volume 9
2019

revista docência do ensino superior

ISSN: 2237-5864

DOI: https://doi.org/10.35699/2237-5864.2019.2600

SEÇÃO: ARTIGOS

PROJECT-BASED LEARNING: EXPERIENCE REPORT ON ANALYTICAL GEOMETRY DISCIPLINE[1]

Waléria Adriana Gonçalez Cecílio[2]
Daniel Guimarães Tedesco[3]

ABSTRACT

The article reports the experience of Engineering courses at Positivo University from the need to engage students and develop the highest order skills in Anderson's Taxonomy *et al*. (2001). In the context of pedagogical practices, a Project-Based Learning was developed with students of the first year of Engineering. The didactic sequences articulate theory and practice, favoring the study of conic, quadratic, cylindrical surfaces and their applications. Specifically, Project-Based Learning was used as a methodological strategy to make classes more interactive, reducing student passivity, developing autonomy and engagement from real problems and situations. The results of the experiment demonstrated a significant difference in student performance in the assessments that involved the proposed study themes.

Keywords: Active methodologies. Project-Based Learning. Higher education. Analytical Geometry.

How to quote this document – ABNT
CECÍLIO, Waléria Adriana Gonçalez; TEDESCO, Daniel Guimarães. Project-Based Learning: experience report on Analytical Geometry discipline. *Revista Docência do Ensino Superior*, Belo Horizonte, v. 9, e002600, p. 1-20, 2019. DOI: https://doi.org/10.35699/2237-5864.2019.2600.

Received on: 15/02/2019
Approved on: 28/05/2019
Posted on: 17/09/2019

[1] A tradução deste artigo foi de responsabilidade dos autores.
[2] Universidade Positivo (UP), Curitiba, PR, Brasil.
ORDIC ID: https://orcid.org/0000-0001-6650-4381. E-mail: wcecilio@gmail.com.
[3] Universidade Positivo (UP), Curitiba, PR, Brasil.
ORDIC ID: https://orcid.org/0000-0003-2757-5296. E-mail: tedesco11@gmail.com.

APRENDIZAJE BASADO EN PROYECTOS: RELATO DE EXPERIENCIA EN LA DISCIPLINA DE GEOMETRÍA ANALÍTICA

RESUMEN

Este artículo relata la experiencia realizada en los cursos de Ingeniería de la Universidad Positivo a partir de la necesidad de involucrar a los estudiantes y desarrollar las habilidades de más alto orden en la Taxonomía de Anderson *et al*. (2001). En el ámbito de las prácticas pedagógicas, se desarrolló con estudiantes del primer año de Ingeniería una Aprendizaje Basada en Proyecto. Las secuencias didácticas articulan teoría y práctica, privilegiando el estudio de cónicas, superficies cuádricas, cilíndricas y sus aplicaciones. Específicamente se utilizó Aprendizaje Basada en Proyecto como estrategia metodológica para hacer las clases más interactivas, disminuyendo la pasividad de los estudiantes, desarrollando la autonomía y el compromiso a partir de problemas y situaciones reales. Los resultados de la experiencia demostraron una diferencia significativa en el rendimiento de los estudiantes en las evaluaciones que incluían los temas de estudios propuestos.

Palabras clave: Metodologías activas. Aprendizaje Basado en Proyectos. Enseñanza superior. Geometría Analítica.

APRENDIZAGEM BASEADA EM PROJETOS: RELATO DE EXPERIÊNCIA NA DISCIPLINA DE GEOMETRIA ANALÍTICA

RESUMO

Este artigo relata uma experiência realizada nos cursos de Engenharia da Universidade Positivo, a partir da necessidade de engajar os estudantes e desenvolver as habilidades de mais alta ordem na Taxonomia de Anderson *et al*. (2001). No âmbito das práticas pedagógicas, desenvolveu-se com estudantes do primeiro ano de Engenharia uma Aprendizagem Baseada em Projeto. As sequências didáticas articulam teoria e prática, privilegiando o estudo de cônicas, quádricas e suas aplicações. Especificamente utilizou-se Aprendizagem Baseada em Projeto como estratégia metodológica para tornar as aulas mais interativas, diminuindo a passividade dos estudantes, desenvolvendo a autonomia e o engajamento a partir de problemas reais. Os resultados da experiência demonstraram uma melhora significativa no desempenho dos estudantes nas avaliações que envolviam os temas de estudos propostos.

Palavras-chave: Metodologias ativas. Aprendizagem Baseada em Projeto. Ensino superior. Matemática.

INTRODUÇÃO

The power of competence[4] training, coupled with new teaching methodologies and pedagogical practices aimed at student autonomy, emphasizes the mobilization of resources that support the mastery of know-how and learning to learn. In this process, we value the knowledge that allows a solid theoretical base and the personal construction of knowledge. When it comes to learning topics, they are relevant in that they provide theoretical support to the competences proposed in the course project. Thus, it is understood that the mastery of the skills worked is confirmed in the action performed in face of practical situations, unique to everyday life, so that the approach leads the student to learn through active activities.

Going in this disruptive line, Freire (2002, p. 13) argues that teaching is not a simple transfer of knowledge, but the creation of possibilities for its production or construction. In addition, Ortiz understands that it is necessary to "[...] implement a comprehensive vision [...] of teaching, [...] aiming at the collective construction and at the same time self-taught of a new knowledge that fits so much in the form. as in content to the new demands of society" (ORTIZ, 2015, p. 31).

Pascarella and Terenzini (2005) point out that students engaged in the teaching and learning process remain in the university with greater motivation and interest. Thus, it becomes increasingly evident the need to create learning situations that enable greater engagement. In this context, we understand the indispensability of the dynamic process of teaching and learning in implementing attractive, dynamic classes, a learning space and the development of projects that contribute to the egress we wish to graduate.

Masseto (1998) reinforces that the teacher should not forget that the main objective of teaching is the learning of our students. Thus, the teacher has to be clear about what it means to learn and how it can happen significantly, always seeking greater effectiveness and greater fixation.

The aim of this article is to report the authors' experience in conducting a project, applied in all Analytical Geometry classes of Positivo University Engineering courses, which resulted in the exhibition called Quádricas, Cônicas e Possibilidades (Quadrics, Conics and Possibilities).

DEVELOPMENT

The themes conic sections and quadric surfaces are covered in the first year of Engineering, in the discipline of Analytical Geometry offered in the annual format, in which partial

[4] According to Scallon, "competence is the ability for an individual to mobilize an integrated set of resources internally to solve a family of problem situations. [...] Competence is a capacity, a potential (unobservable) or even a permanent characteristic of individuals. An individual is competent even if he is momentarily inactive. Competence is distinguished, then, from the notion of performance, which is its concrete manifestation" (SCALLON, 2015, p. 143).

assessments are made (in class or not) and a bimonthly evaluation, in a proportion 30% - 70% of the bimonthly average. The annual average is made by the arithmetic average of the four bimonthly notes. There is no practice of final exam, but a test taken at the end of each semester, called substitute, which replaces one of the semester grades, if it is higher. In the construction of this discipline by the professors of the Positivo University's common core of Engineering, these themes are presented at the end of the school year and are often associated with a brief exposition regarding practical applications.

In seeking to develop a concrete product that relates to the real world, we sought to apply the active methodology known as Project-Based Learning, to enhance the practice and experimentation in the study of conics and quadrics

Project Based Learning is a teaching and learning strategy that aims to stimulate engagement and problem solving skills by promoting critical thinking and collaborative team work. In addition, it is a teaching approach that challenges students to learn to learn in search of solutions to real or potentially real problems. It is characterized by a problem, not the content; encourages the formulation of hypotheses to solve the problem; develops communication and argumentation skills; interdisciplinarity and autonomy, among other cognitive and socio-emotional skills.

According to Schliemann (2016, p. 34) other skills and competences that project learning favors are "[...] the capacity for reflection, criticism, [...] and able to evaluate and decide on the problems of life and reality". The author also reinforces the student's role as protagonist of the learning process, the teacher's role as a mediator of knowledge and that the learning process has different times and positions by those involved, focusing on the process itself.

Díaz Bordenave and Pereira (2012, p. 259) emphasize that the project method was inspired by the ideas of J. Dewey[5] and its "main objective is to fight against the school's artificiality and bring it as close as possible to the reality of life". In addition, Dewey was in favor of the concept of active school. For Dewey,

> [...] knowledge is a directed activity that has no end in itself but is directed towards experience. Ideas are hypotheses of action and are true when they function as guides for this action. The education has a purpose of providing

[5] John Dewey, an American philosopher and pedagogist, was one of the leading representatives of the pragmatist current and is still a reference in the field of education today. He was one of the main creators of the Active School. "His thought represents a pragmatic, instrumental philosophy of action, at the service of integrating the results of science with the deepest needs of human social life, always with the aim of maintaining the total unity between the educational ideals and the social values most useful to the life of man in society, [...]" (PENTEADO, 1959, p. 1). "Dewey focused his attention on the student's learning so that he could acquire a reflexive way of thinking scientifically about reality. As a result, the evaluation should have the function of helping to build this capacity; hence his proposition that there should not be, in school practice, a period for teaching and learning and another for tests and exams. The evaluation will be made as the teaching and learning develops, serving as an auxiliary instrument of the teaching and learning itself" (LUCKESI, 1992, p. 307).

> people with the conditions to solve their problems for themselves, not the traditional ideas of forming according to previous models, or even orienting them to a future (VIEIRA, 2016, p. 5).

Dewey's (1979) thoughts convey the idea that knowledge becomes meaningful as it is acquired through experience. Thus, teachers and students go through their own experiences, which should be used in daily school life. In addition to the formal contents, the student would have something concrete to learn and the production of knowledge and learning would be collective and undergo constant reconstruction.

For Vieira (2016, p. 10) the learning by projects:

> [...] in higher education can provide diversified and real-time learning, inserted in a new pedagogical context, in which the student is an active subject in the process of knowledge production. It breaks the imposition of rigid and pre-established content, incorporating it as it is a fundamental part of the project development.

In order to stimulate the students in their learning process through active activities, Luckesi (1992) corroborates Dewey's considerations and underlines that the assessment can and should be done as it is taught. In addition, it should be a time to raise questions so that learning becomes dynamic and deep. In this dialog about active methods6 and evaluations, the authors understand that questioning the student in the midst of practical situations, associated with practical problems, is an opportunity to build knowledge through well-planned projects, with pre-defined objectives that highlight the understanding of "what" and "how" to evaluate.

In this sense, Anderson's Taxonomy[7] corroborates by substantiating the didactic-pedagogical planning. For Ferraz and Belhot (2010, p. 421), the purpose of the taxonomy is to "assist in the identification and declaration of objectives related to cognitive development". In addition, it

---

[6] Cecílio (2018) in her thesis Avaliação da Matemática Escolar: contribuições da Pedagogia da Escola Nova, stresses that the practice of active methods in Brazil was in force between the 1920s and 1960s, a period marked by the main educational movement, called the Movimento da Escola Nova (New School Movement). During this period the dissemination, consolidation and officialization of ideas, principles, methods and techniques occur. Every effort was made to create situations in which the principles of investigative and experimental activity were carried.

[7] In 1990, Bloom's taxonomy underwent a review process and in 2001 it was published by Lorin Anderson and his collaborators. Bloom's revised taxonomy combined the type of knowledge to be acquired and the process used to acquire that knowledge (ANDERSON, *et al*., 2001). According to Conklin (2005, p. 153 apud Ferraz and Belhot, 2010, p. 423), Bloom (1956) proposed a hierarchical classification of learning objectives, structured into increasing levels of complexity, and is divided into six categories, which are part of the cognitive domain, but not all are directly related to it, only five of them (comprehension, application, analysis, synthesis and evaluation). In the revised taxonomy, the basis of categories has been maintained, there are still six categories, but Anderson conceptually separates knowledge from the cognitive process. Thus, the categories undergo a change, a new model emerges, changing, in addition to other aspects, new categories (remember, understand, apply, analyze, evaluate and create).

is understood that it is easier to achieve objectives when they are well defined by different levels of knowledge acquisition.

Therefore, the Project-Based Learning experience contemplates the current categorization of the taxonomy proposed by Anderson *et al*. (2001). Such taxonomy divides knowledge into two types: knowledge as cognitive process and knowledge as assimilated content. A two-dimensional organization must be followed in order to organize the educational objectives. Thus, the dimension of knowledge can be verified in the vertical column and the cognitive process in the horizontal.

Knowledge Dimension	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Efective/factual						
Conceptual/principles						
Procedural						
Metacognitive						
	Knowledge		Competence		Ability	

Chart 1 – Two-dimensional character of the Taxonomy of Anderson et al.
Source: adapted from Ferraz and Belhot, 2010, p. 429-430.

In order to develop in students the engagement and skills proposed in the taxonomy of Anderson et al., it was sought, through Project-Based Learning, the rise to the highest class objectives by students (remembering, understanding, applying, analysis, evaluation and creation). This categorization helps us when it comes to planning learning situations that meet the competences we want to achieve.

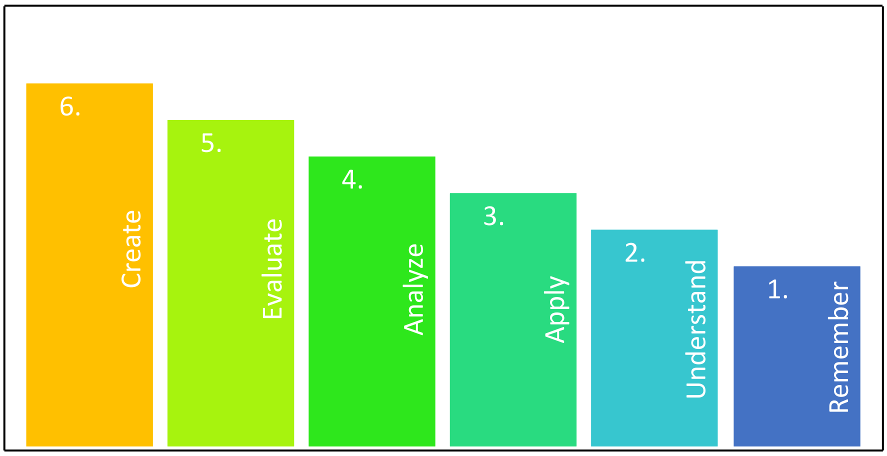

Figure 1 – Categorization of Anderson *et al*.'s taxonomy
Source: the authors, 2019.

Thus, the project aims to lead the student to identify, analyze, design, create and evaluate, through mathematical models, surfaces associated with practical applications. In addition, it seeks to involve the student in extracurricular practices and encourage engagement in activities.

Given the above, it is understood that new projects, supported by learning theories, should be implemented in order to enable the understanding of "what" and "how" to evaluate. It is worth mentioning, in the Taxonomy of Anderson et al. in each objective the verb gerund enables the understanding of "what" and "how" to evaluate. Moreover, with verbs it is possible to see whether or not the objectives were achieved.

METHODOLOGY

Project-based learning applied from the project called *Quádricas, Cônicas e Possibilidades* (Quadrics, Conics and Possibilities) was proposed by the Analytical Geometry professors, a discipline at the Positivo University's Engineering Common Core. The activity was designed by the discipline supervisor, Waléria Cecílio, and organized by the discipline's teachers, Waléria Cecílio and Daniel Tedesco. These professors work at the University campuses (Ecoville and Osório), located in the city of Curitiba, Paraná.

Through the practice of Project-Based Learning it was possible to evaluate the student in a diversified way. The project was an excellent opportunity to engage students and, to the right extent, to observe their behavior in problem solving that involves remembering, understanding, applying, analyzing, evaluating, and creating. The project corroborates the need for studies and proposals for active activities that enable the teacher to rethink the evaluative instruments he uses, the elaboration of the tasks they propose and their own evaluative practice.

For the development of the project, a ten-step didactic sequence was applied that resulted in two products: a mockup and a poster.

Develop cognitive and socio-emotional skills.	Order	Activity
	1	Form teams of up to five members, get organized by setting goals and tasks.
	2	Search for objects that identify with the shapes of the studied surfaces.
	3	Define an object of study that identifies with one of the shapes of quadric surfaces (formulate hypotheses) and research its importance in the area of engineering.
	4	Identify the general equation that describes the surface shape of the chosen object.
	5	Define, based on the measurements of the real object, the parameters that approximate the equation of the real object shape.
	6	Define a scale that allows the construction of the model of the chosen study object, in the space defined by the teachers of the subject (40cm x 40cm base).
	7	Create the mockup's layout and define the appropriate materials for the construction.
	8	Build the model based on the defined measurements and the appropriate materials for the chosen structure.
	9	Organize the information searched in poster format, following the template defined by the teachers.
	10	Reflect on your own learning.

Chart 2 – Project-Based Learning Didactic Sequence
Source: the authors, 2019.

To perform the didactic sequence, the teachers involved had a common planning that would involve four to six class hours, according to the schedule of class hours (of each class) for the fourth quarter. Regardless of the class workload, the teams worked on extra-class activities. Thus, the practice was divided into three moments:

- At the first moment, in the classroom, the teachers held a dialogued class addressing possibilities of equations, traces and surface graphics motivated by images of engineering works available on the internet. Following, the students divided into teams of up to five members and began to research, through cell phones, which would be the object of study of the team. After *remembering* studied concepts and *understanding* the problem, students discussed many possibilities of equations and formulated hypotheses. Then each team decided on the object of study and formulated an outline of the general equation for the problem situation. From the general outline, each team began a first analysis of the parameters that really define the chosen object. At the end of the first moment of the project, each team went to the classroom computer and inscribed the chosen object, the object shape and the name of each member in an Excel spreadsheet prepared by the teachers of the subject.

- In the second moment, there was the extraclass activity, which consisted of four steps: (1) researching the dimensions of the real object and defining a measurement scale, so that the team could build an object model on a 40cm x 40cm basis (2) *create* the mockup's layout, (3) *analyze* and model the study object using real parameters/measurements and the equations studied, identifying at least one conical section and (4) focusing on the modeling performed in step 3 students began to evaluate the defined data and parameters and then defined the materials to create the mockup of the study object and the summary for the poster's design.

- In the third moment, which occurred after delivery of mockups and posters, the teachers promoted a class discussion. There was an argument directed to the teams about the choices made to define the object of study, the parameters and materials needed to create the model and a reflection was made about the learning.

In time, the delivery of the activity was consolidated through mock-up and poster, template defined by teachers.

The temporary exhibition of *Quádricas, Cônicas e Possibilidades* (Quadrics, Conics and Possibilities), exhibited for a limited period of time (30/10 to 05/11/2018) and organized from the main theme, highlights elements (organization, models and posters) that show the public, engineering students and teachers, a message of an activity that provides first semester students with a unique, active and innovative experience. The thematic exhibition highlights applications of the theme Quadric Surfaces, extracted from reality and daily life, relating the presentation, description and meanings of the chosen objects.

In the posters the students presented a short descriptive text that deals with the importance of the chosen application; the description of the surface by quadratic model; calculations of the conical sections found; equation charts and team photos working at all stages of the project. About the contributions of mathematical models and their graphs presented in the projects, it can be corroborated with Scremin *et al*. (2018, p. 119), who consider that “the use of graphic visualization enables a facilitating path in the teaching and learning of abstract concepts of mathematics, present in definitions and theorems [...]”.

It is noteworthy, the students had to remember and understand some concepts, such as: scales, conic equations (parabola, ellipse and hyperbole) and construction of graphs. In addition, it was necessary to analyze the chosen object to apply the mathematical concepts focusing on defining the model equation. From the equation defined by the teams, students had to evaluate the model and then, based on it, analyze the sizing and material possibilities to create the layout and then make the model. From the definition of the model, each team turned to the construction of the object and the preparation of the poster, summarizing all the work developed and ending with a reflection on their own learning.

The authors understand that the Taxonomy of Anderson *et al*. facilitates the planning and systematization of the evaluation process. Taxonomy allows for more concrete and effective planning in an attempt to make evaluation a component at the service of teaching and learning processes. Figure 2 shows the learning objectives linked to this taxonomy.

1. Remember
   - Recognize and select a conic (parable, ellipse and hyperbole) that identifies the object of study chosen for the construction of the model.
2. Understand
   - Establish a connection between the conic (prior knowledge) and the quadric surface that describes the object of study.
3. Apply
   - Apply the knowledge of conics associated with surface features and identify the general equation that describes the shape of the object studied.
4. Analyze
   - Analyze different measures, assigning meanings of importance and understanding under what circumstances the parameters chosen in the model sizing should be changed.
5. Evaluate
   - To evaluate the results obtained associated with the measures and materials defined for the construction of the model. Synthesize the information in poster format.
6. Create
   - Plan, layout and produce the model of the object focusing on the study.

Figure 2 – Taxonomy categorization and learning objectives
Source: the authors, 2019.

Focusing on the learning objectives presented, Table 3 presents the two-dimensional aspect of the proposed objectives. It is worth mentioning that in objectives 4 and 5 the development of metacognitive knowledge, which was consolidated through reflection on learning and project delivery, was also stimulated.

Knowledge Dimension	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Efective/factual	Objective 1					
Conceptual/principles		Objective 2	Objective 3	Objective 4		Objective 6
Procedural				Objective 4	Objective 5	
Metacognitive				Objective 4	Objective 5	
	Knowledge		Competence		Ability	

Chart 3 – Two-dimensional character of the Taxonomy of Anderson *et al*.
Source: the authors, 2019.

In the evaluative perspective, emphasis is also placed on intention, preparation and organization, peer dialogue, execution and the ability to synthesize. In this context, the volume of messages received from students about project development and difficulties, classroom discussions and posters delivered by the teams to the teachers were key to the final project evaluation, valuing all phases of Project-Based Learning. Control of team activity observations such as participation, engagement, quality of dialogue, organization, and interest were recorded by teachers through annotation worksheets, so that each teacher was free to set up his or her own control worksheet.

For the dissemination of the project carried out and the incentive for new projects, the practice was carried out through an exhibition named *Quádricas, Cônicas e Possibilidades* (Quadrics, Conics and Possibilities). Thus, after a reflection on learning through Project-Based Learning and the validation of the posters, focused on the defined objectives, the forty best works (posters and mockups) were selected and exhibited in the ground floor of the main block of the Engineering building at Positivo University Ecovile Campus.

The idea of the exhibition aimed to highlight the best work done by students of the first year of Engineering, in view of the large circulation of teachers and students in the area. It is also noteworthy that, in line with the competences of the courses, the activity sought to strengthen the articulation between theory and practice, which values learning for life.

The results of the selection of works were disclosed in the Virtual Learning Environment (Blackboard) through the bulletin board.

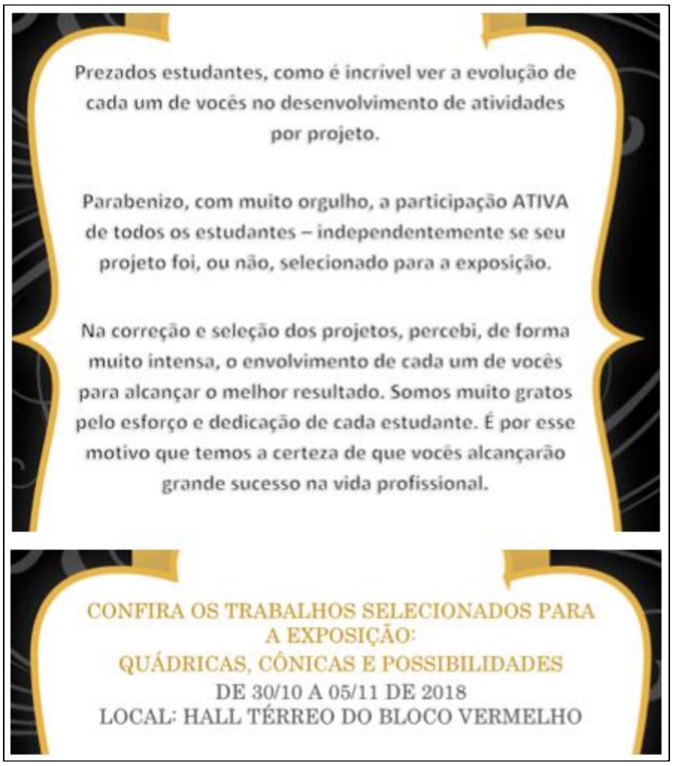

Figure 3 - Dissemination of results
Source: the authors, 2018.

After the results were disseminated, the exhibition was organized by the subject's teachers, the students from the morning period and the University's support team.

Figure 4 - Assembly and organization of the exhibition
Source: the authors, 2018.

In practice it was also sought to develop, according to Díaz Bordenave and Pereira (2012) a scientific attitude, motivated by curiosity. The systematization of the content studied for the construction of the poster led the students to develop critical analysis, objectivity, precision, and other characteristics that are part of the scientific attitude.

As a way of publicizing the exhibition, the Engineering coordinators sent an invitation to students and teachers.

Figure 5 – Invitation sent to Engineering students and teachers
Source: the authors, 2018.

The works were exhibited in the form of posters accompanied by their models, as can be seen in Figure 6.

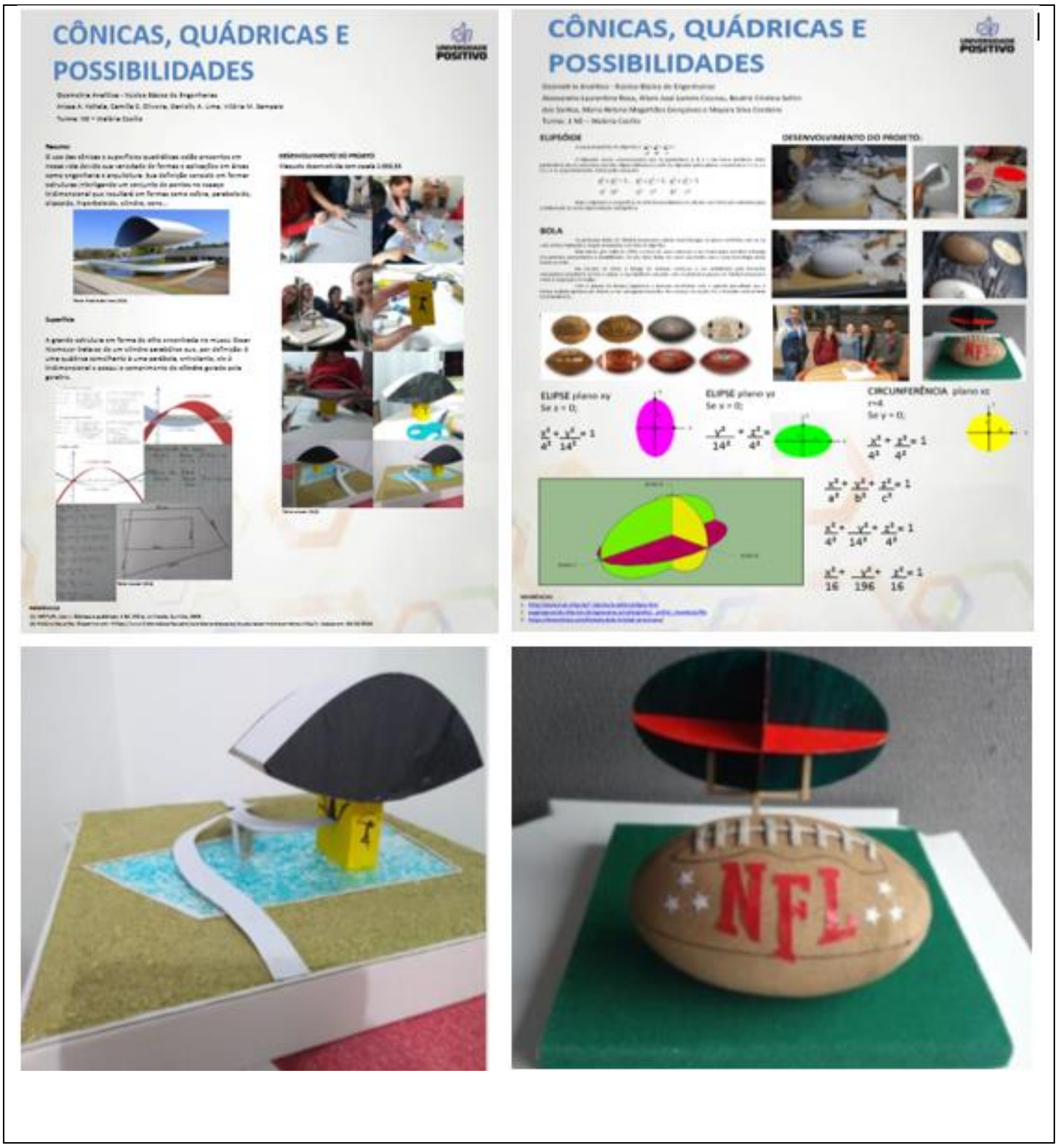

Figure 6 - Examples of posters and their models
Source: Engineering 1st year students, 2018.

The themes presented in the posters portrayed the diversity of engineering works that present the themes of conics and quadrics studied in the subject and fulfill some of the objectives of Project-Based Learning underlined by Schmidt (2001): stimulate engagement, research, adaptability to changes, problem-solving skills in diverse situations, critical and creative thinking, and teamwork with a systemic approach.

RESULTS

In this analysis, it was considered to observe the activity delivered by the teams as a whole. The development of the activity, understood as a very rich process, would not necessarily have to be perfect, but would need to be oriented and discussed throughout the process. Thus, communication between teachers and teams coexisted and permeated beyond the classroom environment, also the exhibition space and the virtual learning environment, either by discussion forum, messages or e-mails.

As teachers, moved by the search of new methodologies, we look at the activity as if it were a first attempt that explains how the student thinks, creates, communicates and relates to other students and teachers. In this process the reaction of the students was evidenced, which initially was of resistance, since there was a paradigm shift. Throughout the project, there has been an increase in engagement, involvement in learning, responsibility and willingness to make it work. In this sense, the feedback from the activities, after the disclosure of the selected projects, became imperative.

The feedback occurred in parallel to the third moment of the practice. At this time the student can reflect on their learning, point out their difficulties and challenges. In addition, student impressions prompted teachers to reflect on a new format for upcoming practices.

Practice has also shown that often the certainties we have in the classroom fall apart when we get our hands dirty out of the classroom context. Thus, it was possible to realize, through messages, e-mails and dialogue with students, that the vast majority of teams have redefined the concept of error, which is part of the process of (re)construction of new knowledge. In addition, the student's development of the ability to observe, analyze, theorize, systematize, apply and transfer learning was evidenced.

The project proved to be recognized and valued by students who participated in the Project-Based Learning, and by others already approved in the Analytical Geometry subject, as pointed out by the comments made in moments of interaction that occurred during the period in which the works were exposed.

> *Setting up the model required our team to do things they had never done before, such as sawing, sanding, and welding. It was very cool!* (Student A).
>
> *It's really cool when we can connect the real world with math, right [sic] teacher?* (Student B).
>
> *Teacher, this holiday I traveled with my family to the countryside of Paraná, it seems that everything I looked at was connected to what we were studying* (Student C).
>
> *In the midst of the project our team had to chase after content we no longer remembered. We had to re(learn) some concepts already studied* (Student D).
>
> *I would like to have participated in such a project when I took the course of Analytical Geometry* (Subject's tutor).

The comments of students A, B and C, in line with the comments of other students expressed during the 3rd phase of Project-Based Learning, showed the satisfaction of performing different experiences, such as sawing, sanding and welding, with the purpose of building something that has been mirrored in a real situation that is part of our lives and that is marked by mathematical concepts and operations. Student D's comment highlights a difficulty presented by many students, re(learn), which has been studied at some point. Thus, the need to analyze, apply and create led students to reflect on the content needed to perform Project Based Learning in order to instigate autonomy and the pursuit of knowledge.

Also noteworthy is the testimony of the discipline monitor who expressed the desire to have participated in a similar project during the course of the course. According to her, the discipline of Analytical Geometry, taught to her class, followed a very traditional line and, in her view, did not contribute to a learning for life. From this perspective, the students commented that when visiting the exhibition with their friends from other periods, many were surprised and delighted with the mathematics presented in the exhibited works. Proof of this was that some students who participated in Project-Based Learning brought their parents to visit the exhibition and others from later periods made a point of taking pictures of posters and mockups, as if to perpetuate that moment of witnessing to the importance of learning. mathematics, especially in engineering works.

In these manifestations, the students show interest both in the factory part and in the connection of the study with its reality, resignifying the concept of mathematical modeling, in an initial step of their differentiated formation in Engineering.

The students' testimonies, especially in the third moment of the activities, and the quality of the exposure result showed that when the student has the opportunity to actively participate in the teaching and learning process, he will show greater engagement and interest in solving problems, as well as having the opportunity to find strategies to reduce or overcome your difficulties, as Project Based Learning leads you to mobilize your knowledge, providing better results.

In contrast, some of these students reported difficulties both in making the model and in mathematical modeling of the object. The report on this difficulty lies not only in the meaning of the idea of modeling, but also in the lack of mathematical basis necessary for the development of Project Based Learning, as pointed out by Student E.

> *My group and I had talked to you last class because we are having a hard time finding the actual measurements of the Oscar Niemeyer Cultural Center and you said we could change the subject if we thought it was necessary, but it couldn't be repeated with other groups. [...] Let's analyze other themes then [...]. Our work is almost done, but I have some doubts about the calculations ... We chose the Arecibo Radiotelescope and the measurements we found was that its satellite dish is 305m in diameter* (Student E).

The difficulty in mathematical modeling is demonstrated through the commentary presented here as a counterpoint, however the overcoming of the difficulty shows the active character in the teaching and learning process. In addition, the difficulty in researching the data related to the architectural projects chosen by them, initially harmful to the group, is a great opportunity for the teacher as advisor to lead the student to reflect on the planning and execution of engineering projects.

Another relevant comment is reported by student F who took a position on the cost of materials, leading to a reflection of changes regarding the restriction of low cost projects.

> *Teacher, the project was great, but it was very expensive to buy materials to build the model. What do you think of coming up with alternatives that decrease expenses with materials?* (Student F).

From the reflection of student F's comment, new ideas have emerged for the application of Project-Based Learning in a new semester, such as the construction of models with recyclable material. Or, add to the project a cost spreadsheet, so that the selection of the models permeates the project at little or no cost, such as recycled materials. Also, choosing the best designs could be associated with creativity or environmental preservation.

It should be noted that students' comments and impressions were collected during classroom meetings, during the exhibition, through e-mails and informal conversations with the students and teachers of the subject, especially at the time of reflection about the learning, which occurred in the delivery of the projects and visits to the exhibition.

FINAL CONSIDERATIONS

Experience with the use of mockups and posters to study conics and quadrics in Engineering courses proved to be able to engage students in order to present surprising and innovative results for a first semester class. Moreover, in the development of the project, it was realized that it is necessary to constantly mediate, dare and interact with the students. And, as teachers, we have to plan every detail of the project and define what questions to ask students so that we can go beyond the core content proposed in the course. Mediation proved to be relevant throughout the process, precisely because it involved the students in a balance of knowledge exchange, and from that experience the teams actively participated in the project and later in the classes.

Almeida Xavier and Campos Xavier (2017, p. 21) corroborate the above when they emphasize that “[...] the role of the teacher in understanding the limitations of students in seeking knowledge is of fundamental importance. Some can do the activities more easily, others not. This mentoring role is paramount to the success of the activities [...]”.

In time, after application of the project, it can be stated that the teacher, when applying the project-based learning methodology, should assume the role of advisor and actively encourage each student to think and reflect on their actions. of decisions amid the development of activities, aiming to form critical thinking, built through discussions and reflections between teams.

In addition, the experience shows that getting our hands dirty, inside and outside the academic environment, contributed significantly to the engagement, autonomy and appropriation of the knowledge studied. Students were more open to new knowledge, overcoming their difficulties and presenting better results in the proposed activities. This was evidenced by the fact that there were no complaints from students about the absence of lectures on topics related to Project-Based Learning. In addition, during the orientations, many of them requested Reading sugestions and went looking for content of their interest to overcome their difficulties. It is noticed that this parallel study, has become linked to learning, leading to better results.

Another important point is the project management development and strategies, communication, critical analysis, objectivity and accuracy. These were highlighted during the project development and were consolidated through evidence of the scientific attitude printed on the posters. In this context, new strategies must be analyzed and implemented providing, in the midst of teaching in higher education, the practice that is done, undone and redone. And, the use of these new practices, as long as they are well planned, with well-defined objectives and strategies, significantly increases students' participation in activities, interest and learning for life.

REFERENCES

ALMEIDA XAVIER, André Felipe de; CAMPOS XAVIER, Paloma de Oliveira. Laboratório de cálculo: aprendizagem baseada em jogos nas disciplinas de exatas. *Revista Brasileira de Ensino Superior,* Passo Fundo, v. 3, n. 4, p. 7-22, dez. 2017. ISSN 2447-3944. DOI: https://doi.org/10.18256/2447-3944.2017.v3i4.2107. Disponível em: https://seer.imed.edu.br/index.php/REBES/article/view/2107. Acesso em: 21 dez. 2018.

ANDERSON, L. W. *et. al*. *A taxonomy for learning, teaching and assessing*: a revison of Bloom’s Taxonomy of Educational Objectives. Nova York: Addison Wesley Longman, 2001. 336 p.

BLOOM, B. S. *et al*. *Taxonomy of educational objectives*. New York: David Mckay, 1956. 262 p. (v. 1).

CECÍLIO, Waléria Adriana Gonçalez. *Avaliação da matemática escolar:* contribuições da pedagogia da Escola Nova. 2018. Tese (Doutorado em Educação) – Pontifícia Universidade Católica do Paraná, Curitiba, 2018.

CONKLIN, J. A taxonomy for learning, teaching and assessing: a revision of Blooms's taxonomy of educational objectives. Educational Horizons, v. 83, n. 3, p. 153-159, 2005.

DEWEY, John. *Experiência e educação*. 3. ed. São Paulo: Ed. Nacional, 1979.

DÍAZ BORDENAVE, Juan; PEREIRA, Adair Martins. *Estratégias de ensino-aprendizagem.* 32. ed. Petrópolis: Vozes, 2012.

FERRAZ, Ana Paula do Carmo Marcheti; BELHOT, Renato Vairo. Taxonomia de Bloom: revisão teórica e apresentação das adequações do instrumento para definição de objetivos instrucionais. *Gest. Prod.,* São Carlos, v. 17, n. 2, p. 421-431, 2010.

FREIRE, Paulo. *Pedagogia da Autonomia:* Saberes necessários à prática educativa. 25. ed. São Paulo: Paz e Terra, 2002.

LUCKESI, Cipriano Carlos. *Avaliação da aprendizagem escolar:* sendas percorridas. 1992.. 1992. Tese (Doutorado em Filosofia) - Pontifícia Universidade Católica de São Paulo, São Paulo, 1992.

MASSETO, Marcos. *Docência na Universidade.* 11. ed. Campinas: Papirus, 1998.

PASCARELLA, Ernest; TERENZINI, Patrick. *How College Affects Students*: a third decade of research. San Francisco: Jossey-Bass, 2005. v. 2.

PENTEADO, J. A. A pedagogia de Dewey e os problemas sociais. *Revista Atualidades Pedagógicas,* São Paulo, Ano X, n. 48, p. 1, set./dez. 1959. Disponível em: https://repositorio.ufsc.br/xmlui/handle/123456789/133545. Acesso em 19 dez. 2017.

SCHLIEMANN, Ana Laura. Aprendizagem por projeto. *In*: SCHLIEMANN, Ana Laura; ANTONIO, Jorge Luiz (org.). *Metodologias ativas na Uniso:* formando cidadãos participativos. – Sorocaba: Eduniso, p. 31-46, 2016.

SCHMIDT, H. G. *As bases cognitivas da aprendizagem baseada em problemas. Aprendizagem baseada em problemas*: anatomia de uma nova abordagem educacional. São Paulo: Hucitec, 2001, p. 80-108.

SCREMIN, G. *et. al.* O uso de tecnologia no ensino e na aprendizagem de cálculo diferencial. *Revista Docência do Ensino Superior*, Belo Horizonte, v. 8, n. 2, p. 119-139, jul./dez. 2018.

VIEIRA, Josimar de Aparecido. Aprendizagem por projetos na educação superior: posições, tendências e possibilidades. *Revista Travessias*, cascavel, v. 2, n. 3, n. p. Disponível em: http://e-revista.unioeste.br/index.php/travessias/article/viewFile/3115/2453. Acesso em: 19 dez. 2018.

ORTIZ, Felipe Chibás. Gestão Criativa em Ecossistemas de Educação a Distância (EAD). *In*: CHIBÁS ORTIZ, Felipe; SANTOS, Fernando de Almeida. (org.). Gestão da Educação à distância: Comunicação, Desafios e Estratégias. São Paulo: Atlas, p. 12-34, 2015.

SCALLON, Gérard. Avaliação da aprendizagem numa abordagem por competências. Tradução de Juliana Vermelho Martins. Curitiba: PUCPRess, 2015, 445 p.

Waléria Adriana Gonçalez Cecílio
É doutora em Educação pela Pontifícia Universidade Católica do Paraná (PUCPR) e graduada em Licenciatura em Matemática pela Universidade Tuiuti do Paraná. Professora da Universidade Positivo (UP) e professora tutora da Pontifícia Universidade Católica do Paraná (PUCPR). Dedica-se às metodologias de ensino e aprendizagem. Interessa-se, sobretudo, por ensino de matemática, metodologias ativas e qualidade na Educação a Distância. wcecilio@gmail.com

Daniel Guimarães Tedesco
Bacharel em Física e doutor em Ciências (Física) pela Universidade do Estado do Rio de Janeiro (UERJ). Atualmente é professor da Universidade Positivo (UP), membro do Núcleo Docente Estruturante das Licenciaturas em Física e Matemática. Dedica-se a pesquisa em Teoria Quântica de Campos, e interessa-se por metodologias ativas no ensino de Física e Matemática. daniel.tedesco@up.edu.br