHORSHIP CONTRIBUTION STATEMENTS

All authors actively participated in the discussions of the results, writing, review and approved the final version of the article. EAS and MCS conceived the actions, interventions, and data. These authors, together with SC, organised the writing, revision, and editing**.**

DATA AVAILABILITY STATEMENT

The data that support the results of this article are under the custody of the author EAS, and can be made available upon request.

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