# DIGITAL TECHNOLOGIES IN TEACHER TRAINING: INTEGRATION OF TEACHING, RESEARCH AND EXTENSION

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## INTRODUCTION

In the scope of the Technical and Vocational Education and Training, Teacher Education degree programs have been performing an important role when preparing those professionals, especially after Law Nº 11.892, of December 29th of 2018 (BRAZIL, 2008). This law creates the Federal Institutes of Education, Science and Technology. Among other aspects, the referred law institutes that "[...] Teacher Education degree programs as well as special pedagogical training programs, aiming the preparation of teachers for Elementary School, mainly in the Sciences and Mathematics areas, and for professional education." (BRAZIL, 2008) should be offered in Higher Education. Furthermore, it decrees that at least 20% of the spots at the Federal Institutes should be destined towards these courses.

The Fluminense Federal Institute (*Instituto Federal Fluminense* - IFF) Campos Centro *campus,* place where the research described in this chapter occurs, gathers six[3] out of the eleven Teacher Education degree programs offered at the Institute. At the second semester of 2018, the number of enrollments in these six courses amounted to 44.9% of the total number of students registered in Higher Education programs by the *campus*, and to 26.4% of all enrollments among every level of education of the *campus*. It is highlighted, with these data, that the *campus* complies with the demands from Law Nº 11.892, of December 29th of 2018 (BRAZIL, 2008), and, therefore, takes on an important role with the society as for teacher training.

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In the context of the fast transformations of the contemporary world to contribute to the training of professionals who are able to aid the youth on their educational road is of fundamental importance. From the moment they are born, these youth deal with technological devices and feel several reflexes of those, both positive and negative. Thus, in contemporary society, teachers also need to be prepared to incorporate Digital Technologies (DT) in their pedagogical practices and to guide the young learners in the appropriate use of these technologies.

The DT can aid pedagogical activities, raise students' motivations and enhance visualizations, investigations and critical analysis, among other actions, at any time and place. In teacher training on the pedagogical use of those technologies, many aspects must be considered such as: role of the teacher, school management, student's autonomy, school and digital culture, among others. Beyond that, teacher training must include the discussion of questions related to the concept of education that every teacher has. If utilized under the traditional educational concept, the DT bring only illusions of innovation.

Aiming at contributing to the pedagogical use of DT, in 2003, at the then CEFET-Campos, currently IFF Campos Centro *campus,* the authors of this chapter began the "Information and Communication Technologies in the Process of Teaching and Learning Mathematics" research project. In the scope of this project, actions towards Mathematics teachers, both in training and in service, have been promoted. Furthermore, digital pedagogical resources have been developed, validated and made available with the participation of Scientific Initiation Scholarship scholars, mainly from Mathematics Teacher Education Degree Program.

Several resources have already been developed such as: i) Online learning units containing numerous materials and investigative activities; ii) Didactic Sequences that utilize resources on computers and tablets; iii) pedagogical strategies based on the use of smartphones. The DT are always discussed as mediation instruments, in activities that students take on active roles. The resources are experimented with teachers and undergraduate students, and, afterwards, are used on the disciplines of the Mathematics Teacher Education Degree Program (teaching dimension) and in mini-courses for the community (extension dimension). On the same way, aspects evidenced by the teaching and extension dimensions encourage new research actions, in a continuous circle, in which the DT are worked upon in several contexts of the education of a teacher.

Those actions have been expanded, and, currently, are also promoted by *Lato* and *Stricto Sensu* Graduate Programs, in teacher training courses. The described project has a trajectory of 15 years and the data obtained throughout this time signalize that the integration between teaching, research and extension is an important proposal for the promotion of changes in the educational scope.

About the triad teaching, research and extension, it is emphasized that the article 207 of the Brazilian Constitution (BRAZIL, 1988) has that "The universities [...] will comply with the principle of inseparability between teaching, research and extension". According to the article 2nd of the Law 11.892 of December 29th of 2008 (BRAZIL, 2008), "The Federal Institutes are cross-curricular multi-campus institutions of higher, basic, and vocational education specialized in offering vocational and technological education in the different levels of teaching [...].". The first paragraph of this article, affirms that "For the purpose of incidence of the dispositions that rule over the regulation, availability and supervision of the institutions and Higher Education Programs, the Federal Institutes are equivalent to Federal Universities." Thus, it is understandable that the principle of inseparability between teaching, research and extension needs to be present in the actions of every IFF's Higher Education programs as an institution. However, this chapter focuses on actions towards teacher training promoted by two professors of this Institute.

In this context, the objective of this chapter is to report actions towards teacher training, promoted at IFF Campos Centro *campus*. These actions make use of DT and address the dimensions of teaching, research and extension in an integrated format. In this sense, beyond this introduction, the chapter is compound by four other sections. In the second section, a brief literature review on teacher training and on the use of DT is promoted, as the activities described in this chapter relate directly to these themes. The third section describes the trajectory of the main actions, performed by the authors, which have contributed to the integration amongst research, teaching and extension in teacher training. The fourth section, discusses some results obtained throughout the time, fruits of the actions directed at teacher training, and, in the fifth section, final considerations will be made.

## TEACHER TRAINING AND DIGITAL TECHNOLOGIES

Teacher training is a continuous and permanent process of professional development (IMBERNÓN, 1994), it begins before admission at Teacher Training Degrees and proceeds during the exercise of professional practice. Therefore, it is important that the knowledge and representations built by the teachers throughout their lives are considered in initial and continuing education programs (REGO; MELLO, 2002).

At the continued process of teacher preparation it is important, among other aspects, the awareness and critical thinking while using the DT according to a conception of education that enables exploring the potential of this technology. Various researches have been made on the use of DT in teacher training (SALOMÃO, 2017; SABOTA; ALMEIDA FILHO, 2017; SILVA; SANTOS, 2018; SILVEIRA; NOVELLO; LAURINO, 2018), highlighting the importance of this theme.

A theoretical perspective that can substantiate teacher training is the Technological Pedagogical Content Knowledge - TPACK (MISHRA; KOEHLER, 2006). The TPACK is based on the pedagogical knowledge concept (knowledge over teaching and learning), developed by Shulman (1986). According to Mishra and Koehler (2006), this theoretical framework is defined as the knowledge needed by teachers to teach with and about technologies over various areas of knowledge, including the discussion over pedagogical questions related to the use of DT in studying subjects. Technology should not be considered out context. In order to ensure that the teaching and learning process occurs properly, it is fundamental to understand how pedagogy, technology and content relate to each other. This means that, in addition to looking at these components isolated, it is necessary to consider them as two by two and all three together (MISHRA; KOEHLER, 2006).

Beyond this theoretical perspective, it is highlighted that the fifth general competence of the Common National Curricular Base (*Base Nacional Curricular Comum* - BNCC)[4] for Basic Education refers to the use of DT:

> Comprehend, utilize and create digital information and communication technologies in a critical meaningful reflexive ethical way in the several social practices (including at school)

[4] Document that defines what students need to learn during their school trajectory (BRAZIL, 2018).

> to communicate, access and disseminate information, produce knowledge, solve problems and exert ownership and authorship in collective and personal life. (BRAZIL, 2018, p. 9).

This competence highlights the importance for the teacher to be prepared to accomplish the integration of DT at the teaching and learning process as well as the importance of actions that contribute towards the development of digital competences.

Digital competences, according to the European Union (2006), comprehends the safe and critical usage of these technologies (name, in the referred document, information society technologies), both at work as well as in other contexts. People must be able to use these technologies in production, presentation and comprehension of data and must able to access and to utilize properly the Internet (EUROPEAN UNION, 2006). Furthermore, individuals must use technologies in order to "[...] support critical thinking, creativity and innovation." (EUROPEAN UNION, 2006, p. 16).

In this context, in 2017, the European Union launched the European *Framework* of Digital Competences for Teachers (DigCompEdu) that aims to describe specific digital competences for teachers, proposing 22 elementary competences that are organized in six areas: i) professional engagement with four competences; ii) digital resources with three; iii) teaching and learning with four; iv) assessment with three; v) empowering learners with three; vi) facilitating learners' digital competence with five competencies (REDECKER, 2017). This document helps orienting and implementing regional and national level politics for digital competencies development, and it's intended for teachers of all levels of education. The identification of digital competencies' levels can contribute with educators so they are able to analyze their accomplishments and to progress even further, and this can imply in an improvement of their pedagogical practices (REDECKER, 2017).

The development of digital competences aiming at the pedagogical use of DT in teaching practice is fundamental to education's current context, in which pedagogical proposals supported by these technologies are becoming more frequent. One of those proposals is Blended Learning (HORN; STAKER, 2015). In general, Blended Learning can be defined as a teaching modality that combines moments in which the learner studies face-to-face, aided by classmates and under teacher's supervision, along with moments of online content studying (CHRISTENSEN; HORN; STAKER, 2013). According to these authors, there are four basic Blended Learning

models: Flex Model, A La Carte Model, Enriched Virtual Model, and Rotation Model. The last is divided in subcategories: Station Rotation, Lab Rotation, Flipped Classroom and Individual Rotation. Section 4 of this chapter describes experiences with Flipped Classroom and Station Rotation, thus, these subcategories are characterized as follows.

Flipped Classroom proposes the inversion of traditional classroom practice (BERGMANN; SAMS, 2012), that is, the subjects are to be studied by the students before the face-to-face classes. The study contemplates the usage of DT in order to contribute towards knowledge construction by means of video lessons, games, audio files, applets, among other tools. Aided by these resources, the teachers can optimize their time in classroom and spend it in interactive activities, discussion and deepening over covered topics (BARSEGHIAN, 2011).

In Station Rotation, the teacher divides the classroom into stations with at least one of them containing on-line activities (CHRISTENSEN; HORN; STAKER, 2013). According to Horn and Staker (2015), Station Rotation is the category of Blended Learning that attracts teachers the most. This is attributed to the fact that this proposal makes use of traditional teaching strategies, and therefore a sustained innovation. Rotating between stations is something old in education, the novelty is online teaching as part of the cycle (HORN; STAKER, 2015). Students go through stations where different activities are proposed. It is possible to propose activities of the same content, but different contents can also be proposed in each of the stations. The choice depends on the subject and the purpose of the study (BACICH; TANZI NETO; TREVISANI, 2015). Two positive aspects of this proposal are: the possibility of the teacher getting closer to the grouped students and the variety of activities, strategies and resources proposed in the stations which contributes to the personalization of teaching (BACICH; TANZI NETO; TREVISANI, 2015).

In Blended Learning the role of the teacher is essential. They should encourage collaborative work with focus on experience sharing, and students' autonomy (BACICH; TANZI NETO; TREVISANI, 2015). As defended by Moran (2015), in the current context, in which there is a lot of information and ways, combining group work with personalization is very important.

In summary, considering the subjects addressed in this section, it is possible to highlight some important aspects regarding the teacher training for DT's pedagogical usage: i) to consider the knowledge that teachers already

have; ii) to discuss DT's usage associated with conceptions of education; iii) to integrate technological, pedagogical and content knowledge as proposed by TPACK; iv) to consider the competences previewed by BNCC during the planning and execution of the training courses; v) to develop digital competences in teachers in order to develop these competences in their students; vi) to experience and evaluate the usage of DT in innovative pedagogical proposals such as Blended Learning; vii) to place the student at the center of the teaching and learning process in order to enable them to manipulate DT, establish conjectures and build knowledge.

## INTEGRATION OF RESEARCH, TEACHING AND EXTENSION

The "Information and Communication Technologies in the Mathematics Teaching and Learning Process" research project began in September 2003, at the then CEFET-Campos, currently, IFF Campos Centro *campus*. The project proposal was derived from the Master's Degrees studies[5] of this chapter's authors, which related Mathematics and Digital Technologies. One of them focused on Mathematics in High School (BATISTA, 2004) and the other on Mathematics Teacher Education Degree Program (BARCELOS, 2004).

Both of these researches, despite having different foci and target audiences, were closely related, since actions for High School required adequate teacher training which is linked to the teacher training degrees. The pedagogical usage of DT was already present in the classroom actions of the authors even before the Master's Degree. Thus, the mentioned studies were based on teaching experiences that allowed defending the pedagogical potentialities of these technologies.

The project's actions have always been guided by the idea that the best way to minimize resistance to the pedagogical use of DT is to promote activities that show teachers the actual possibilities of using these technologies in classrooms in a daily basis. Activities like this are promoted in both initial and continuing education, always through pedagogical approaches that consider technological resources as mediating instruments that can contribute to learning. In this sense, the research project goal is, up to the present day, to promote actions aimed at: i) Mathematics teachers that work in Basic Education, seeking through integration with the community

[5] Both at the Master's Degree of Engineering Sciences, in Norte Fluminense State University (*Universidade Estadual do Norte Fluminense* - UENF).

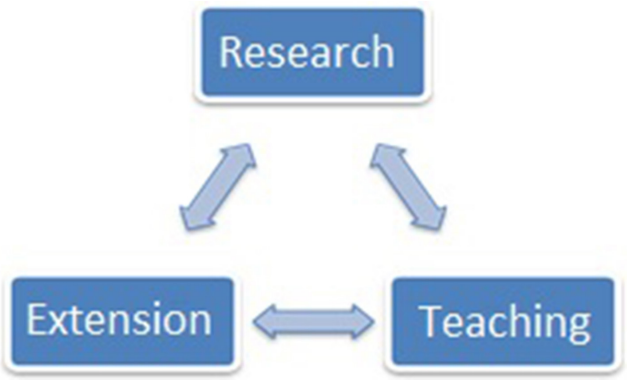
to contribute to the important role that IFF plays in the education of our region; ii) Students of the Mathematics Teacher Education Programs from both the Campos Centro *campus* and other institutions, aiming to contribute to their initial education.

The general objective of this project is to investigate the possibilities of DT usage in pedagogical practices, including teaching methodologies in order to improve the Mathematics teaching and learning process. It is clarified that the expression "Information and Communication Technologies" (ICT), present in the title of the project, means "Technologies used for treatment, organization and dissemination of information" (TAKAHASHI, 2000, p. 176). Although the referred expression is closely associated with digital resources, it also includes non-digital, used for information and communication throughout human evolution (ROCIO, 2010). The title of the project signals that the focus is on the use of DT, but does not exclude the possibility of using a handful of non-digital resources as well.

In addition to actions aimed at teacher training, several pedagogical resources are developed, tried and made available aiming at facilitating the use of DT for didactic purposes. The project always counts on the participation of CNPq[6]'s Scientific Initiation Scholarship students, predominantly of the Mathematics Teacher Training Course.

These resources are experimented with teachers and undergraduates and are later used in subjects of Mathematics Teacher Education Degree Program (teaching) and mini-courses for the community (extension). Equivalently, aspects observed in the teaching and extension dimensions encourage new research actions. The development of this continuous cycle amongst teaching, research and extension (Picture 1) was not intentional and the perception of its existence was not even immediate, becoming clearer to the authors through recent actions, described below. However, this integration, conducted since the beginning of the project, is an important methodological strategy for teacher training, and certainly also for professionals from other areas.

[6] We thank the National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico* – CNPq) for the Scientific Initiation Scholarships.




**Picture 1 - Integration Research - Teaching - Extension**
Source: Self-elaboration

In 2011, the authors concluded their PhD in Informatics in Education, at the Federal University of Rio Grande do Sul (*Universidade Federal do Rio Grande do Sul* – UFRGS), which have broadened the research interests, opening new fronts for the project. Also in 2011, began at the Campos Centro campus, the Teaching in the 21st Century: education and technologies *Lato Sensu* Graduate Program (*Pós-Graduação Lato Sensu Docência no Século XXI: educação e tecnologias*), which the authors participated in the conception, have already coordinated and are currently professors. In 2017, the Vocational Master's Degree in Teaching and its Technologies (*Mestrado Profissional em Ensino e suas Tecnologias* - MPET) began, in which the authors also participated in the conception, were already coordinators and are teaching. Between the mentioned *Lato Sensu* Graduate Program and the MPET, there is a close relation, both being due to actions of teachers of the Informatics in Education Research Nucleus (*Núcleo de Informática na Educação* - NIE).

The *Lato Sensu* Graduate Program has the following general objectives: to build technical-scientific competence for teaching in higher and secondary & technical education and discuss and experiment with digital technologies. In the same perspective, MPET's objective was established, which is to provide training in teaching and its technologies to professionals who work in the area of education, aiming at both the production and experimentation of technologies and the execution of studies that involve technological resources. In both courses, the focus is always on learning with technology being a mediating instrument, and students are teachers of various levels of teaching and subjects. Thus, the work developed by the authors was expanded, contemplating other areas of teaching besides Mathematics.

The courses' activities are reflected in the classrooms of schools in the region either through the application of the acquired knowledge, as reported by several students, or through the experiments resulting from the researches performed. In addition, students of these two courses lecture on various mini-courses for teachers and undergraduates, since the socialization of knowledge is highly encouraged. Hence, in the context of Graduate Programs, the integration of research, teaching and extension is taken as a strong ally of teacher training.

Although the dimensions of teaching, research and extension must be inseparable, each of them has its specificity. In the work described in this chapter, in short, it is possible to characterize the current actions as follows:

- in the research: studies and investigations on the pedagogical use of TD in the teaching and learning process are promoted. In addition to this, various pedagogical resources are developed, experimented and made available aiming at contributing to the pedagogical use of these technologies. Some research questions come from the other dimensions, as well as what is produced in the research is used in teaching and extension;
- in teaching: several digital resources are used in the study of curricular subjects and these are also analyzed in terms of pedagogical contributions. The resources used are quite varied; including some elaborated within the scope of the research project and experimented in extension actions. The observation of this usage, the results of the evaluations and the perception of the need of new resources allow to raise data for actions in the other dimensions. Classroom activities related to DT also raise the interest of undergraduates in terms of research, and the pedagogical usage of these technologies is addressed in the final paper of the Mathematics Teacher Education Degree Program at the Campos Centro campus. This generates new cycles involving teaching, research and extension;
- in the extension: several mini-courses are performed for teachers and undergraduates, in which, in general, are shared knowledge and resources coming from the research as well as of the teaching. By socializing knowledge, a lot is learned and numerous classroom realities are made aware of, which is important for those who

work in teacher education. Understanding what happens in Basic Education contributes to teaching and research, as it enables the development of more contextualized actions. Furthermore, the opinions expressed during the analysis of resources, doubts, questions, among other positions of the participants of the extension actions, motivate new activities in the other dimensions.

It is certain that throughout the academic trajectory difficulties have occurred in the promoted actions, such as:

• in teaching actions:

✓ although seemingly contradictory, some students still resist the pedagogical use of DT, likely due to the lack of using these technologies for this purpose. As the students perceive the contribution of this use towards the comprehension of the studied subjects, this resistance is minimized. It is highlighted that selecting user friendly resources collaborates in this sense;

✓ keeping up with digital resources updates demands time and dedication. Besides that, sometimes free applications establish new restrictions on the use of certain tools, releasing them only in paid versions. This ends up implying new searches for applications that allow their usage more broadly, for free;

✓ there are numerous digital didactic materials available, but they are not always appropriate for pedagogical actions aiming at knowledge building. Many only replicate, in digital media, the approaches of the traditional teaching resources. Moreover, some digital resources present issues that affect their quality such as technical and usability questions, adequation to the target audience and correction of the digital content. All this requires a critical posture when selecting adequate materials to the intended pedagogical goals.

• in research actions:

✓ the development of didactic material often involves redoing the tasks so as to provide a more adequate resource to your pedagogical goals, which requires study and determination;

✓ The substitution of the project's scholars implies a resumption of actions. In the project, the scholars are usually undergraduate

students in Mathematics and the activities require a certain skill in Computing, which will be further improved throughout the scholarship. In addition, a theoretical foundation on Informatics in Education is necessary, which the students will acquire throughout the Program (in a higher or lesser degree, depending on the initial knowledge they bring). For this reason, the training of new scholars requires time for them to perform properly. On the other hand, as they are undergraduate students, this training is also a teacher training action.

• in extension actions:

- ✓ technical problems related to equipment and resources used sometimes occur, despite the planning. In times like these, participants should be alerted that to work with DT involves matters like those;
- ✓ the number of teachers working in classes that have condition to take part in the actions is low, being a lot higher the number of undergraduates. The importance of the undergraduate's participation is unquestionable, however, it is frustrating not to be able to expect a bigger participation of those who already act in the classroom, which would make the exchange of experiences far richer for all;
- ✓ participants with very distinct levels of knowledge on mini-courses make it difficult to adequate the flow of activities. The acquired experience allows better dealing with situations like this; however it is always an aspect that depends on the characteristics of the participating group and the lecturer's skill to understand this context quickly, aiming to contemplate all in the best possible way.

In the next section, some actions performed in the described trajectory are detailed.

## EXPERIENCE SHARING

As mentioned in the previous section, the actions aimed at teacher training occur in the Mathematics Teacher Education Degree Program, in

the Teaching in the 21st Century: education and technologies *Lato Sensu* Graduate Program and in the MPET. Thus, the actions are described below, in subsections corresponding to each of these courses.

## Actions in Mathematics Teacher Education Degree Program

### Technology and Mathematics Education Curricular Component

The Technology and Mathematics Education (*Educação Matemática e Tecnologias* - EMT) component became part of the curriculum of the Mathematics Teacher Education Degree Program in 2004, two years after the beginning of this course. The structure of this component was the result of activities developed within the scope of the research project mentioned in section 3. EMT has a three-hour course load per week in the course's first term and its general objectives are to analyze and experiment DT in the construction of mathematical knowledge.

The activities developed are based on the TPACK theoretical framework. Some of the activities developed in the EMT discipline are: i) texts readings and discussions; ii) educational software study through activities that aim at the construction of mathematical knowledge (Chart 1); iii) evaluation of Mathematics educational software; iv) development of research activities utilizing one of the studied software; v) analysis of websites related to Mathematics learning; vi) development of applets utilizing Dynamic Geometry software; vii) analysis and usage of applications in tablets and smartphones; viii) discussion on the usage of social media in education; ix) development of presentations, amongst others.

a. Open a New File.
b. Construct a ABC triangle.
c. Using the **Perpendicular Bisector** tool (in the same menu as the **Perpendicular Line** tool), construct the $\overline{AB}$ and $\overline{AC}$ sides' perpendicular bisector. Mark the D point, these lines' intersection.
d. Trace $\overline{BC}$ side's perpendicular bisector, move one of the vertexes and verify that it also goes through D.
e. Trace D centered circle that goes through A. Observe the B and C points' positions in relation to the circle.
f. Move one of the vertexes and describe what happened regarding the perpendicular bisectors' intersection point.
g. Save the file.

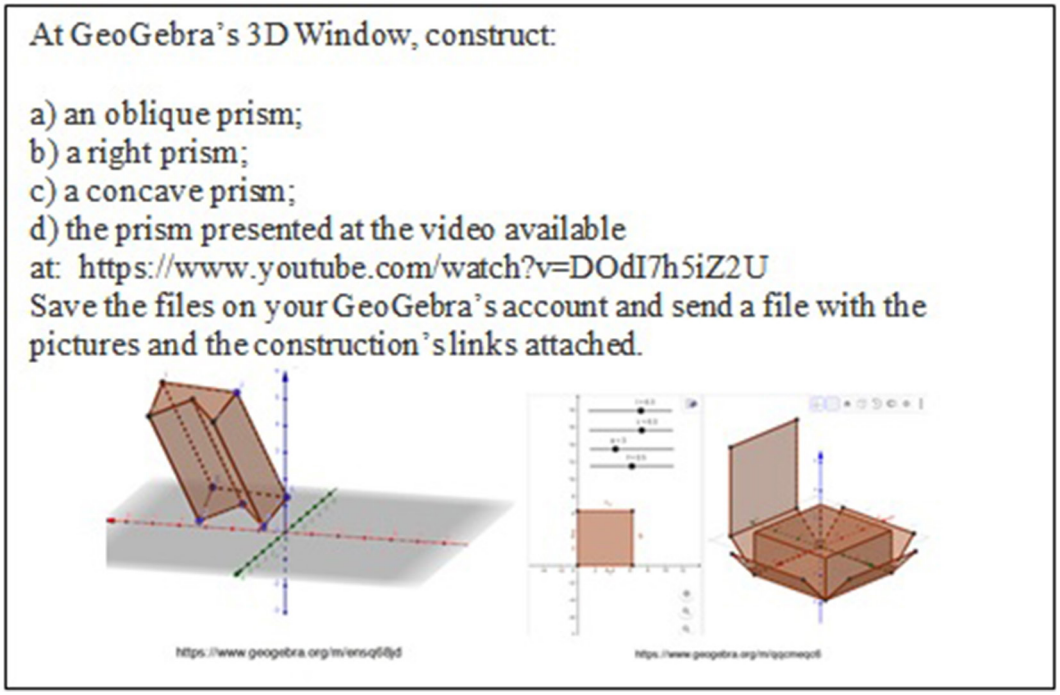
**Chart 1 - Activity with GeoGebra software**
Source: Own elaboration

The activities conducted influence other curricular components of the course and also curricular internship activities developed in Basic Education schools. Three examples are described in the next subsection.

## Other curricular components

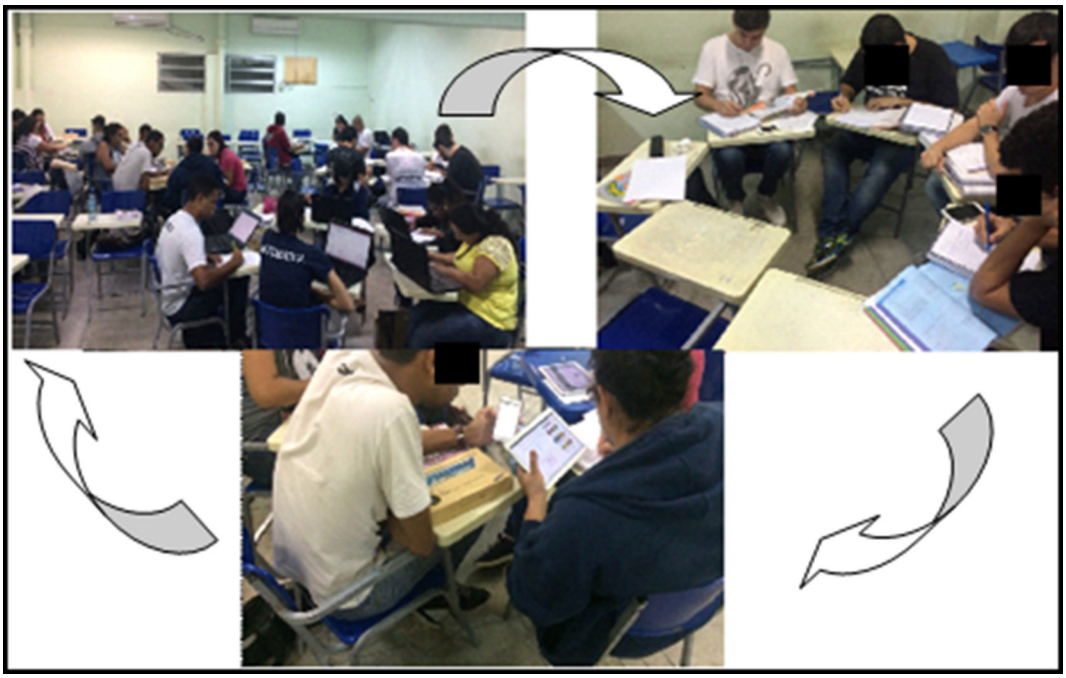
In addition to the EMT discipline, it is highlighted the pedagogical use of DT in the construction of mathematical knowledge in other curricular components of the Mathematics Teacher Education Degree Program.

Geometry I, II, III and IV are components in which geometric constructs and/or applets are elaborated or manipulated by the undergraduates to establish conjectures. It is emphasized that these actions allow the deepening of subjects beyond what the textbooks present. Some of the resources used are developed within the scope of the research project described in this chapter and others are selected in the materials section of the GeoGebra website. The applet shown in picture 2, for example, was developed in class with the purpose of making possible the manipulation of a concave prism, which is not usually illustrated in textbooks.




**Picture 2 - Activities proposed in Geometry IV**
Source: Own elaboration

Furthermore, a pedagogical practice conducted in an evening-second-term class in Geometry II in 2017 for nine hours/class. For the study of Thales' Theorem, the classroom was arranged in five stations (Picture 3). In each one there was an activity on the subject with different materials (Chart 2). The students grouped themselves spontaneously in the stations and solved the activities with great interest. The time allocated to each station varied significantly, according to the characteristics of the students. The teacher was able to answer the questions in a more personalized way. In the students' perception, expressed orally, at the end of the last meeting, the achievement was great.



**Picture 3 - Station Rotation in Thales' Theorem studies**
Source: Own elaboration

| |
|---|
| **Station A:** To study the book's theory on Thales' Theorem and to solve exercises.<br>**Station B:** To solve the investigative activities proposed by the teacher, handling a GeoGebra applet with notebooks.<br>**Station C:** To analyze the Thales' Theorem approach in six didactic books used in Elementary and High schools. To record how the theme was approached and how are the proposed exercises.<br>**Station D:** Using a tablet, research about Thales' Theorem's history and write an essay with at least 20 lines. Input the used references.<br>**Station E:** To select and/or to elaborate three activities about Thales' Theorem. |

**Chart 2 - Activities proposed in the stations**
Source: Own elaboration

Another curricular component in which DT are constantly used is the Mathematics Teaching and Learning Laboratory (*Laboratório de Ensino e Aprendizagem de Matemática* - LEAMAT), which, among other objectives, seeks to investigate pedagogical materials that may contribute to the teaching and learning process of Mathematics in Basic Education. At LEAMAT, the students' research works (projects) must result in didactic

sequences that will be applied to students of Basic Education, educational institutions in the community or at IFF. Based on resulting experiences from this curricular component, courses are also offered for teachers as a way of disseminating the work produced and contributing to the continued teacher training education in the region. Therefore, LEAMAT allows the experience of integration amongst teaching, research and extension. As an example, the "Geometric Approach in the Teaching of Square Root" project (MACABU; PARAVIDINI, 2018) is reported, in which applets on tablets were used (Picture 4). The experimentation of the didactic sequence of this project was carried out in the sixth year of Elementary School, in a municipal network school located in a landless settlement, in Campos dos Goytacazes, RJ, in 2018. The objective was to approach, in a contextualized way, the square roots through the geometric exploration with the aid of applets. The tablets used belong to IFF[7] and were taken to the school by the undergraduate students, under the supervision of the advisor professor. The sequence was applied to 24 learners during three classes. The analysis of the obtained data indicated that the students had an easy handling of the tablets and applets, and that the using of those stimulated the participation of the students. In addition, it was possible to perceive that the students used different strategies to reach the result, which contributed a lot to the teaching and learning process of the theme.

**Picture 4 - Application of the project developed in the LEAMAT component**
Source: Macabu and Paravidini (2018)

[7] The tablets were purchased with Coordination for the Improvement of Higher Education Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* - CAPES) allowance for the Interdisciplinary Laboratories for Educators Training Support Program (*Programa de Apoio a Laboratórios Interdisciplinares de Formação de Educadores* – LIFE) – Call Notice n.º 67/2013, published in the Brazilian Union Official Gazette (*Diário Oficial da União* – DOU) of September 23rd, 2013, Section 3, p. 31.

In addition to the activities developed from the curricular components, there are many final papers of the Mathematics Teacher Education Degree Program that contemplate the pedagogical use of DT. It was decided to briefly describe the work entitled "Study of 1st. Degree Equations with Two Variables in Elementary School with Tablet Assistance" (BARBOSA, 2017), because it was developed in the Young and Adults Education Program (*Educação de Jovens e Adultos* - EJA) at IFF. Thus, the scope of actions in the different modalities of teaching is highlighted. In the mentioned work, a didactic sequence was elaborated and experimented for the study of 1st. degree equations with two variables, destined to students of Elementary School (EJA), using the Desmos application, in tablets. The research was based on the Theory of Registers of Semiotic Representation, according to which the representations registers conversion is responsible for intensifying the subject's cognitive activity and providing a better understanding of mathematical subjects. The objective of the research was to investigate the importance of representations registers conversion for the study of 1st degree equations with two variables, with the Desmos application's help, in tablet, associated to investigative activities.

The research was qualitative, through a case study, and the data collection tools were questionnaires, interview, observation and responses to the didactic sequence activities. Experimentation occured from September to November 2016 with five students from the 8th grade of EJA from IFF (Picture 5).

Data analysis has shown that the use of Desmos, associated to investigative activities, provided time savings for the conversions of algebraic and graphical registers, as well as allowing a better understanding of the subject through the visual exploration of the 1st degree equation with two variables.

**Picture 5 - Didactic Sequence's Experimentation**
Source: Own elaboration

## Teaching in the 21st Century: education and technologies Lato Sensu Graduate Program

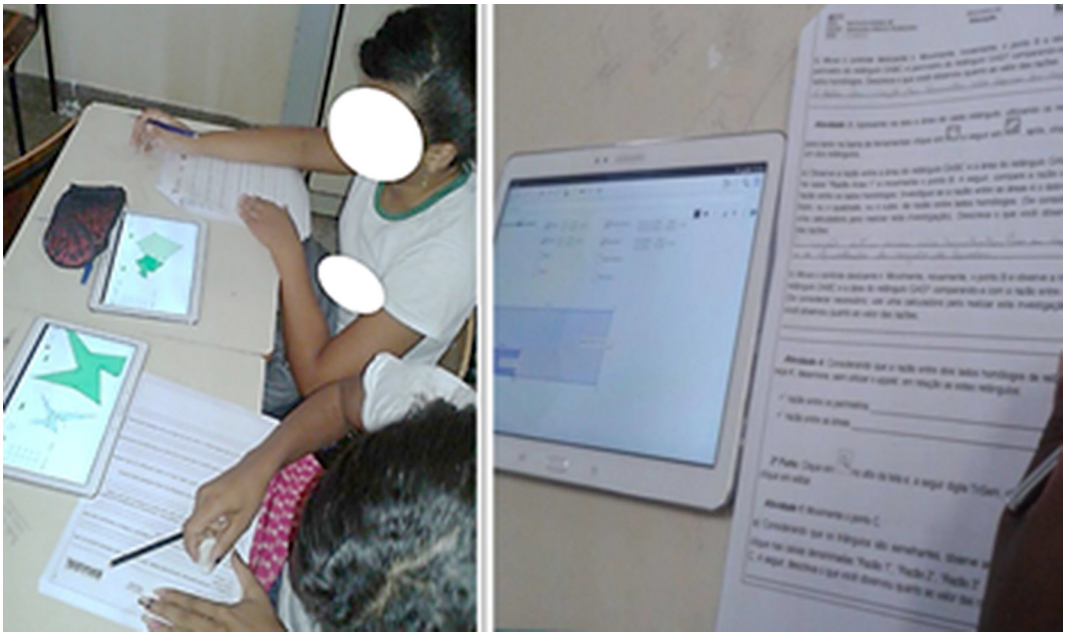
In 2011, the Teaching in the 21st Century: education and technologies *Lato Sensu* Graduate Program was created. Its target audience is made up of bachelors and teachers in all areas of knowledge that have an interest in teaching. The program includes curricular components of two areas: Education and Informatics in Education. As mentioned in section 3, the authors of this chapter participated in the proposal's elaboration and were coordinators of the course for six years and act as professors since its inception. The activities developed in the curricular component "Information and Communication Technologies in Education" (*Tecnologias da Informação e Comunicação na Educação*), taught by the authors of this chapter, are the result of the research performed in the project "Information and Communication Technologies in the teaching and learning process of Mathematics" and of teaching experiences in Mathematics Teacher Education Degree Program.

In order to complete the course, in addition to the approval of the curricular components, it is necessary to present to a committee an article describing a research developed with Basic Education students and that contemplates the pedagogical use of DT. With the development of these researches, activities with DT use in the teaching and learning process are shared with schools in the region.

In 2018, the fourth group of this Graduate Program was started. Next, three academic research developed by students of the three groups that have graduated.

The first research was selected due to the fact that it involved Elementary School students from the state network. It is called "Investigation of quotients between elements of similar figures in tablets: applets created in GeoGebra" (SILVA; SIQUEIRA, 2016). This final paper's objective was to elaborate and analyze the experimentation of a sequence of investigative activities promoted with students of 9th grade of Elementary School. In that sequence, it was used applets created in GeoGebra and made available for use in tablets. The option to use mobile digital technologies was due to the fact that these have generated many pedagogical possibilities for research and construction of knowledge. The research was qualitative and, to this end, a case study was promoted at a state school during Mathematics classes. Four meetings were held, adding up eight hours. Eight out of the 22 students in the class have participated in all four meetings, so the only data analyzed was from these eight students. The investigative activities approached existing relationships between homologous lines, perimeters and areas of similar figures (rectangles, triangles, trapezoids and any polygons). For the solution of these activities, the applets elaborated by the described research's authors were used (Picture 6).

In addition to conducting investigative activities, the students answered an initial questionnaire, a survey activity sheet, and a final questionnaire. The results found in this pedagogical experience were analyzed from the Sociohistorical Theory perspective, and evidenced that the sequence of activities contributed to the study of the theme, since the students participated actively and were successful in their answers.



**Picture 6 - Similar Figures Activity**
Source: Silva and Siqueira (2016)

The second research selected to be shared in this chapter is also a final paper and is called "Blended Learning: Study of Proportionality in High School through Station Rotation" (VILLAÇA; SANTOS, 2018). The study sought to analyze how the Blended Learning teaching modality, in particular the Station Rotation subcategory, can contribute to teaching and learning process of the relation between Directly Proportional Quantities & Linear Functions and between Inversely Proportional Quantities & Hyperbole.

The qualitative research was of the pedagogical intervention type and the data collection tools were observation, questionnaire and responses of the proposed activities. The activities proposed at the stations were tested by students in the 1st grade of high school at a state school in Campos dos Goytacazes (RJ).

Two meetings were held, adding up to five hours. These occurred in the school's Mathematics laboratory, which consists of a room of the SESI Mathematics Program and is an FIRJAN (Federation of Industries of the State of Rio de Janeiro) System initiative. The room is composed by the SESI Mathematics kit that contains acrylic geometric solids, cart with 40 laptops,

a projector, a digital and a regular whiteboard and suitable furniture. This research is highlighted by the use of the school's own technologies.

The class, the target audience of this research, had 33 students. In both meetings, the class was divided into five groups that composed the five stations (Picture 7). At the first meeting, there were 27 students and in the second, 31 students. For the data analysis, it was considered only the 27 students who attended both meetings.

The investigative activities, separated in the five stations, included reading the Proportional Quantities Theory, solving universities' admission exams exercises and activities that explored relationships between quantities, through the manipulation of applets that were selected, adapted and created by the authors.

The data showed that the Station Rotation and the pedagogical resources used contributed to the study of Proportionality, making the students active and favoring the collaborative work.

**Picture 7 - Station Rotation**
Source: Villaça and Santos (2018)

The third paper is an article published in the event Proceedings, it was selected due to the fact that it was written by a student graduated in the first class of the Graduate completed in 2014. This student sought the guidance of her Graduate final paper's advisor, one of the authors of this chapter, and asked for help in conducting and recording a pedagogical experience in her classroom in 2017. This action shows the impact of the course on teaching practice beyond the activities proposed at IFF. The research was reported in the article called "Flipped Classroom: use of Google Classroom in the study of History" (SILVA; BARCELOS, 2017).

The aim of this research was to analyze a pedagogical experience carried out with students from a Regular High School class in São João da Barra, RJ, using the Flipped Classroom and the Google Classroom virtual environment in the study of European Maritime Expansion and African continent's diversity. The research had the participation of 22 students (Picture 9). The data collection tools used were observation and the responses to the proposed activities.

The activities were divided into two parts: i) an inaugural class with the objective to present the proposal to the class; ii) performance of the activities throughout three weeks, both in online classes via Google Classroom (with video exhibition, image searches, videos and texts creation) as well as in face-to-face classes (Picture 8).

The data analysis showed that the Flipped Classroom methodology proposal with the use of Google Classroom allowed the interaction and ownership of the students. It allowed noticing an expressive participation and collaboration in the platform used, autonomy and creativity. Furthermore, the proposal contributed to the process of constructing knowledge over the addressed subject in a critical, integrated and flexible manner since the students researched, shared and presented, in the learning spaces used, quality content.

**Picture 8 - Flipped Classroom**
Source: Own elaboration

## Vocational Master's Degree in Teaching and it's Technologies (MPET)

In September 2017, MPET classes began. This chapter authors acted as coordinators of this program since its approval by CAPES in early 2017

until March 2019. In addition, they are professors of the program and responsible for several disciplines.

MPET is intended for training the pedagogical use of DT as well as for the development and experimentation of digital didactic resources. In this way, the program enables the upright (verticalization) of the training for the graduates of any Teaching Training Degree, or of other areas that are willing to research and to contribute to teaching improvement.

This Master's Degree is expected to train professionals who can act in their educational context, using innovative teaching methodologies, with the support of technological resources, understood as mediating tools.

In MPET subjects, several activities are proposed with digital resources. The students use them for the accomplishment of tasks, however, in addition, they reflect on possibilities and limitations of these resources. In terms of teaching methodologies, the focus of the course in the 2017 and 2018 classes was on the active and problematizing methodologies, which seek to create favorable environments for the student to be the center of their teaching and learning process, and to use the technology as a means of favoring learning.

Extension actions are developed by the MPET's students, since the beginning of the course through professor's guidance. MPET's role is to contribute towards the improvement teaching in the region in which it is inserted. These actions are conducted as evaluative activities of the course's subjects or in academic events or, even as part of the Master's Degree research. Exemplifying some of these actions, the mini-courses promoted by MPET's students along with their advisors, at the 5th Teacher Training Course Week at IFF Campos Centro *campus* in 2018: i) "Conceptual maps: enrichment of the future teachers practices" (CARVALHO *et al.*, 2018), ii) "Science Teaching: Using Educational Apps on Smartphones" (MANHÃES *et al.*, 2018) ; iii) "Digital Technologies in Didactic Sequences Elaboration: Powtoon as a tool to aid in the teaching and learning process" (MARCELINO; OLIVEIRA, 2018); iv) "Educational Games: our students can choose" (SANCHES; BATISTA, 2018). These mini-courses show the integration of MPET1 with Teacher Education Degree Programs.

Some actions promoted under two subjects taught by this chapter authors for the 2017 and 2018 classes are highlighted below.

In the "Approaches and Trends in Digital Technologies" subject, the role of DT in education was discussed, public policies for Informatics in

Education were analyzed and it established a conceptual basis on several aspects related to the pedagogical use of digital tools. In addition, a critical analysis of scientific articles was carried out through activities developed with the support of an evaluation formulary. Besides to contributing to the knowledge of the topics addressed in the articles, the objective was to collaborate to better understand the academic writing process. Hence, the actions of this compulsory subject motivated other activities of the course.

The "Mobile Technologies in Education" subject is elective. In it, a contemporary society characterization was promoted and several aspects, positive and negative, were discussed regarding the use of mobile devices in the teaching and learning process. In addition, various features for mobile devices were researched and evaluated in order to develop educational activities. Every student in the subject, as a final activity, had to try out some mobile application, using smartphones or tablets in a learning context (mini-course or classes for their own students). Thus, the studies carried out would not be restricted to the context of the subject; they should be socialized in some way. In general, the performed pedagogical practices were very interesting with reports that signaled, in a significant way, the contributions to the many people involved.

Ending this section, it is highlighted that, in addition to teacher training, which is fundamental, several other aspects influence the positive result of the pedagogical use of DT, such as the existence of adequate infrastructure, commitment and support of the school's management, students' responsibility with their learning, among others.

## FINAL CONSIDERATIONS

The whole experience, briefly shared in this chapter, makes it possible to affirm that, in teacher training, it is important that teaching is inserted in a broader context, one that allows lessons learned in the classroom to be broadened and shared. Teaching, research and extension, in fact, should be inseparable to enable wider learning experiences. Each teacher in training should be able to perceive himself as an agent of social modification, capable of contributing through education to the improvement of the quality of life in their region.

The "Information and Communication Technologies in the Teaching and Learning process" research project's actions were fundamental for

understanding this scenario. Since 2003, this project has been linked to the Advanced Studies in Education Research Nucleus (Núcleo de Estudos Avançados em Educação – NESAE), which, on the other hand, was created in 2002. When the project was launched, education research at IFF was in an early stage and was not even fully understood. Thus, it is possible to affirm that the mentioned project also contributed to advances in this sense.

In the core of the Lato and Stricto Sensu Graduate Programs, as mentioned previously, is the NIE, a research nucleus created in 2010 by 12 doctors of Informatics in Education, linked to IFF, graduated at UFRGS. The NIE's main objective is to develop applied research to the teaching and learning process of different areas of knowledge with the DT support. The authors are both NESAE and NIE researchers. Thus, the importance of the research nuclei as a basis for academic initiatives is emphasized.

It is hoped that the actions developed and described in this chapter will stimulate initiatives compatible with the 21st century's context, regarding the teaching and learning process centered at the student.

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