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ARTICLE

Project-based learning in professional and technological education as a proposal to forced remote learning

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ABSTRACT

The pandemic that started in 2020 was challenging in many areas, including education, with a mandatory migration to remote learning. This work presents the migration of disciplines from the traditional face-to-face methodology to project-based learning in forced remote learning. The contents were transformed into projects, developed in oriented groups, with detailed feedback, freedom of organization and presentation, and group and individual assessment. The general perception was of initial difficulties, of adaptation, but of skills development such as groupwork, presentation of ideas, decision making, planning, organization, and socialization, with the development of critical and creative thinking and commitment to learning itself since the selection of the level and of the amount of information to explore. The development of skills and maturity to deal with projects and problems shows a way forward in the use of active methodologies.

KEYWORDS

PBL; professional and technological education; high school; active methodologies; pandemic.

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APRENDIZAGEM BASEADA EM PROJETOS NA EDUCAÇÃO PROFISSIONAL E TECNOLÓGICA COMO PROPOSTA AO ENSINO REMOTO FORÇADO

RESUMO

A pandemia iniciada em 2020 foi desafiadora em muitas áreas, entre elas a educação, com a migração obrigatória para o ensino remoto. Este trabalho apresenta a migração de disciplinas da metodologia presencial tradicional para a aprendizagem baseada em projetos no ensino remoto forçado. Os conteúdos foram transformados em projetos, desenvolvidos em grupos orientados, com *feedbacks* detalhados, liberdade de organização, apresentação e avaliações em grupo e individual. A percepção geral foi de dificuldades iniciais, de adaptação, mas de desenvolvimento de competências como trabalho em grupo, apresentação de ideias, tomada de decisão, planejamento, organização e socialização, com desenvolvimento do pensamento crítico e criativo e comprometimento com o próprio aprendizado desde a seleção do nível e da quantidade de informações a explorar. O desenvolvimento de habilidades e maturidade para lidar com projetos e problemas mostra um caminho a avançar no uso de metodologias ativas.

PALAVRAS-CHAVE

ABP; educação profissional e tecnológica; ensino médio; metodologias ativas; pandemia.

EL APRENDIZAJE POR PROYECTOS EN LA EDUCACIÓN PROFESIONAL Y TECNOLÓGICA COMO PROPUESTA AL APRENDIZAJE REMOTO FORZADO

RESUMEN

La pandemia de 2020 fue un desafío en muchas áreas, incluida la educación, con la migración obligatoria al aprendizaje remoto. Este trabajo presenta la migración de disciplinas de la metodología tradicional presencial al aprendizaje basado en proyectos en el aprendizaje remoto forzado. Los contenidos se transformaron en proyectos, desarrollados en grupos orientados, con retroalimentación detallada, libertad de organización y presentación, y evaluaciones grupal e individual. La percepción general fue de dificultades iniciales, de adaptación, pero de desarrollo de habilidades como el trabajo en grupo, presentación de ideas, toma de decisiones, planificación, organización y socialización, con el desarrollo del pensamiento crítico y creativo y el compromiso con el aprendizaje desde la selección del nivel y de la cantidad de información para explorar. El desarrollo de habilidades y madurez para afrontar proyectos y problemas muestra un camino a seguir en el uso de metodologías activas.

PALABRAS CLAVE

ABP; educación profesional y tecnológica; bachillerato; metodologías activas; pandemia.

INTRODUCTION

The year 2020 was challenging in many areas, including education. The pandemic caused by the emergence and the massive spread of the new Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV-2) virus worldwide has imposed a need for dramatic changes in educational practices; schools, institutes, and universities began to offer their courses and educational programs in fully electronic modes for the first time in their history (Daniel, 2020; Shawaqfeh *et al.*, 2020). In April 2020, more than 80% of educational institutions worldwide were closed. In 161 countries, the closure was complete; in the middle of the beginning of the 2021 school year — February 2021 —, there were still more than 200 million students affected, 12.7% of students enrolled in the world, and 28 countries completely closed, including Brazil (UNESCO, 2021).

Distance Education (DE) has limitations, even with planning and teachers and students with the profile to do so; when forced and with a rushed planning, the limitations can be even greater. The challenges for students, servers, and their families during the pandemic range from the impact on mental health, economic impact on families, lack of motivation, difficulty adapting to distance learning methods, technical and bandwidth problems to creating content from distance learning materials, mainly affecting practical and laboratory courses (Shawaqfeh *et al.*, 2020). In addition, the need for training for students and teachers, information technology infrastructure and support, and computer skills are barriers that need to be evaluated in planning. With a positive attitude on the part of students towards the situation (*ibidem*), it is necessary to think about the motivation for DE in these conditions. Active methodologies, in which the student is a co-author of the teaching-learning process, not a mere spectator (Akili, 2011), can create a challenging environment that arouses more student interest.

Many efforts have already been directed towards motivating, attracting, and involving students in their learning processes, even in normal situations; in Europe, the Bologna Declaration and the implementation of the European Higher Education Area promote the use of active learning methodologies (Pérez-Martínez *et al.*, 2010) since the early 2010s. In Brazil, the guidelines for engineering courses of the National Council of Education (CNE) also provide a stimulus to the use of active methodologies, centered on the student, based on interdisciplinary practices (Brasil, 2019).

The acquisition of knowledge as a result of an interaction between individuals and their surrounding environment, in which they respond to external stimuli, constructing and organizing their knowledge, can be stimulated by different active learning methods (Novais, Silva, and Muniz Junior, 2017), some of which are: problem or project-based learning (PBL); cooperative learning (CL) and collaborative learning (CLA) (Pérez-Martínez *et al.*, 2010; Hassan *et al.*, 2012; Novais, Silva and Muniz Junior, 2017; Kalaian, Kasim, and Nims, 2018); flipped classroom (Seery, 2015; Novais, Silva, and Muniz Junior, 2017); peer instruction (Lehtovuori *et al.*, 2013; Kalaian, Kasim, and Nims, 2018); or strategies such as the use of quizzes, screencasts, or podcasts (Ferreira de Oliveira *et al.*, 2017), reading and discussion as in the "cumbuca" method (Muniz Junior *et al.*, 2017), among many others. The presence of the

teacher as a facilitator in real problems, developed through groupwork, can increase students' dedication to a specific topic, create opportunities for learning at their own pace (Seery, 2015), stimulate skills such as teamwork, communication, organization in the formulation of ideas, and time management (Muniz Junior *et al*., 2017), besides helping to develop soft skills, conflict resolution characteristics (Deep, Mohd, and Hussain, 2019), leadership (Barreto *et al*., 2017), and autonomy (Seery, 2015), which are not developed in traditional teaching and are an essential part of students' lives (Hsieh and Knight, 2008). On the other hand, the adaptation of students to any of these methodologies is an initial challenge. The teacher may take three times longer to prepare their course (Seery, 2015), and the students may also be overwhelmed. However, with the advent of the pandemic and forced remote teaching, students and teachers were obliged to adapt to a new methodology (Shawaqfeh *et al*., 2020), mitigating this difficulty and potentiating the migration to active methodologies.

PBL emerged in the late 1960s at McMaster University's Faculty of Medicine in Hamilton, Canada. Initially, it was more common in health-related courses, but it has been used in engineering courses (Casale, Kuri, and Silva, 2011; Wang *et al*., 2012; Barreto *et al*., 2017; Cecílio and Tedesco, 2019), natural science education (Martins *et al*., 2016; Pasqualetto, Veit, and Araujo, 2017), humanities and administration (Sugahara, Jannuzzi, and Sousa, 2012; Almeida, Camargo, and Camargo, 2016; Santos, 2020), teacher training (Erdogan and Senemoglu, 2014; Pasquarelli and Oliveira, 2017), adult education (Anastacio and Pereira, 2014), primary education (Borochovicius and Tassoni, 2021), professional and technological education (Barbosa and Moura, 2013; Kalaian, Kasim, and Nims, 2018), and is also used in (DE) (Almeida, Camargo and Camargo, 2016) and massive open online courses (MOOC) (Dong *et al*., 2020). The problem or project-based methodology consists of using real-life situations related to the context and life. Students are confronted with an open, poorly structured real-world problem, identifying learning needs to develop a viable solution, with teachers playing the crucial role of facilitators rather than primary sources of information (Akili, 2011; Justo and Delgado, 2015).

Students in PBL should be encouraged to understand the basic concepts and relationships of a particular theory and learn how to use them in problem-solving or project development (Lehtovuori *et al*., 2013), relating theory to practice more closely (Seery, 2015); it can still be used to integrate teaching and research (Ríos *et al*., 2010). The key to success is in problems or relevant projects, together with enthusiastic teachers (Kingsbury and Lymn, 2008). Also, the success of some depends on understanding their practical objectives (Ross *et al*., 2007); therefore, communication must be very well elaborated from the beginning. Detailed feedbacks are not essential to follow the process to keep the motivation of two students (Strohfeldt and Khutoryanskaya, 2015). Furthermore, the way of working must be well structured, striving for cooperation — the engagement depends on aspects such as a positive interdependence and interaction among themselves, shared responsibility (group evaluation, but also student performance), sharing of known skills, collaboration, and constant monitoring of progress (Akili, 2011). Benefits as students who take the best exams (Galvão *et al*., 2014; Strohfeldt and Khutoryanskaya, 2015; Nguyen *et al*., 2020) and results showing women with better performances in engineering (Nguyen *et al*., 2020) of which men are also encouragers to expand the paths of ABP.

Vocational education and training (VET) in Brazil has a long history, starting with the Schools for Apprentices and Artisans in 1909 and consolidated with the creation of the Federal Network of Vocational, Scientific, and Technological Education in 2008 (Brasil, 2008). In this model, the Federal Institutes of Education, Science, and Technology have the characteristic of integrating basic education with vocational education, with vertical integration that allows offering basic education up to higher education by the same institution. These institutes aim at the integral education of their students, emphasizing the inseparability of teaching, research, and extension (Gonçalves, 2016; Marques and Vieira, 2020). According to data from the Federal Nilo Peçanha platform (Ministério da Educação, s.d.), the Federal Network is composed of 656 units, totaling more than 1.5 million enrollments in 2022. With a budget managed directly by the Secretary of Vocational and Technological Education of the Ministry of Education, the network, in 2022, has a ratio of in-person enrollments per teacher of 21.76.

In VET, especially in technical education, there is a common scenario of overwhelmed students, often due to the traditional high school workload and concerns about college entrance exams, which can generate a scenario of indefinite anxiety (Barbosa and Moura, 2013). With forced remote learning, the concern for mental health is greater, the feeling of uncertainty increases, and therefore adequate counseling services must be available to support students' mental health and well-being — the workload for students may also increase. Faculty members must embrace technology and pay close attention to students' experiences to make learning rich and effective (Sahu, 2020), with health and safety as a top priority. PBL can be relevant to the student to increase motivation and interest and reduce the required work (Bender, 2014). Even when working in remote education, PBL contributes to the development of skills related to human and social development, such as the well-known 21st-century skills, which include critical thinking, effective communication, collaboration, and creativity (Medeiros *et al.*, 2018).

In this context, this study presents the transformation of three regular courses at the high school level into PBL in forced remote learning; the novelty lies both in the unique pandemic situation and in the application of this teaching methodology in technical high school courses.

METHODOLOGY

A study on the application of PBL in remote teaching was conducted with 95 students of the Brazilian vocational course at the high-school level and is presented and discussed. The case study was carried out in professional base disciplines of three different classes of the technical courses in Chemistry (3rd year) and Sugar and Alcohol (2nd and 3rd years) integrated into high school education at the Federal Institute of Education, Science, and Technology of São Paulo, *campus* Matão. In this course model, students have a comprehensive education that includes a common high school education integrated with professional content in their respective technical areas.

Classes were suspended with approximately one month of traditional in-person teaching during the 2020 school year. After about four months, classes resumed remotely and PBL was applied with three projects for each of the classes. Each of the projects was developed from the beginning to the end of two months, with only one exception — in one of the classes, a project lasted for the last two bimesters. In the first remote class, conducted synchronously, students were introduced to the methodology through dialogue and were allowed to give their opinions on the formation of groups, the presentation format of the project (type of artifact), and some aspects of the schedule and project itself, which became effective from that point on. The seed or project proposal was presented to the students by the teacher through dialogue, with some participation from the students, but not created by them, as is characteristic of PBL (Bender, 2014), during this transitional period.

The methodology took place at a micro level (Akili, 2011), with individual disciplines in specific periods. The projects were designed to cover the contents of each two months but were broad enough to allow for very distinct solutions depending on the choices of the groups and intentionally missing some essential information for the project development — always with the care of ensuring that the information was available in the places researched by the students. Thus, all the theoretical content of the discipline could be into a specific project stage, to a lesser or greater extent, but always with practical application. Chart 1 presents some important topics of the executed projects.

Chart 1 – Projects key points.

Key points:
1. Based on a real industrial scenario
2. The specific and well-detailed driving question
3. Tasks that include critically utilizing the syllabus
4. The depth level of content can be determined by students
5. Freedom to solve problems in different ways
6. Critical thinking and decision-making challenges
7. Integrates opportunities for problem-solving activities within the project
8. Well-defined evaluation rubric

Source: Elaborated by the authors.

CONSTRUCTION OF GROUPS

A first challenge in the development of the projects was the construction of groups, initially for the first project, but which could continue in the following projects or not, according to the students' choice. A form was assigned to the students for a self-assessment of their profile with some specific characteristics or abilities defined by them as primary, secondary, or tertiary. The assigned characteristics were liking for photos, videos, and editing; reading and research; computer skills; writing; hands-on work; and creativity. The students decided to divide themselves into groups (rather than a directed lottery based on the characteristics) and were instructed that each group should

have all the attributes in the primary and secondary levels of its members, which could be modified if there was no such distribution. The number of members in the groups was between six and nine students (six to eight or seven to nine, depending on the class). The students chose the leader of each of the groups, which is good in terms of their valorization (Barreto *et al.*, 2017) compared to a voluntary or teacher-chosen leader.

BIMESTER PLANNING

The planning of each project followed the structure presented in Figure 1, undergoing some specific adjustments due to calendar issues, science fair, etc. In some cases, with a tight schedule with fewer instructional days than usual, weeks 1 and 2 were condensed into one or week 9 of one project coincided with week 1 of the following project.

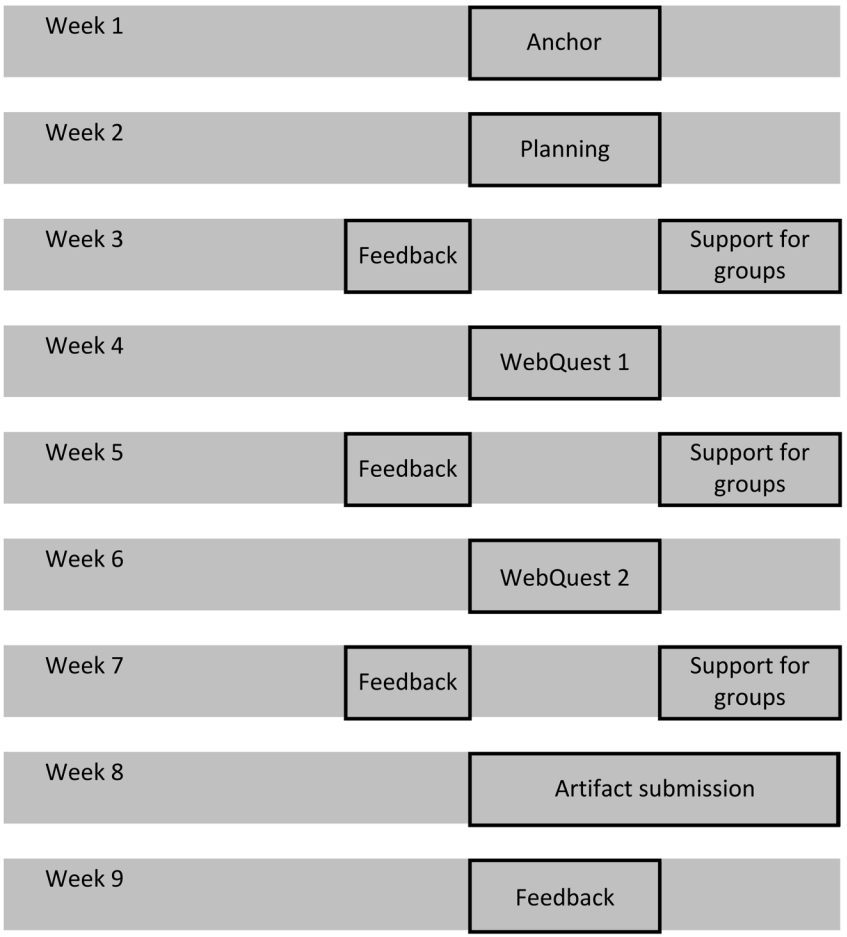

Figure 1 – Bimester planning.
Source: Elaborated by the authors.

At the beginning of each project, the students received the project's anchor, a driving question, and a list of tasks they have to execute. In addition to this document, they had access to Moodle, a virtual platform that contained the semester schedule with the dates and themes of the WebQuests and the final delivery date, as well as bibliographies that could be useful along with internet research. Based on this material, the first deliverable was always a planning document that should contain the name of the leader, the secretary (responsible for communication with the teacher and group records), and other functions defined by themselves, in addition to a list of tasks to be executed throughout the project. The list should include the approximate date and the person responsible for each task. The functions were not individual, they could be formed by subgroups. Allowing students to organize their way of working, the roles to play in solving their own problems, and the resources to achieve their goals is one of the characteristics of PBL (Loyens, Magda, and Rikers, 2008).

The first group feedback was based on this planning, aiming to help students understand the complexity of the problem they would face, which content they would need to study and research, and how to organize themselves. This would also allow the teacher to evaluate, in addition to groupwork, the individual development of each student (Akili, 2011). Whenever students received feedback, they had the next class time to meet with the subject teacher and ask questions about the feedback and future activities. It is important that feedback is always very detailed (Strohfeldt and Khutoryanskaya, 2015). Small doubts could always be clarified in asynchronous appointments. The same dynamics occurred during the WebQuest feedback weeks. The WebQuests were generally two (possibly three) per project and they were presented to the students in the form of a text with an introduction to the specific item of the curriculum, contextualizing this content with the project itself and a research activity that should be fully completed, addressing all the main topics of the content. Given the possible difficulty of students in finding materials on technical subjects, bibliographies, videos, and websites were always made available as suggestions, but with an incentive to explore new sources of information. The level of detail and amount of information to be explored in the WebQuests were the responsibility of the groups, aiming at the development of critical and creative thinking, encouraging possible concern with their own learning (Casale, Kuri, and Silva, 2011).

The final stage of the project was an artifact that the students chose to develop in the form of a video presentation. Since the projects were industrial in nature, the presentations were geared towards the owners, managers, or someone in the industry to which the project applied (who, in general, did not have the technical knowledge and would need it to understand the proposal), giving a tone of formality and a need for technical detailing to the artifact.

The project evaluation was carried out through an evaluation rubric prepared at the beginning of the project, following the evaluation model proposed by Bender (2014). The group's grades ranged from 1 to 10 and were assigned to four declared objectives, each worth 2.5 points and with four levels of objective fulfillment. The group grade corresponded to 60% of the average and the individual grade, based on the fulfillment of the planned activities for each member (or subgroup) and the perception of individual work development, when possible, 40%.

RESULTS AND DISCUSSION

The results of transforming three traditionally taught in-person courses to PBL in remote teaching, forced by the pandemic, will be presented and discussed according to students' perceptions before, during, and after completing the courses. The analysis is presented qualitatively, and it is not the objective of this study to present quantitative discussions. The students' opinions presented were selected as relevant in a large group to represent the main aspects raised and expressive opinions. For each set of student responses, a summary of the main aspects raised is presented.

STUDENT'S PERCEPTION BEFORE THE METHODOLOGY CHANGE

Chart 2 presents some student responses regarding their perception of challenges, limitations, and potentialities they saw in remote learning at the beginning of the activities.

The student's perception of the problems of remote learning were mainly related to organizational and motivational aspects, the environment to study, internet connection, lack of contact with peers and professors, and lack of proficiency for both professors and students to work with remote learning or DE. Almost all perceptions about remote learning were limitations. However, students found potentialities, such as their own organization, independence, flexibility, learning about computer use, and a sense of responsibility for themselves with this new challenge. In general, communication was the biggest challenge and limitation encountered by students. Chart 3 presents the students' perception of PBL after the initial presentation of the method.

The students saw PBL as a great challenge, with prospects of being something difficult in their own words, but with the potential to stimulate characteristics such as teamwork, creativity, communication, involvement, and interest in the content, which were also seen as major sources of difficulties. Little or no rejection, which can occur if initial care is not taken to present the methodology (Ross *et al.*, 2007), has been noted. Overall, we noticed a fear of the unknown but this fear was seen positively by the students — as in other cases (Shawaqfeh *et al.*, 2020) — and with potential for the development of soft skills, in addition to the content of the disciplines. The students' perception was aligned with the objectives of PBL, an important fact at the beginning of implementation (Ross *et al.*, 2007).

In the same initial questionnaire about student's perceptions, a self-evaluation of profiles with some chosen characteristics or skills was conducted. The students were encouraged to choose, among the characteristics, which ones they saw as primary, secondary, and tertiary in themselves. The profile of the classes is presented in Figure 2.

Even though working with a generation that was born with the internet and saw smartphones emerge in their childhood, computer knowledge is the skill with the least responses, and even in the era of social networks, photo and video editing is also a characteristic with few responses. The classes are formed by students who consider themselves organized and with a good distribution among writing, research and reading, hands-on work, and creativity, among other selected characteristics. This good distribution facilitated the formation of groups, and there was no need to

change the groups formed by the students themselves. The general distributions presented in Figure 2 reflect the individual patterns of each class, which showed similar distributions. An interesting point was that the choice of the leader showed no relation to characteristics such as organization — leaders from various profiles were chosen.

STUDENTS' PERCEPTION AT THE END OF THE INTERMEDIATE BIMESTERS

At the end of each bimester, a new form was assigned to the students, with open questions about their perception of remote teaching and PBL and a space

Chart 2 – Student's perception* of future remote teaching.

Student's perception	Some topics
Challenges "I believe that we are going to have several challenges because everything is new for both sides. One of the challenges, which affects me the most, is the contact we had with our teachers for everything, which amid this pandemic is impossible." "I believe that the interaction between the two sides will be very complicated, taking into account problems with the internet and things like that, but mainly because there is not a discussion where the two are present in the same place. I also really consider the side of the students, who are losing confidence and faith in their potential, putting it in their heads that they can't." "Conciliate time for school activities and entrance exams." "Professors who were not prepared to teach online classes and difficulty in adapting content and students getting used to this pace of study."	• Adaptation • Lack of physical contact • Volume of tasks • Organization • Motivation • Lack of aptitude for the method
Limitations "I believe that this is the moment to clarify doubts because this is very valuable and being in this DE routine, I believe that this interaction is a little complicated." "The limitations would be that the teachers won't be there to teach you and support you privately, for example, come to your desk. We'll have to send texts explaining." "Probably what will affect the most is inequality, not everyone has access to networks and does not even have adequate/sufficient equipment for remote teaching."	• Internet bandwidth • Practical classes • Communication • Combating inequality
Potentialities "This class model is adaptable, each one can organize their studies according to their routine, which in a way is an advantage." "When the class is recorded students can pause, go back, and copy more calmly." "I believe that students will learn to study by themselves, and that is very good." "I believe it will be advantageous for shy students who don't like to talk in class, they can feel more comfortable, and the content can be done calmly at home." "Best learning on the computer side." "For me, there are no benefits to this teaching model."	• Sense of responsibility • Flexibility of schedules • Study pace flexibility • Use of computers

*The responses are reproduced in their entirety as sent by the students.
Source: Elaborated by the authors.

Chart 3 – Student's perception* of future teaching based on projects.

Student's perception of PBL	Some topics
"I find it interesting. With the development of projects, I believe that when doing research on a certain topic, you tend to know more about the subject." "I think it's going to be cool, there are research stages and there's the whole group that can help each other :)" "It will be a little difficult at first, we will have to get in touch with the project group and normally speaking in groups is a little messy, but I think with time we will get used to it. My expectation is that it will be something very interesting and that we will learn a lot from it, we will have to do research and edits, it will be cool." "It will be a challenge as I am not an extrovert." "I think it's an interesting approach that encourages creativity and more dynamic learning with some difficulties because it's something we weren't very used to (in parts) in traditional teaching." "Groupwork in face-to-face is already complicated, I believe that virtually it will get even worse. In my opinion individual work is better." "I feel like it's going to be full of very difficult challenges, and we're going to be very tired and worried about that, but I also feel that this in a way is going to help us prepare for the future." "It appears to be difficult, but I think it enhances our creativity in how to approach the content."	• Initial challenge and adaptation • The potential of groupwork • The difficulty of working in a group • Autonomy • Interest • Creativity • Use of technology • Motivation • Afraid of the unknown

*The responses are reproduced in their entirety as sent by the students. PBL: project-based learning.
Source: Elaborated by the authors.

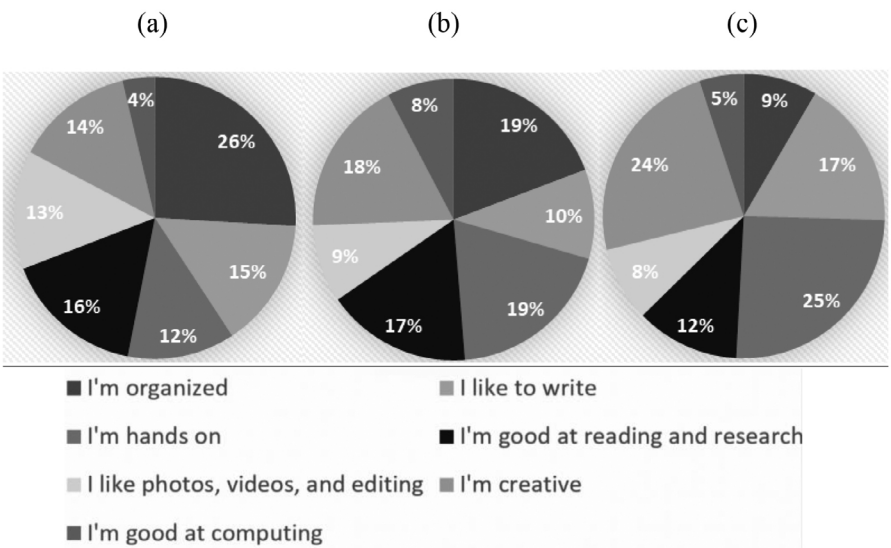

Figure 2 – Student profile according to self-assigned primary (a), secondary (b), and tertiary (c) characteristics.
Source: Elaborated by the authors.

for suggestions and complaints for the continuation of the work. Charts 4 and 5 present the students' responses and some relevant topics about each theme. The responses from these forms showed adaptation difficulties that persisted throughout the year. On the other hand, they did not show difficulties with the platforms used and highlighted a self-assessment of their own characteristics, such as organization. At the end of the second bimester, the characteristics of this development become clearer, including answers about improved autonomy and independence, teamwork, and other positive points amid a few more complaints — in much smaller numbers.

Chart 4 – Student's perception* of remote learning and project-based learning at the end of the first two months.

Student's perception	Some topics
Opinion on remote teaching after one bimester "Remote teaching is not so easy for me, it is difficult to adapt and learn, it is very different from face-to-face classes." "More difficult to understand alone, the study time seems to be longer and the time to study for the entrance exam is almost non-existent." "Without a doubt, remote teaching is far from resembling a face-to-face class, the contact is greatly missed and at home, it is much more difficult to concentrate on classes, where we all have different factors that prevent us. However, these classes are teaching me to be more organized about my schedule and homework." "It's not the same thing as being in the classroom, sometimes we have difficulties communicating with some teachers and are ashamed to be answering our questions. The platform we use is easy to understand and the video lessons and pdfs have helped a lot to understand the subjects." "Teaching is very complicated and confusing."	• Lack of time • Best organization • The vestibule in the background • Difficulty with focus • Good adaptation to the platform
Opinion on the PBL after the 1st project "I prefer this method to assessment tests, so I think it's easier to learn from research and videos." "At first I thought it could be easy, but in practice, it is not that easy, even more so when you have to work in a group virtually, much more complicated, even more so in a scenario where we are full of tasks, sometimes not everyone has the availability of a time to discuss the project." "It was a little more difficult, maybe because I don't like working with large groups, but I'm proud of the result." "I thought it was cool, I think it should be a more used method, even in face-to-face classes." "We were able to have direct contact with the course area before working in the industry."	• Difficulty working online • Contact the course area • Funny • More laborious/difficult • Curiosity in applying to face-to-face classes • Self-criticism • Further research

*The responses are reproduced in their entirety as sent by the students. PBL: project-based learning.
Source: Elaborated by the authors.

Regarding PBL, at the end of the first project, students reported difficulties, such as online groupwork and the method's difficulty itself, but amid many positive points, such as it being fun, the contact with the work world, the freedom for more in-depth research, and the curiosity to work with the method in a face-

Chart 5 – Student's perception* of remote learning and project-based learning at the end of the second bimester.

Student's perception	Some topics
Opinion on remote teaching at the end of the 2nd bimester "DE has become something very boring and tiring now, before it seemed that it would be something different (less bad), now everything is very boring..." "I keep thinking that it is difficult to organize myself and fulfill all the tasks." "My opinion regarding remote learning has not completely changed, for example, I still find it difficult to work away from teachers and classmates. On the other hand, I have learned some lessons, as a matter of fact, the ones I have acquired the most are autonomy and independence, I do things I've never imagined. I would be able to do it alone, I see this as something super positive."	• Tiring • A large volume of tasks • Improved autonomy and independence • Distance between teachers and students remains a challenge • Best organization • Difficulty understanding the subject
Opinion on the PBL at the end of the 2nd project "The PBL method makes it easy to develop teamwork and this is a very important skill for our future." "I believe it ends up being more difficult to carry out, even more so in a situation like the pandemic. Research ability and self-control." "I like the method used, I acquired a lot of autonomy with teaching in DE and the resource used by the teacher was one of the contributors for this to happen." "I liked this method, as it helped us to develop more thinking by looking at the problems in more detail." "I find PBL much more difficult because it requires a lot more time and effort from all of us, so far I haven't noticed any skills I've developed with it."	• Teamwork development • Difficulty • Autonomy • Maturity in the organization • Research skill • Search deeper and for a longer time

*The responses are reproduced in their entirety as sent by the students. PBL: project-based learning.
Source: Elaborated by the authors.

to-face course. At the end of the second project, even with comments about the difficulty, students showed maturity in organization, teamwork, and more in-depth research for a longer period as positive factors of using the method. In the open space for suggestions and criticisms, the few comments made were generally about problems with large groups. Some complaints of this type resulted in the splitting of one of the groups into smaller ones, one student who left one group and joined another, students who stopped participating in the activities by submitting or not submitting recovery assignments instead, and the need to reorganize some groups at the beginning of the next project for it to work better. The need for individual evaluation in student motivation was clear in the groups that had this type of problem and, therefore, should always be taken into consideration (Tadjer, Lafifi, and Seridi-Bouchelaghem, 2019). The students who left the groups were always students who had been presenting problems with not submitting assignments in other disciplines, showing no relation between the dropout and the methodology specifically in any case.

When thinking about deep learning, some of its main aspects (Muniz Junior *et al.*, 2017) can be noticed in students' comments, such as an appropriate motiva-

tional context, adequate learning activities, and interaction between student and teacher — considering the limitations of the application context. The well-structured knowledge base is the missing item, but it can be noted in the comments. Overloaded students tend to fall into superficial learning, its opposite, which produces a student focused on reproducing knowledge (*ibidem*), a characteristic not perceptible in students' perception.

PERCEPTION OF STUDENTS AT THE COURSES' CONCLUSION

Chart 6 presents students' responses to a closed questionnaire at the end of their courses.

The results of Chart 6 show some of the aspects that were raised in the open-ended questions applied during the courses, along with the perception of students regarding typical aspects of active learning methodologies. Most students believe that the methodology should be complemented by theoretical classes (Q1) and are curious to experience the methodology in in-person classes (Q18), even though some of the classes had difficulty with projects (Q2). In this scenario, detailed feedback proved important in overcoming these difficulties (Q10 and Q11). Activities related to planning, research, feedback interpretation, discussion, and presentation (Q4) were seen as important in developing soft skills, partially creating confidence in applying these contents in a future life (Q3). One of the biggest problems is the lack of time generated by remote teaching and the pandemic itself (Q13), along with problems related to distance (Q14); the platform used was not seen as a problem (Q15). Planning was viewed positively (Q6), as was the experience of explaining content to a colleague at some point (Q12). Students generally agree that projects, even if carried out online, encompassing no more than one discipline and with the delivery of a video artifact, provide a view of work in a company (Q7), make learning more meaningful through groupwork, cooperation (Q8), and application of theoretical content (Q5) and believe they have retained the studied and applied concepts (Q9); the method is seen as a good solution for forced remote teaching (Q17). The comparison with traditional online methods (Q16) brought some confusion that diverges from the responses in the rest of the questionnaires. This type of confusion can be perceived when students have difficulties organizing their time with everyday activities (Seery, 2015), a difficulty that could be overcome in face-to-face teaching using PBL.

Chart 7 presents students' opinions regarding remote teaching after having gone through it in an almost entire school year experience. Chart 8 presents the expectation versus reality of PBL. In comparison with the initial view, which was quite negative, some positive points, such as the development of better organization and responsibility skills, were raised by the students. On the other hand, feelings of anxiety, insecurity, and lack of commitment to studies were also raised, which may be related to higher dropout rates than usual in this atypical year — out of the 95 students who started in the three disciplines, nine completely dropped out of classes. Flexibility, initially seen as an advantage of remote teaching, ended up being raised as a difficulty in the end.

Chart 6 – Student's perception of the project-based learning at the end of the course.

Question	TA	PA	I	PD	TD
Q1. Project-based learning needs to be complemented by traditional lectures	42%	35%	16%	6%	0%
Q2. The difficulty level of problems presented was very difficult, we could not solve them without the teacher's help	16%	44%	0%	41%	0%
Q3. I feel ready to use the knowledge acquired in the course in future activities: professional, graduation, etc.	25%	50%	6%	19%	0%
Q4. Activities such as planning, researching, interpreting feedback, discussing, and presenting helped to develop my independent study skills	55%	33%	9%	3%	0%
Q5. With teaching based on projects, learning is more meaningful because we research the theory thinking about how to apply it	36%	42%	15%	6%	0%
Q6. Planning helped the group to organize itself to develop the project	67%	9%	18%	6%	0%
Q7. I have a better understanding of technical content because with projects it's like working in a company	30%	45%	15%	9%	0%
Q8. With projects, learning is more meaningful because, with group solving, students help each other	26%	45%	13%	16%	0%
Q9. I retained more knowledge about the discipline with the projects because, in addition to reading concepts, we had the chance to apply them	27%	52%	15%	6%	0%
Q10. Teacher feedback helped us to move forward with the project	79%	9%	9%	3%	0%
Q11. Teacher feedbacks were detailed enough	76%	15%	6%	3%	0%
Q12. When I'm explaining a principle to a colleague, I feel like I'm learning more	48%	36%	12%	3%	0%
Q13. Because of my daily commitments, I could hardly dedicate myself to the project	22%	33%	22%	22%	0%
Q14. Although we had already worked as a group before, we had difficulties caused by the distance	53%	19%	19%	9%	0%
Q15. It was great to have the material stored in Moodle, I always had access to what was being studied	79%	18%	3%	0%	0%
Q16. I did not understand the content because I prefer to learn through the traditional method, with classes and solving exercises, even online	4%	30%	48%	19%	0%
Q17. The project-based method was a good solution for online teaching	39%	55%	6%	0%	0%
Q18. I would like to try the project-based method with face-to-face classes	58%	29%	13%	0%	0%

Source: Elaborated by the authors.

Chart 7 – Students' opinions* on remote teaching.

Opinion on remote teaching	Some topics
"My view on remote teaching changed a little, as I realized that the lack of face-to-face interaction with both colleagues and teachers can end up harming the psychological. I ended up becoming a more anxious and insecure person with everything that was happening, but I found the best way for me to be able to study and learn." "Remote teaching in my mind was easier and better because I was at home and more comfortable. In reality, it was not like that, you need a lot of discipline to have DE." "Yes, despite the difficulties, I discovered myself as a person capable of learning remotely and I felt that I had matured a lot since delivering activities and maintaining a study routine was my greatest responsibility and helped me to gain more maturity and independence." "Unfortunately, no, I still don't like this form of teaching. I believe that because of everything that happened this past year, I ended up relaxing a little in my studies."	• Organization and responsibility • Anxiety • Insecurity • Disengagement from studies

*The responses are reproduced in their entirety as sent by the students.
Source: Elaborated by the authors.

Chart 8 – Did the project expectations of the students* change from the first impression?

Expectation vs. reality of the PBL, has your opinion changed?	Some topics
"Yes, a lot. In the beginning, I found some jobs complicated, mainly because it was a new subject, but as the course progressed, we saw that despite all the difficulties, we managed to do them all." "I don't remember very well, but I believe I found the idea different and quite challenging, and these projects were challenging. But I learned many things that perhaps in a normal class I would not be able to understand." "At first, I didn't like it very much, I thought it wouldn't work, but now, my vision has completely changed. It was great to be able to work in a group, get to know each other better, learn to share functions without overloading anyone and we learned to get along better with each other."	• Complicated and then it got better • Better learning • Good results from the student's point of view • Learning in practice • Interpretation • Organization • Coexistence

*The responses are reproduced in their entirety as sent by the students. PBL: project-based learning.
Source: Elaborated by the authors.

The responses presented in Chart 7 can be compared with those ones presented in Chart 6, in an attempt to separate two basic issues: PBL and remote learning. Although the topics were presented to the students at the same time, one can see a perception of remote learning generates greater difficulty in learning, especially with regard to organization and commitment to routine, along with the sudden lack of social interaction at school — with students and teachers —, generating anxiety and insecurity. As a result, various responses appear in the direction of a more uncommitted view of teaching and the school itself. On the other hand, the overall view of the responses from Chart 6, about PBL presented earlier, shows the development of planning and organization skills, interaction within workgroups

and with the tutor (in this case, the teacher) that can collaborate to alleviate the problems generated by forced remote learning.

Chart 9 presents a summary of the difficulties, challenges, and limitations encountered by students in PBL. The greatest difficulties encountered by students are related to working in remote groups. The commitment of all group members, organization, and debate of ideas are seen as major challenges. On the other hand, students cited learning in a group, helping each other, discussing, and planning as difficulties that were positively overcome. The responses about students' challenges were also largely focused on those of remote learning and require a broader interpretation, as they demonstrate failures in the organization of the study environment, student-student and student-teacher interaction, aspects of the student's integral formation that go beyond acquired knowledge, the human

Chart 9 – Difficulties, challenges, and limitations of the project-based learning according to the students*.

Student's perception	Some topics
Difficulties "Doing a group project takes time and patience, both to discuss ideas and opinions, and to organize everything correctly." "It is tiring as it requires a lot of research and reading." "Without a doubt, planning is a difficulty, as it has to be something very well done, so as not to get lost when putting the project into practice." "The need to know, seek and study the information to be able to apply it to the project is the most difficult step, in my view."	• Commitment, interdependence, and group organization • Group brainstorming • Help from colleagues • Difficulty finding content on the internet • Planning • Group discussion • Tiredness • Search for technical information
Challenges "It's your project, so you worry 10 times more." "The issue of organization and autonomy and also more research for understanding." "I believe that if this method were applied in the face-to-face modality, it would be much better." "I believe the biggest challenge for a student is to stop receiving information and start looking for it on their own."	• Greater commitment • Difficulties of remote teaching • Communication • Organization and autonomy • Research and theory pursuit • "Don't give up when something is wrong, see the mistakes and try to correct them" • Autonomy
Limitations "Perhaps authenticity. As it is in a group, sometimes their opinions end up falling apart." "Since this year it was in the distance learning modality, I feel that this was the impasse, but if it had been in person, the method would be much more dynamic and with no limitations."	• Lack of computer • Dialogue and communication • Communication by text • Missing face-to-face class • Group discussion and brainstorming • No limitation

*The responses are reproduced in their entirety as sent by the students.
Source: Elaborated by the authors.

formation through solidarity, values, and attitudes that come from social interaction. The challenge of having a project to complete was seen as a source of better commitment from group members, even with all the difficulties. The students mentioned that detailed feedback at various stages of the project helped them maintain their commitment when things were not going so well, which shows the importance of close contact between the teacher and the groups (Strohfeldt and Khutoryanskaya, 2015). As for limitations, the greatest time commitment, computer or internet connection problems, and communication were points raised by students, in the vast majority of responses referring to remote learning as a whole and not specifically to PBL. However, the most common response was "there are no limitations."

Chart 10 presents the student's opinion on planning, which was frequently mentioned by them throughout the course, and the lessons learned from using the PBL methodology. In one of the classes, the planning of the final project was not mandatory, unlike all other projects. In this class, the students themselves found it difficult to plan, organize project tasks, and divide them among group members. This fact highlighted the need to encourage them quite strongly to carry out detailed planning of tasks and member assignments, as designing the environment for solving their own problems with their own resources is an important feature of PBL (Loyens, Magda and Rikers, 2008). Planning helped students perceive their skills, and help each other when someone was struggling, which was noticed more easily due to clearly defined assignments; actively providing explanations during a discussion positively

Chart 10 – Planning and lessons learned by the students*.

Student's perception	Some topics
Planning "At first we had difficulty, even to understand the area of ease of each one, but we soon adapted and the plans became very useful." "Our group followed the planning very well... those who couldn't or didn't understand would clear up their doubts and sometimes, if necessary, we'd change the functions of these people, so that everyone could do it."	• Perception of skills • Disappointment with people in the group • Praise for groupwork • Self-help within the group • Subgroups that performed well • It helped in the subdivision of the project stages
Lessons learned "With this method, I was able to have a different vision of groupwork and we can see the people who really make an effort and help to develop the activities and those who are there just to get grades without giving their best." "I learned how to do better and more detailed research." "Learn to work in a group and better understand how things work in practice instead of just working with theory." "With this method, I learned to be more autonomous, create good plans, work in groups, and have a broader view of certain subjects."	• Groupwork • Search • Independence • Broader view • Theory and practice aligned

*The responses are reproduced in their entirety as sent by the students.
Source: Elaborated by the authors.

affects long-term memory (Bender, 2014). In some cases, planning resulted in subgroup divisions, which worked well for those who chose to divide and is a possibility to be encouraged in large groupwork (Dolmans, 2019). Planning makes it possible to identify the student who is not fulfilling their task, a fact evident in complaints during projects and in various student responses. The lessons learned by students parallel the difficulties raised by them, which is very positive in the evaluation of the method, as it shows obstacles that have been overcome. The main lessons were related to groupwork, research skills, independence, a broader perspective on school content, and the practical application of theoretical content.

Finally, Chart 11 presents an overview of the student's perspective. The students encountered some difficulty at the beginning of the work due to adaptation, mainly because there was a transition to an unknown methodology in a non-face-to-face format, which was also unfamiliar to them. However, the transition was seen as challenging, a teaching method that brought learning in the discussion of ideas, in groupwork, in defining their own skills, planning, interpreting, discussing ideas, and working with shared responsibilities.

Chart 11 – Methodology overview by the students*.

Overview of PBL	Some topics
"As I said, it requires a lot from the student in terms of reading and research. But I also think we created a kind of responsibility with the project." "This form of learning is very good, as it offers students a variety of different contents, and even how the creation of projects within an industry works." "Maybe I'm very supportive of the traditional method, so I didn't like it very much, but I can say that I learned the content." "Well, since the method demands that the person or group that will carry it out know the subject very well, this method ends up by itself making the learning happen in fact. The person needs to know, otherwise, they will not be able to develop." "I liked the method used. It's a good way to bring divergent thoughts together to form something necessary." "I think it's good, in addition to learning the subject itself, we also have the learning of groupwork and all the organization that it needs."	• Challenger • Initial difficulty • Groupwork • Discussion of ideas • Learning

*The responses are reproduced in their entirety as sent by the students. PBL: project-based learning.
Source: Elaborated by the authors.

Phrases such as "I find it more interesting than the traditional approach for the Industrial Processes subject" were found in several of the questionnaires throughout the student perception evaluation, which shows the success of a challenging application of PBL in technical education at the high school level, something not found in the literature until then. High school technical education, especially in integrated courses, has one of its biggest challenges in the students' workload (Barbosa and Moura, 2013). Nevertheless, the contents of the disciplines used in this study were fully covered, even if to a greater or lesser degree of depth.

According to the students' perception, PBL took up a lot of their time, which is a possible limitation of the method, especially when considering the preparation time of the teachers (Seery, 2015). When thinking of closer monitoring and detailed and numerous feedback, this time tends to increase, but the possibility of successful learning also increases (Strohfeldt and Khutoryanskaya, 2015), forming students with a passion for seeking knowledge, knowing where and how to seek it when necessary, and, most importantly, having their methodology for learning it. Students who have gone through a deep learning experience possess these characteristics, becoming professionals ready to face new problems and lead innovative projects in their future professional journeys.

FINAL CONSIDERATIONS

This study presented the migration of isolated disciplines from integrated technical courses in one unit of the VET with traditional face-to-face teaching methods to PBL, which was new to the students. The subjects involved 95 students from three classes of two different courses. Analyses of this migration were carried out based on the student's perception of the change, both for forced remote learning and for PBL at the beginning, in intermediate periods, and at the end of the courses.

The PBL proved to be a task that was not simple, without unanimous acceptance initially; a detailed initial presentation proved to be of utmost importance for better acceptance, which ultimately involves a cultural change for the students and teachers involved. The increased workload for teachers was expected, but students perceived a large amount of time dedicated to projects as well. Advance planning, with determination of member roles, project task division, and responsibilities, proved important for group members' commitment to the work. Additionally, this pre-division allows for an individualized view by the teacher and enables individual evaluation in conjunction with group evaluation. Detailed feedback at various stages also proved important for students to continue with project tasks and correct problematic paths. Group meetings with tutors or the teacher were also seen by students as important for the continuation of their work.

After the initial difficulties, students' responses showed the development of teamwork competencies, such as discussion and presentation of ideas, group decision-making, planning, organization, and socialization. Skills to research technical subjects not so readily available on the internet, deciding where to search and what to study to apply this knowledge to solving a real problem were observed. Students were able to have contact with real industry situations for which they are being trained, learning to relate theory to practice. With the joint construction of knowledge, students dedicated time to particular topics and could learn together, decide together, with opportunities to use their creativity in a more attractive environment. Difficulties with organization, planning, and lack of social interaction were cited as the biggest challenges of remote learning, generating anxiety, insecurity, and disengagement with education. The same

topics were cited as advantages of the PBL method, even in the distance learning mode, demonstrating a possibility of attenuation in the problems generated by forced remote learning.

The study was conducted at the micro level, i.e., in isolated disciplines and specific topics at a time. For an increasingly intense experience with PBL, macro levels — two or three modules together — or mega levels — an entire year of a course — can be structured. In this case, curriculum restructuring is necessary, and the creation of a working group for adaptation and coordination, professional training, and preparation of teaching material, i.e., the institutional effort is necessary for it to occur. This may encounter limitations in teacher workload and resistance to change, but these are difficulties that, if overcome, can yield immeasurable benefits as the literature shows. It should be noted that the methodology was applied in a unit of the VET network that presents differentiated characteristics regarding the resource per student and the number of students per teacher in relation to other public education networks in the country.

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