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Mathematic e-textbooks in different didactic configurations

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Abstract: The e-textbook is one of the main resources that distance learning institutions make available in the virtual learning environment (VLE) for teachers and students. According to the Brazilian References for Distance Learning, the authors should follow some methodological, epistemological and political principles for its production: to allow students and teachers (educator and tutor) to construct knowledge through interaction with peers. In this paper we seek to map the enrichment of the content in DE carried out by teachers' educator, from the use of e-textbook, in the light of the analysis of the teacher's instrumental orchestrations. The theoretical framework comprised Luc Trouche's Instrumental Orchestration, focused on understanding the didactic configuration. Three trainers of Analytical Geometry from two courses of Mathematics teachers' initial education of Brazilian Open University composed our subjects. As for the method, we adopted some techniques used in the documentational approach to didactics, introduced by Ghislaine Gueudet and Luc Trouche. We made a virtual visit to the teachers' virtual classroom protocols in VLE, and then an interview with each teacher was undertaken. Finally, we asked them to draw a map of the resources they use in class. Our results revealed the need to add other content resources, during didactic mediation forcing the teacher to change his didactic configurations, and the need to think about a collective construction of the e-textbook, discussing in parallel with the main authors of distance learning, teachers and tutors of the performers.

Keywords: textbooks, instrumental orchestration, distant education, instrument.

Introduction

In the context of Distance Education of the UAB- Open University of Brazil model, the *e-textbook* is an artefact that guides the development of activities for teachers, tutors, and students. It is one of the main artefacts that distance education institutions make available in the virtual learning environment (VLE) for teachers and students.

The Brazilian References of Distance Education (Brasil, 2007) states the e-textbook must be organised to allow students to develop competencies, skills, and learning that give meaning to this knowledge in different contexts. The *e-textbook* author, called *content-educator* in distance-education

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(DE) courses offered by UAB, must follow some methodological, epistemological, and political principles that must also be explicit in their Institutional Pedagogical Project. According to the guidelines, the *e-textbook* must present contents that enable students and teachers (educator and tutor) to interact in the reserved spaces to construct knowledge.

In this paper we seek to map the enrichment of the content in DE carried out by teachers-educator, from the use of the e-textbook, in the light of the analysis of the teacher's instrumental orchestrations. It is an excerpt from a master's research (Pereira, 2017), which aimed to characterise the didactic configurations performed by teachers of the mathematics teaching degree in the DE modality, based on the choice of teaching situations, mapping of resources, and planned schemes of use. Pereira (2017) investigated the conceptions of teachers involved in DE, mainly responsible for the didactic configuration of the VLE, i.e., the choice of mathematical situations, resources and their schemes of use, instrumented actions, the organisation of the virtual classroom, and the roles of the subjects involved. The excerpt of the research discussed in this paper refers to the e-textbook as an artefact in this context.

Theoretical Framework and Distance Education in Brazil

The instrumental approach (Rabardel, 1995), and the instrumental orchestration (Trouche, 2005) had the face-to-face teaching rich in technological resources as their field of study. Our research takes them as a theoretical basis, however, with a look at the field of Distance Education of the UAB model, based on the study of the decree that defines Distance Education (Brasil, 2007). Within this context, we set out to discuss some studies on DE in Brazil, taking as a reference some studies developed within the scope of the Study Group on Resources for Education (Grupo de Estudos sobre Recursos para a Educação- GERE) (Lucena, 2015; Lucena, Gitirana, & Trouche, 2016), focusing on the role played by the executing-teacher, our subject, within distance learning in the DE-UAB model. In addition to these theoretical constructs, our methodological bases also included the reflective research (Pepin, Gueudet, & Trouche, 2015).

The Scenario of Distance Education in the UAB Model

Distance education in the Brazilian scenario has multiple models. The programs can present different designs and multiple combinations of languages and educational and technological resources (Brasil, 2007, p. 7).

distance education is characterised as an educational modality in which didactic-pedagogical mediation in the teaching and learning processes occurs with the use of means and information and communication technologies, with students and teachers developing educational activities in different places or times. (Brazil, 2007).

DE-UAB was one of the public policies aimed at expanding and improving teaching and learning, in particular mathematics, to lead teachers' initial education to all parts of the country. However, in this scenario, Lucena (2015), Pereira and Gitirana (2016), and Pereira (2017) point out obstacles to the mathematics teachers' education in the distance modality, whether in planning, in the dialogue between the actors (teachers' educator, tutor, student), in the artefacts made available by the educational institution.

Several subjects work in this type of teaching, for each activity a subject play his/her specific role, as stated by Pereira (2017, p. 20):

1. Author (content-teacher) – a person who produces the e-textbook that is made available online and, in some cases, printed to students;
2. Teacher Facilitator/Educator - a person who systematises the entire discipline and lists the resources and schemes of use that will be mobilised;
3. Tutor - a person who establishes online, sometimes face-to-face contact with the students, does the didactic mediation, shares the questions, proposes suggestions for study, exchanges experiences with peers. The teacher, in some cases, also plays this role;
4. Student - besides other actors contributing to this education system.

It has three kind of teachers: Author, Facilitator and Tutor.

The Instrumental Orchestration in the Context of Distance Education - UAB

According to Trouche (2005),

An instrumental orchestration is the systematic and intentional arrangement of resources and subjects involved in the process, to effect a situation given and thought a priori by the teacher to guide learners in instrumental genesis and in the evolution and balance of their instrumented systems. (Trouche, 2005, p. 126). (Our translation)

Therefore, the instrumental orchestration (IO) is a model to develop such systematic and intentional arrangements, focused on face-to-face teaching. However, in our research, we used it to analyse and understand the institutional and teachers' practices in distance education. Therefore, the IO definition shows the importance of first understanding the notion of instrumental genesis (Rabardel, 1995) and situation (Vergnaud, 1991).

In the instrumental approach, Rabardel (1995) discusses the transformation from an artefact into an instrument that each one does to expand his/her ability to carry out an activity. For him, an instrument is composed of two components: the artefact (which can be material or symbolic) and the associated schemes of use. The schemes are the result of a construction inherent to each subject, autonomous or of appropriation of social schemes of use (ShSU), in this case, formed outside the subject.

Trouche (2004; 2005) typified an instrumental orchestration of a mathematical situation by through two components: didactic configurations and the exploitation mode of these configurations. The didactic configuration is "defined by arrangements of artefacts in the environment, corresponding to each phase of a situation" (p.39) (Tradução Pereira, 2017). The exploitation mode is the way the didactic configuration may be exploit by teacher and students, teacher predicts different ways students, tutor and himself/herself may performance the planned configuration.

The didactic configuration is much more than the choices of disposition of artefacts in the environment, it is the intentional choice of the artefacts to be made available and mobilised, the schemes of use planned to understand mathematical knowledge through artefacts, the definition of the role of the subjects involved and the instrumented action schemes. In other words, a computer environment is necessarily an active agent of orchestrations (Bellemain, & Trouche, 2016).

The technical and pedagogical institutional team carries out a first didactic configuration before any course starts, and the teacher is given elements of the configuration. Then, the team's collective schemes, which transform the artefacts into ideal instruments, are turned into instructions of use. From this configuration, the teacher chooses a situation to explore, makes didactic choices to provide conditions for the student to develop the instrumental genesis and disposes of his/her choices in his/her virtual classroom, using artefacts made available, changing them and including others. In our research, it was possible to characterise and classify the artefacts made available to the teacher in his/her virtual classroom by the institution: assessment, interaction, management, and content tools² (Pereira, & Gitirana, 2016, Pereira, 2017). For example, when selecting a situation and performing the didactic configuration for that situation, the teacher establishes all the points to be discussed, the artefacts available and those that will be mobilised, and the execution time. These elements can be changed during (predicted or not) interactions in the virtual classroom through teacher decisions. To understand and characterise the teachers' didactic configurations and the transformations of artefacts and schemes of use, as well as the evolution and assimilation schemes, we rely on the instrumental approach. However, many of the institution's configuration artefacts serve as a source for the construction of new artefacts and instruments. They then appear as a resource for the constitution of the teacher's documents. In this sense, we also rely on the documentational approach to didactics (Gueudet, & Trouche, 2009, 2015).

Documentational Approach to Didactics and Reflective Methodology

According to Adler (2000), "resources extend beyond the material to the immaterial, as well as mathematical, cultural and social resources" [...] Documents are developed along these documentational geneses and are organised in a documentation system, and the documentational genesis is deeply interconnected with the teacher's professional development. (Gueudet, & Trouche, 2009, p.200).

² Pereira (2017) classified the resources mobilised by three teachers of the mathematics teaching degree, in the discipline of analytical geometry in the virtual learning environment (VLE) in the following resources: Tools, Content, Evaluation, Management and Interaction, see **figure 1**.

The object of the documentational approach to didactics is understanding the teachers' documentational genesis from their practice, at different times and situations, and different spaces. The teacher acts on (re)source as the elements that serve as a source for the construction of his/her documents. Resources and schemes of use make up the teacher's documents. In this transformation process, the documentational genesis is essential for the constitution of the documents. As stated by Gueudet & Trouche (2015, p. 8),

The teacher's documentation work is the engine of a documentational genesis, which jointly develops a new resource (composed of a set of selected, modified, recombined resources) and a scheme for using this resource.

The documentational genesis "combines the instrumentation processes (resources instrumentalise the teacher's didactic action) and the instrumentalisation process (the teacher appropriates, modifies resources)" (Gueudet, & Trouche, 2015, p.34).

Thus, a documentation work seeks to characterise and map resources, mathematical tasks, planning, management of artefacts, technological resources, time, etc. that the teachers use to carry out their practice.

In the context of DE - UAB, to rescue the work of didactic configuration of disciplines already taught, which is recorded on a platform, a teacher's process of rescue and reflection on this process, culminates in the identification not only of the configuration, but also elements of the teaching documentation. In this rescue, we used the methodology related to DAD, developed by Gueudet & Trouche (2010). The methodology starts from three founding principles of the DAD:

- the diversity of resources that feed this work and what results from it;
- the variety of (collective, institutional and social) interactions that influence this work;
- the time required for the development of the documentational genesis (adapted from Gueudet & Trouche, 2010, p.27).

Based on these principles, they developed a *reflective investigation methodology of teachers' documentation work*. In turn, five principles were outlined for this methodology:

- a comprehensive collection of material resources used and produced during the documentation work;
- long-term monitoring; the geneses are developing processes and schemes develop over long periods;

- monitoring everywhere (inside and outside the classroom). The classroom is an important place where planned teaching is implemented, an implementation that requires adaptations, reviews, and improvisations. However, a significant part of the teachers' work takes place outside the classroom (at school, for example, in the teachers' room, at home or in continuing education courses);
- reflective monitoring of documentation work, in which the teacher's view of his/her own work is widely requested;
- confrontation, from the viewpoint of the teacher with his/her documentation work and the materiality of this work (materiality arising, for example, from the collection of material resources or even from the teacher's practices in his/her classes).(Trouche, Gueudet, & Pepin 2020, p. 8)

The use of the *reflective investigation methodology of the teachers' documentation work*, therefore, requires the teacher's monitoring in a reflective process, besides the knowledge of the student artefacts and protocols used or to be used by him/her. Researchers also developed the resource map - a "schematic representation of a teacher's resource system" (Trouche, Gueudet, & Pepin 2020, p. 8).

Based on a posteriori reflective investigation on the management of artefacts in disciplines already taught by the facilitator teacher, this study presents an analysis of the teacher's didactic configurations within the documental approach to didactics, focusing on the e-textbook used by teachers, artefacts and the schemes of use planned to enrich their practice, developed in/for moments of interaction in distance education in the UAB model.

Given this complex scenario in which DE-UAB finds itself, we perceived in our fundamentals that the teacher's documentation work would allow us to understand the choices of artefacts and the use of resources, more generally, which enriches the contents listed in the e-textbook.

Methodological trajectory

To carry out the research (Pereira, 2017), we investigated the didactic configurations of analytical geometry disciplines carried out in a mathematics teaching degree course offered by two higher education institutions in Pernambuco in DE modality through UAB.

We contacted three mathematics teachers from a mathematics teaching degree course – DE who taught Analytical Geometry courses in two higher education federal institutions in Pernambuco. We

reached them through the classes already taught in the institutions. Once consulted, they agreed to participate in the research, as described below:

Institution 1

- Teacher's educator A, Lectured Analytical Geometry, (2015.1);
- Teacher's educator B, Lectured Analytical Geometry, (2011.2).

Institution 2

- Teacher's educator C, Lectured Analytical Geometry in two consecutive classes (2015.1 and 2015.2).

In the institutions involved, in DE, the virtual classrooms of the disciplines are filed with all records of the actions taken by the course actors (teachers' educator, tutors, and students). To understand the choices of situations, the artefacts mobilised, other resources used, and the schemes of use, we proposed an individual interview with the teachers' educator.

Initially, we requested authorisation from the educational institution to access both the discipline in the virtual classroom and each teacher. In a second moment, we browsed to collect materials in the virtual classroom to understand how the physical (virtual) part of the didactic configurations was constituted: the existing artefacts, the connections, the types of tasks, the interactions recorded, etc. We video-recorded all our browsing in each teacher's virtual classroom using one of the functions of the aTube Catcher software that enables recording the computer screen, videos, and capture external and internal audio.

After studying each teacher's classroom for a first perception, we proposed an individual interview to talk about the artefacts and schemes mobilised and understand the teacher's choices and their methodological and didactic intentions in the configuration of the environment.

Finally, we asked the teacher to draw a map of the resources based on the module we browsed, listing, under his conception, the degree of importance (**figure 2**). This was a moment of much reflection on his work. Then, he presented the discipline he had already offered, showing the artefacts that had been made available, the actions taken on them and the roles given. He was then asked to highlight the artefacts he considered to be most relevant in preparing his room.

Analysis of the Results

The analysis of the data obtained in this process of seeking to understand and characterise the didactic configurations of the distance education teacher revealed important information about the use of the e-textbook. Initially, we presented a model of a general didactic configuration constructed from the analyses of the classrooms of the three teachers and the artefacts and their planned schemes of use, which proved to be relevant in our analyses.

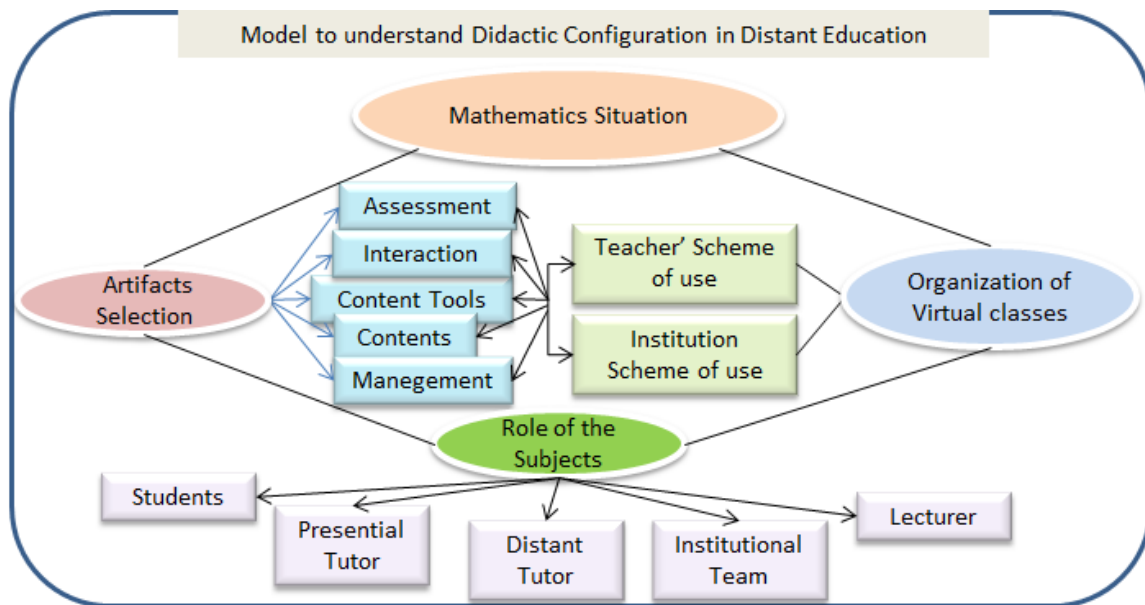


Figure 1: General Model of Didactic Configuration (Pereira, 2017, p. 104).

The e-textbook is considered the main artefact (a type of resource) for teachers, they conceive the didactic configurations based on it. The diagram (**figure 1**) presents the mathematical situation as the main element, it is thought by the teacher who takes as support the e-textbook, and the choices of artefacts, the organisation of the virtual classroom, and the subjects that are authors of the process for the construction and development of knowledge are made from it. This model also seeks to explain the types of artefacts and schematics of the teacher and the utilisation instructions explained by the educational institution.

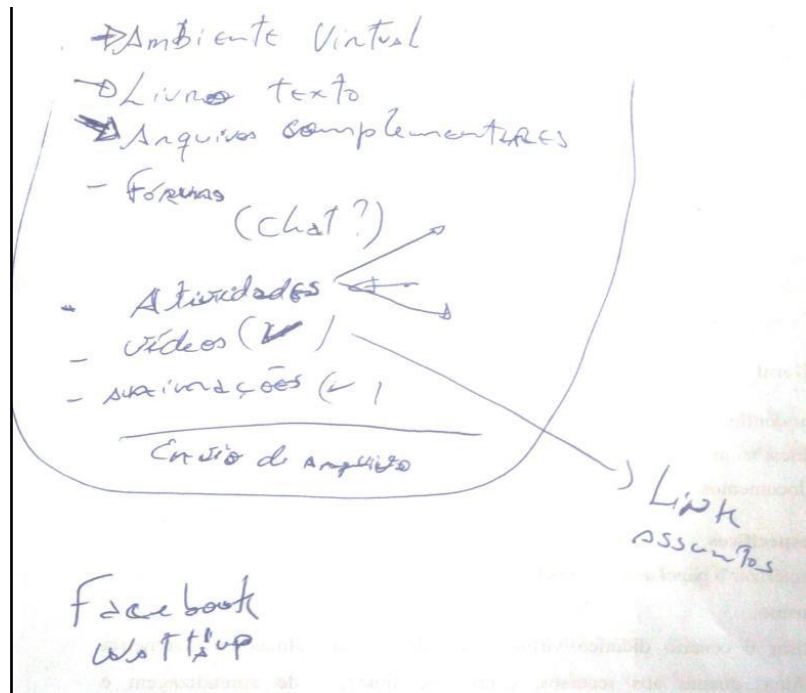


Figure 2: Map of teacher A's artefacts (Pereira, 2017, p. 50).

As we can see, the e-textbook is the most important resource for distance learning. There are other artefacts, called complementary archives such as handouts, textbooks, videos, pdf files, links and activities in the interaction sessions, to mitigate students' doubts.

Considering the e-textbook (**figure 2**) as the most important content resource in this process, we observe that it is at the centre, a starting point for the design of the teacher's didactic configurations. This is where the contents to be studied, definitions, demonstrations, activities, representations, guidelines and suggestions for studies are listed and ordered. An analysis of the e-textbook made available to each of the teachers does not present graphic images of the contents (respective geometric figures of analytical geometry) to be studied, even if geometry.

In our analysis, we observed that these books have flaws, as stated by teacher's educator B: "The book I was adopting had some flaws", which causes the need for proposing complementary files and understanding the didactic intentions of the Textbook Author – who makes the textbook, as Professor A.

We observed that the contents listed in the textbook are presented in modules. The contents are presented through concepts and definitions with algebraic representations. There are few geometric

representations (book made available to teachers' educators A and B), an object that algebraic representation tries to address. Soon after, solved exercises are presented. In the digital textbook made available in teacher educator C's classroom, it has geometric graphic representations to illustrate part of demonstrations and algebraic objects.

The activity book contains the exercises proposed by the textbook author. We observed the module of the book that deals with the content of Lines in \mathbb{R}^2 . They are organised as follows:

1. Teachers' educators A and B – the same textbook.
 - a. List of subjects to be studied in the module;
 - b. Objective;
 - c. A brief introduction of the content;
 - d. The subjects studied: we only observed a geometric graphical representation.
2. Teacher's educator C
 - a. Objectives;
 - b. A brief introduction of the content;
 - c. The subjects to be studied: we observed several geometric graphical representations by subjects articulated to algebraic representations.

Below, we present a scheme of didactic configuration pointed out in our study for the teachers' individual treatment of the e-textbook.

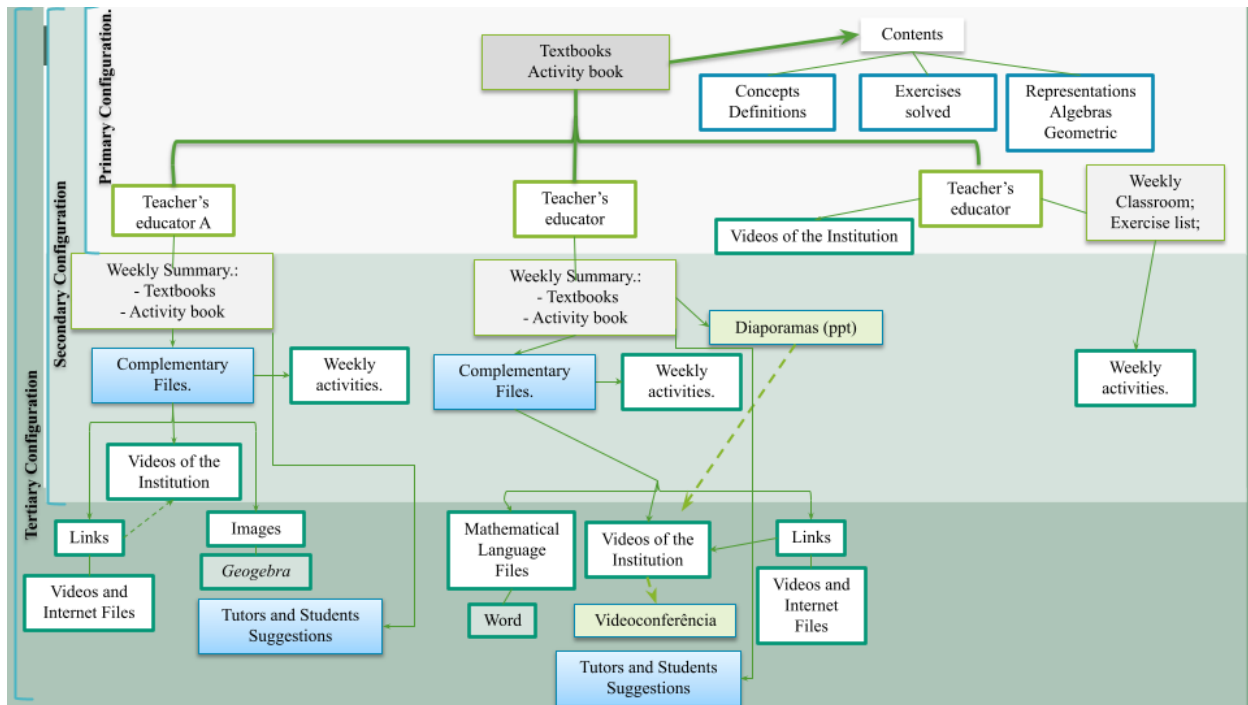


Figure 3: Didactic configuration for the use of textbooks (adapted from Pereira, 2017, p.107).

The textbook and the activity book are made available by the educational institution, separately, to teachers before the beginning of the course, in the virtual classroom. This initial part we call the primary configuration. The other two configurations, the secondary and the tertiary, take place during the teacher's organisation of the virtual classroom and moments of interaction (by him or by the tutor), respectively.

In the primary settings, we observed that the institution offers the e-textbook and the activity book for teachers to use with their students in each module. In the case of teacher's educator C, **figure 3**, the institution transforms the artefact, making it available in parts (in weekly modules) to teacher's educator C. Video-lessons recorded by other teachers are also made available. These are stored in a repository inside a server, on an internal network of the institution.

In the case of teacher's educator A and teacher's educator B, the institution provides the e-textbook and the activity books in single files.

In the secondary configuration, when the teachers organise the virtual classroom, we began to observe the treatment given to the e-textbook and the activity book. We observed that Teacher's educator A and

teacher's educator B transform the artefacts and call them "Weekly Summary" and make them available in parts, in weekly modules.

Other artefacts are also made available: teacher's educator A provides weekly activities in PDF format files with questions about the content of the e-textbook, and videos that the teacher gathers from other virtual classrooms and that are archived on the internal server of the educational institution are also available. Teacher's educator B also provides weekly activities and adds a slide about the class that would be recorded weekly, when there would be no face-to-face meetings.

For teacher's educator C, she was responsible for opening the weekly modules and the weekly activities.

In the tertiary configuration, when the interactions between students, teacher, and tutors occur, we observe that the moment is moved by the students' doubts when studying the weekly content. These interactions are carried out through forums and chats.

Teacher's educator A adds other content artefacts to answer students' questions about the studies carried out with the textbook. To enrich the content, he proposes videos and internet archives about the content. Tutors and students also give suggestions. Like interaction artefacts, the chat does not allow the use of mathematical language, the teacher uses an artefact (GeoGebra), which we classify as a tool, and generates graphical images, which he publishes in the forum for all students to view.

Teacher's educator B also enriches the contents of the textbook through videos and internet archives in interaction artefacts to answer students' questions. She also uses text editing (Word) artefacts to write mathematically and post in the forum. She conducts video conferencing sessions without real-time interactions with students. This is why the teacher provides a slide of the class.

After the videoconferencing sessions, chat sessions were held so that students could solve their doubts. They were also recorded and made available in the virtual classroom. When there were no videoconferencing and face-to-face meetings, classes were recorded and made available in the virtual classroom.

Regarding teacher's educator C, there were no moments of interactions in her virtual classroom. We observed that the didactic configurations evolve during the course with students' doubts, with what the teacher plans and proposes to complement the content. This is a resource used by the teachers in their documentation, and for the improvement of didactic configurations. During the interview, it was clear that the digital textbook has some "flaws" and that teachers propose an artefact of complementary content. There is no planning for the use of artefacts, and neither are the schemes of use explicit.

In the primary and secondary configurations presented in **figure 3**, teachers make it clear, during the interview that it was conducted individually, the schemes of use in their didactic configurations. In the tertiary configuration, teachers' educators A and B develop instrumented actions to enrich the textbook contents in interaction artefacts.

Those transformations of didactic configurations also reveal the lack of specific training for the use of digital technologies that can be integrated into these virtual learning environments. The teachers' effort to add geometric and algebraic concepts and representations through links, web and PDF documents, videos, among other artefacts, makes us reflect on the production of the digital textbook in a collaborative way between textbook author, the educator, and the tutor, as presented by the research subjects.

Concluding Remarks

In this excerpt, we sought to map the enrichment of the content in DE carried out by teachers, from the use of the textbook, in the light of the analysis of the teachers' instrumental orchestrations.

In the results, we noticed that teachers use other artefacts to add other knowledge about the content presented in the digital textbooks made available by the institution during the mediation, such as solved tasks, spreadsheets, and hyperlinks to the video external to the VLE. The instructions for using the artefacts, mobilised and made available by the educational institution and the teachers' schemes of use in the didactic configurations, allowed us to observe three levels of different configurations. We also present evidence of the need to think about a collective construction of the textbook, discussing it in parallel with the main actors of distance education, teachers, tutor educators, and tutors.

The contents are presented through concepts and definitions with algebraic representations. There are few fundamental geometric representations for the understanding of algebraic representations.

Understanding the choice of artefacts and content that enriches what is mobilised in the textbook, its organisation, the activities proposed, and the guidelines for the actors bring us important reflections: How would the collective construction of the textbook of mathematics of distance education be? What and what kind of resources contributed to the students' understanding of the contents of analytical geometry?

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