v. 4, n. 7, 2024

Journal of
Engineering
Research

REMOTE TEACHING MODELING FOR PRE-CALCULUS CLASSES IN ENGINEERING

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Abstract: This article aims to investigate how a Virtual Learning Environment could be organized during the pandemic to cover Mathematics content in Higher Education in order to give students autonomy, without interrupting their studies. To this end, the new Coronavirus pandemic was contextualized (INSTITUTO BUTANTÃ, 2021; OPAS, 2020; VIEIRA & SILVA, 2020), as well as the Virtual Learning Environment (VELOSO & MILL, 2021; GAMA, 2014; MORAN, 2018), the Flipped Classroom (TORI, 2020) and learning trails (LIMA, 2019), through bibliographic and documentary research. Furthermore, the authors' experience in building a Virtual Learning Environment is presented, based on the Flipped Classroom theory, which was designed to be applied to pre-calculus classes in a Higher Education institution. Among the results obtained, it was noticed that the Virtual Learning Environment helps in the development of student skills such as autonomy, responsibility, personal organization and dedication. Furthermore, even students with learning problems benefit both from the multiple activities and circuits proposed on the trails, and from the special attention provided by the team of teachers and monitors who supervise and facilitate the process in this new and rich school space.
Keywords: *Remote Teaching; Mathematics Education; Teaching in Engineering.*

INTRODUCTION

On December 31, 2019, the World Health Organization (WHO) was notified of several cases of an unidentified type of pneumonia in the city of Wuhan (China). This respiratory disease, caused by a coronavirus, spread quickly around the world, characterizing it as a pandemic, which is a disease that spreads across several continents, affecting many people (Instituto Butantan, 2021).

In January 2020, the WHO declared that the outbreak of the new coronavirus had already reached nineteen countries and continued to spread. A new name was adopted to make it easier to pronounce and not stigmatize any country or population. Thus, it came to be called Covid-19, an acronym formed by "Co" for corona, "vi" for virus, and "d" represents "disease", followed by the number 19 which indicates the year of its emergence.

With the daily increase in cases and contamination in several countries and regions of the planet, the WHO classified it as a public health emergency of international importance (PAHO, 2020).

In Brazil, the first case occurred in February 2020 and new cases soon appeared throughout the national territory.

According to Vieira e Silva (2020, 1044), the pandemic scenario required the government and health bodies to adopt officially published legal measures as a strategy to contain the spread of the disease.

Brazilian government authorities initiated a series of legal measures and ordinances that aimed to regulate teaching practices by replacing ongoing face-to-face subjects with classes that used information and communication means and technologies (BRASIL, 2020).

The support provided by Decree Law 1044/69, of October 21, 1969, combined with Ordinance MEC/GM No. 343, of March 17, 2020, which specially regulated the regimes to be instituted while the Pandemic situation lasts of COVID-19, formalized the continuity of face-to-face courses in virtual media.

Thus, the sudden change from face-to-face and blended teaching to remote teaching required educational institutions to adapt classes, materials, activities, assessments, as well as a new system for teaching and learning on the part of students and teachers. There was no alternative, as social distancing and quarantine periods had a direct impact on

school life in the country.

As a result, society, in general, and the University, particularly involving the teaching and learning process, needed the challenge of adapting and transforming traditionally used models (Organization for Economic Co-operation and Development, 2020), leading to the adoption and creation of new educational models supported by digital technologies and based on online education methodologies (VIEIRA; SILVA, 2020).

With the objective of providing conditions for university professors, and in the case of this research, professors who teach mathematics in the first stages of the Engineering course, a model was built using a virtual environment, materials available on the Internet in conjunction with tools and methodologies of educational technology.

A pilot was carried out with the aim of creating a virtual environment used by students and teachers, allowing us to observe strategies that worked properly and others that did not have a satisfactory effect. Therefore, this article aims to present a new version of modeling remote teaching for Pre-Calculus classes in Engineering Education, which can be adapted for other curricular components.

THE VIRTUAL TEACHING AND LEARNING ENVIRONMENT

Whenever an innovation appears in the minds of educators, there is a certain amazement at the possibilities offered on the one hand and, on the other, a classic skepticism regarding the use of technological resources in the teaching and learning process.

Without a doubt, the traditional participation of the teacher will always be welcome and necessary.

Even using a set of technological resources, there is a need for an educator to carry out the planning, organization, articulation, implementation, evaluation and refinement so that positive results are satisfactorily achieved.

Thus, Educational Technology is a systematic way of using technological resources, in multiple ways, to seek efficiency in the Teaching and Learning process.

According to Veloso and Mill (2021), along with all the changes that have accompanied radio and TV in contemporary times, new languages also emerge and, consequently, new pedagogical potentialities. As a result, there are diverse experiences involving the intersection between image and sound media, new technologies and the educational sphere.

With the use of technological resources in Education, Virtual Teaching and Learning Environments (VLE) emerge, a new school space that can be a support for in-person teaching or an alternative in situations such as the Pandemic, where students were unable, for a long time. time, attend classes in person. Other situations may justify the use of Virtual Environments, such as sick leave, the need for extra classes or students with physical limitations to travel to the University.

In this new "technological habitat", knowledge is constructed with the active participation of the student who finds, in an alternative space to the classroom, multiple possibilities for reading, listening, writing, communication and interaction. There are countless resources available in the Virtual Environment that, planned and organized by the teacher, can cognitively develop the student. For Gama (2014, p.66), "The Virtual Environment allows teaching and learning to be practiced, based on a sociocultural, dialogic approach that encourages the development of the student's own autonomy".

Given this possibility of using Virtual Environments to bring study materials and activities selected by the teacher and which are available both in the VLE and in the Internet collection, and also allowing interaction and communication between

students and between them and the teacher, the following arises question: how can a Virtual Environment be associated with the educational process in teaching mathematics in a pandemic condition in which students are geographically distant from the University?

Thus, the general objective of this study was to research how the Virtual Environment could be organized during the pandemic for Mathematics content in Higher Education in order to give students autonomy, without interrupting their studies.

There are countless types of Virtual Environments with different characteristics, some very expensive and others free.

One of the free Virtual Environments, most used around the world, is Moodle (Modular Object-Oriented Dynamic Learning Environment) which, in addition to having numerous digital resources available, is open source and allows customization.

All these features offer the Moodle user the possibility of customizing it and thus creating a specific model for each teaching situation, regardless of the school level, the target audience and even the special needs of an inclusive environment.

The use of the Virtual Environment can take in-person classes to the virtual universe, allowing students who cannot attend the classroom to have contact with the program content and participate in a learning process that is different from the traditional one.

The teacher, in this case, will always be able to use his creativity and the unique ability to build spaces suitable for the teaching process, in fact achieved throughout his teaching practice, now adapted and modernized by remote teaching.

In this new model, the physical separation between students and teachers will be alleviated through the creation of a new model of an interactive, friendly, responsive, motivating, facilitating, stimulating environment, rich and diverse in technological resources to support the student, in short, a prepared space to carry out remote classes, aimed at allowing 21st Century students to continue their studies.

For Bacich and Moran (2018), students have great ease of access to information, participating in social and collaborative networks with people with whom they share knowledge, values, practices and discoveries.

In this project, the Moodle Virtual Environment was used with modeling aimed at teaching Mathematics in Higher Education in Engineering, with access to the selected Internet collection (links and videos), customization of tools and communication/ interaction resources of the Environment itself, as well as the use of the University's virtual library.

The growing interest of university students in their daily lives in technology favors the adoption of the use of Virtual Environments in classes, especially during the pandemic period, allowing them to contact classes, colleagues, teachers and eliminating their needs for academic support.

MODELING THE VIRTUAL ENVIRONMENT

To organize the Virtual Environment, a multidisciplinary team was created with the aim of customizing Moodle in order to serve the student remotely and at the same time allow the teacher to use this new space and the student's role in carrying out remote classes.

The team consisted of the Mathematics coordinator at Universidade Presbiteriana Mackenzie, a pedagogue, a teacher specialized in the educational use of the Moodle Virtual Environment and student monitors who were studying a degree in mathematics at the same University. Everyone participated in meetings before the start of the project and training on the use of Moodle and the Flipped Classroom methodology, both to discuss the idealized

model.

Although the Flipped Classroom is widely used in Hybrid Teaching, as stated by Tori (2009), as two learning environments that have historically developed separately, the traditional face-to-face classroom and the modern Virtual Environment that have been discovering each other complementary activities, it will now be carried out completely online, without face-to-face contact, but with the same effect and the possibility for students to have access to the content before the synchronous meeting with the teacher.

But for this to happen, there must be a study prepared by the teacher, week by week, of what will be covered in remote classes for the consequent preparation of activity planning in the Virtual Environment.

The technological resources were chosen by the teacher with well-defined pedagogical objectives and at the appropriate time in each class. The role of the student and the teacher in an Active Methodology approach were also defined, that is, the student taking the lead in the process and putting into practice other skills, as stated by Lovato et al (2018) such as initiative, creativity, reflective criticality, the ability to self-evaluate and cooperation to work as a team.

The mathematical contents that were explored in the project were: Numerical sets; Potentiation rules; Notable products and factoring; Equation and inequality; Functions and graphical representation; Exponential and logarithmic functions; Trigonometry; Trigonometric transformation; Matrices and Determinants, and Linear Systems.

The intention of offering reinforcement in these topics was to strengthen mathematical concepts, which are very important to provide a basis for university students in learning Differential and Integral Calculus.

In the Moodle virtual environment, arranged in tabs (Figure 1), the project was structured over ten weeks, allowing the student body to easily locate mathematics topics.

The student receives a welcome and sets up the Virtual Environment a week before so that they understand the adopted system, as well as the access test and resolution of pending issues with the team that will conduct the project during classes.

However, for the teacher, there remains the challenge of organizing the Virtual Environment in a way that allows the student to navigate remote teaching with countless possibilities of tools and resources, but with the goal of leading them to obtain knowledge, placing them at the center of the learning process.

To this end, the teacher has previously organized the activities designed for each week so that the student can carry out the planned tasks and the Virtual Environment itself can take them to the following week or return to the necessary point until they can be promoted to the next topic, remembering that the topics have already been defined by the mathematics teacher as fundamental for Calculus studies in Higher Education.

This organization created by the teacher that structures the path that the student will follow remotely was called "learning trail".

For Lopes and Lima (2019), the definition of trail can be taken literally as a narrow path or a trace left in the place where one passes and, in a literal sense, as a path to be followed, route, itinerary or even, "the set of steps and procedures, a recipe" (p. 172).

As it is a learning path, it can be considered as a path or model to be followed to learn. The trail represents the teacher's intention to teach and, for the student, the sequence of steps designed by that teacher so that he can continue independently, according to his performance, to seek knowledge.

The idea of building trails in a virtual

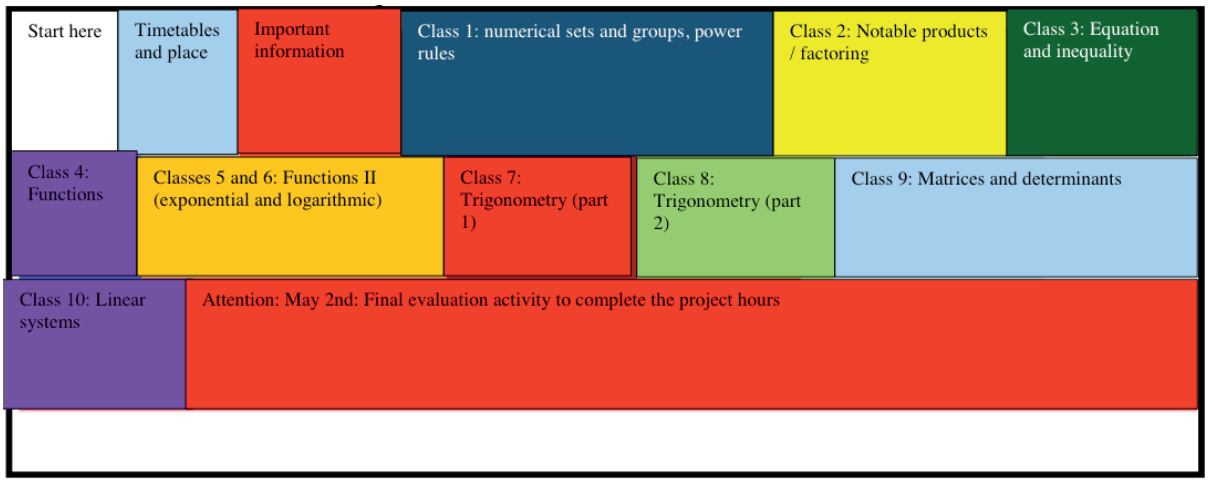

Figure 1 – Ten weeks in the Virtual Environment

Source: own author

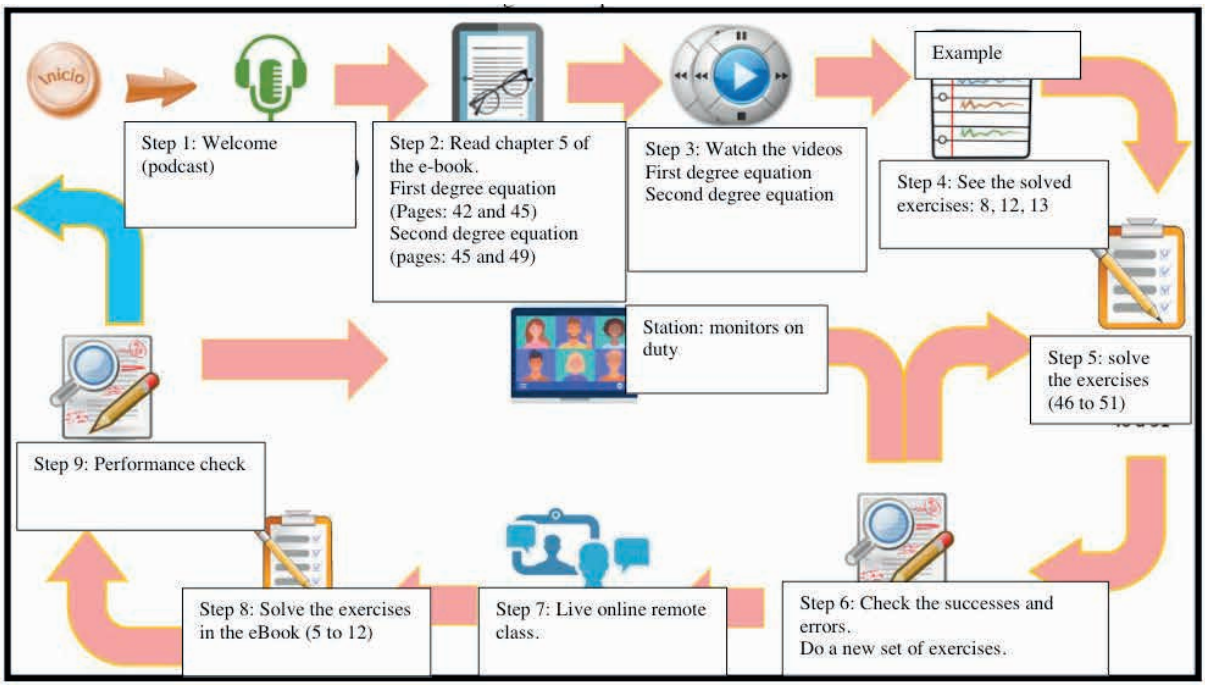

Figure 2 – Equations Trail.

Source: own author

environment allows the student to have a model to guide them, especially at a time when teaching is remote and takes them away from the traditional class, where the teacher articulates the class schedule, mixing content theoretical, exercises, fixation activities and interactions between participants.

Thus, each week, the student is guided through a different learning path that helps them study, resolve their doubts, obtain more confidence and mathematical fluency in that essential foundation for the study of Calculus. The obstacles to be overcome can be reviewed in subsequent trails by redoing activities that can help you strengthen your mathematics.

There are countless possibilities for setting up a "learning trail" that can include stations containing remote activities that offer the student:

- Reading theoretical material available in e-book from the University's virtual library or website previously evaluated by the teacher;
- Podcasts from the teacher that highlights important concepts in that subject;
- Examples with exercises solved in the virtual library e-book or YouTube;
- Activity with exercises proposed in the virtual library e-book or YouTube;
- Questions forum on each topic;
- Recorded video classes available on the Internet, previously evaluated by the teacher;
- Remote online class with the teacher (synchronous);
- Video conference with student monitors (synchronous);
- Digital recreational activities, such as memory games, word searches, fill-in-the-blanks, multiple-choice quizzes, among others.

Students who have difficulty with learning problems and even those whose previous school content is out of date, will remain on track, with new activities and content programmed for this purpose, and will be sent to the station for student monitors (on duty) who, even remotely, will be able to assist this contingent more closely.

The student monitors who previously solved all the exercises and created activity templates, ensuring that they were able to assist students who needed more attention, represented a different duty station, as in addition to the more consolidated knowledge in Mathematics, they also provided efficient dialogue through belong to the same generation as the students.

This "monitor duty" station works like an open videoconference with defined times, where students ask their questions with the entire team, but also participate in solving mathematical problems together with their colleagues, even solving exercises without the intervention of their teachers. monitors and even explaining the solution to their classmates. This action would promote reflection and exchange of solutions to the problems faced, offering the possibility for students to help their own peers.

LEARNING TRACK IN THE VIRTUAL ENVIRONMENT

For each tab of the Virtual Environment, the student finds a different track (Figures 2 and 3) defined by the teacher and covering the concepts necessary for the subject of the week that will be developed remotely.

Thus, for example, in the week's tab on "Equations", the student finds a circuit of actions (Figure 2) designed by the teacher of the curricular component and which would lead the student to interact with the teaching material, playful activities such

as exercises (Hotpotatoes, JClic, Socrative, Khot, Mentimeter, Online simulations, Padlet, Shared Docs, Moodle questionnaires, among others) and traditional activities (such as e-book exercises), online meetings with teachers and monitors, and synchronous assessments in a formative approach that signals, throughout the circuits, how the student is reacting to assessments and interactions with that content covered.

To stimulate students' attention, with each new tab, new circuits are built with different colors and diverse activity stations (Figure 3). This plurality between the trails aims to prevent the different trails from being similar, and preventing the week's trail from being monotonous with the same elements as the previous one.

Young university students, for the most part, like new challenges and lose attention with school content always given in the same way or in the same format.

In all tracks of the project, the "flipped classroom" methodology is present, as the student has contact with the specific content and in a variety of ways (text, solved exercises and proposed exercises and video) and then interacts with the teacher in live, synchronous and remote classes.

At the end of the circuit, the student again performs in-depth exercises on the topic and will be able to use the monitors on duty.

The results in each circuit performed by the student can provide valuable information to the teacher.

For Silva (2006),

> Assessment of learning in the online classroom requires breaks with the traditional assessment model historically crystallized in the face-to-face classroom. If the teacher does not want to underuse the potential of online digital, or if he does not want to repeat the same mistakes made in traditional assessment, he will have to seek new attitudes, new engagement strategies in the very context of teaching and learning and then resize his assessment practices. learning and their own performance (SILVA, 2006, p. 23).

Thus, the teacher has access to the students' performance and the results of the activities and assessments carried out in each circuit, being able to act in an investigative, interpretive and reacting way for the next track and with interventions in their next remote class.

For Bianchi (2021, p. 12), this teacher's concern and observance of students' performance on the learning paths is intended as guidance so that adjustments can be made (in the next paths and in their teaching practice) to convert possible difficulties of students in learning moments.

At the end of the week's trail, students move to the next trail in a learning spiral, since the set of defined trails makes up the concepts necessary to work with the future Differential and Integral Calculus.

According to Valente (2005, p. 12) in every spiral there is a starting point, here represented by the student's knowledge upon entering Higher Education and an ending point, often unattainable, but which keeps "the learning spiral in action producing increasing levels of understanding and learning".

The desired goal is to build learning paths, composed of the mathematical prerequisites and concepts necessary to follow Calculus. This spiral used to carry out remote classes will use the virtual environment according to the model presented. The learning spiral represents the mathematical decomposition (not biological, obviously) of Calculus and the student will follow the circuits along the trails and go up level by level until completing the entire spiral.

For the present project, the learning spiral can be represented as shown in Figure 4:

As trilhas de aprendizagem variam semana para semana, dependendo de seu conteúdo,

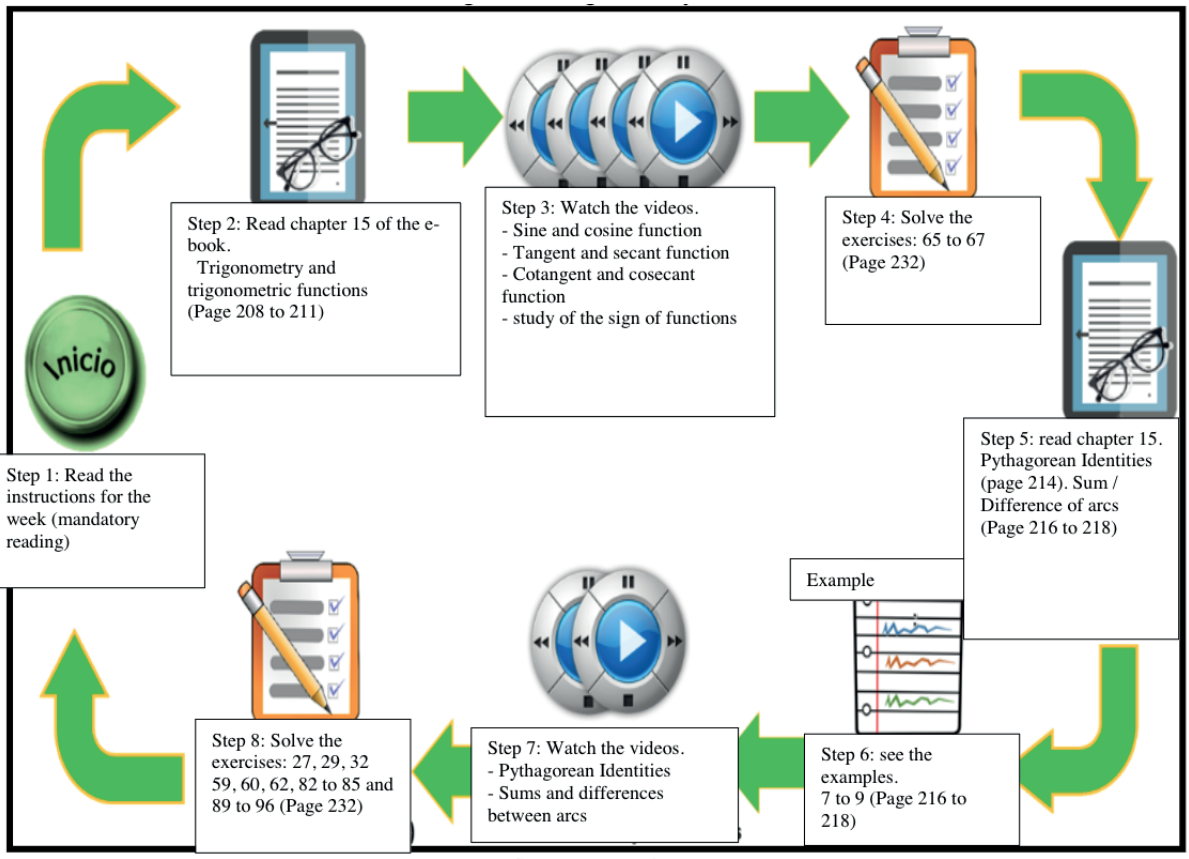

Figure 3 – Trigonometry Trail

Source: own author

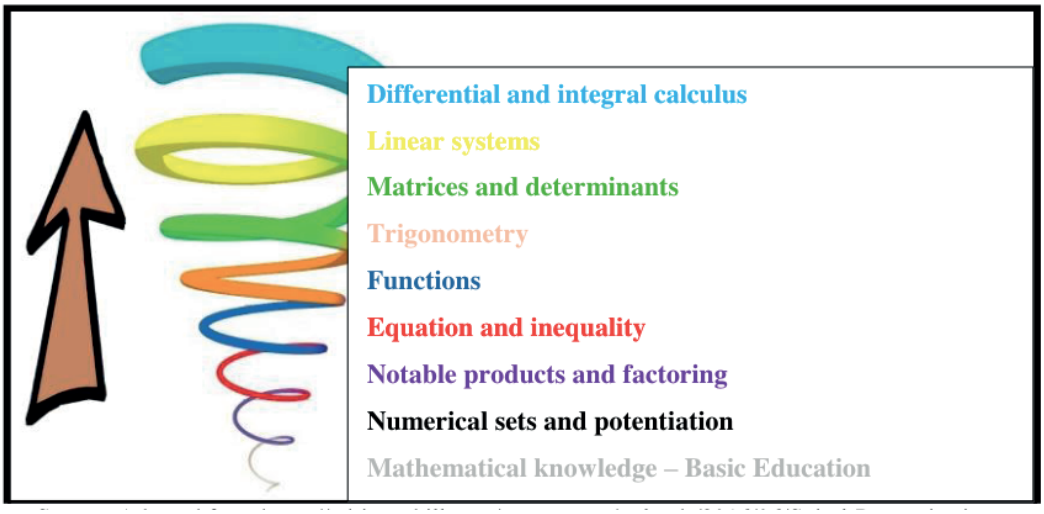

Figure 4: Precalculus Learning Spiral

Source: Adapted from https://adriancahill.com/wp-content/uploads/2016/06/Spiral-Dynamics.jpeg

da complexidade do tema e dos recursos usados. O conteúdo que exige um número maior de atividades apresentará uma trilha de aprendizagem com maior detalhamento, assim como encontramos também situações com poucas atividades, mas sempre com a realização da aula remota on-line síncrona e da estação on-line de monitores.

Após realizar todas as trilhas, em circuitos diferentes, de acordo com seus conhecimentos e desempenho, o aluno teve contato com todos os fundamentos necessários para acompanhar as aulas do componente curricular de Cálculo Diferencial e Integral I do curso de Engenharia.

FINAL CONSIDERATIONS

In remote teaching, more than ever, the student must become the central protagonist. Your actions in the virtual environment allow the development of skills, such as autonomy in studies, responsibility, personal organization and dedication to knowledge. The teacher acts as an advisor, supervisor and facilitator of the process and can use his teaching experience in organizing the Virtual Environment, a new and rich school space.

Students with learning problems or those who are behind due to a lack of previously unseen foundations need special attention, especially because they have not yet achieved autonomy in the learning process. The multiple activities and circuits carried out by this contingent in this model for the Virtual Environment may assist in their future monitoring of Calculus classes in higher education, as well as being adapted for other Engineering curricular components.

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