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Technological Creativity: a study about the construction of Mathematics-Activities-with-Digital-Technologies by teachers in Cybereducation

Criatividade Tecnológica: um estudo sobre a construção de Atividades-Matemáticas-com-Tecnologias-Digitais por professores/as em Cyberformação

Maurício Rosa[1]

Douglas Martins Dantas[2]

Abstract

This article aims to investigate the creative process of mathematics teachers while they construct activities with current and/or unknown Digital Technologies (DT) (new ones for each one), in order to highlight creative possibilities in the mathematical, pedagogical and technological dimensions of "Cybereducation with mathematics teachers". This "form/a(c)tion" suggests working with DT is not mechanical, technical, as if the applied DT were merely auxiliary to teaching and learning, but that participate in the constitution of mathematical knowledge. So, we try hereby to understand how DT can be inserted in mathematics classes, by observing the creativity in this process. Therefore, we conducted a blended course with mathematics teachers, in which we perceive specific acts of technological creativity, that are revealed through updates on the creator potential and/or creative potential of the person, expanding the subjective domain of those involved in this process of "form/a(c)tion".

Keywords: Mathematics Education, Education of Teachers, Digital Technologies, Creativity.

Resumo

Este artigo objetiva investigar o processo criativo de professores e professoras de matemática enquanto esses constroem atividades com Tecnologias Digitais (DT) atuais e/ou que não são conhecidas (novas para cada um), de forma a evidenciar os horizontes da criatividade que podem se desvelar nas dimensões matemática, pedagógica e tecnológica da Cyberformação com professores/as de matemática. Essa forma/ação compreende o trabalho com DT não sendo mecânico, técnico, como se as DT utilizadas fossem somente auxiliares ao ensino e à aprendizagem, mas que participam da constituição do conhecimento matemático. Assim, buscamos compreender, por meio do paradigma qualitativo de pesquisa, como as DT podem ser inseridas nas aulas de matemática, observando a criatividade nesse processo. Realizamos um curso semipresencial com professores/as de matemática e conseguimos perceber atos próprios de criatividade tecnológica, os quais se desvelam mediante

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[1] PhD in Mathematics Education from the State University of São Paulo (UNESP – Rio Claro). Professor at the Federal University of Rio Grande do Sul, Brazil. Email: mauriciomatematica@gmail.com. ORCID: http://orcid.org/0000-0001-9682-4343

[2] MSc in Teaching of Sciences and Mathematics from the Lutheran University of Brazil. Associate Director of Educational Projects at Maestro Educação, Brazil. Email: douglas@maestroassessoria.com.br. ORCID: https://orcid.org/0000-0002-5945-1901

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atualizações no potencial criador e/ou no potencial criativo do indivíduo, ampliando o domínio subjetivo dos/as envolvidos/as nesse processo de forma/ação.

Palavras-chave: Educação Matemática, Formação de Professores, Tecnologias Digitais, Criatividade.

Creating a necessary investigation

Thinking about creative teaching, in other words, when a teacher is creative (Starko, 1995) as finding himself teaching, means also a possibility to overcome the imposed challenges by the insertion of Digital Technologies (DT) in the school environment. DT, in this environment, is a reality and its use in society is something that, according to our perspective, has no return. However, we understand that there are still gaps about how to work with DT in class. The question of how to deal with new technologies presents itself. These technologies are developed every day, with greater complexity of use and different possibilities. Therefore, if we aim to educate citizens to face the problems of society, with values and attitudes, we cannot ignore DT, which are present in our society that is increasingly dynamic and technological. In this way, in the face of constant technological updates, Oliveira and Alencar (2008, p.297) point out that "Contemporary times require creative teachers to form creative students". For these authors,

> [...] the teacher has the responsibility to contribute to the formation of these new contemporary citizens, using creativity to streamline their classes and provide that education become a component of the life and of the progress of the world (Oliveira & Alencar, 2008, p.304).

When we thinking about creative teaching, one must first notice the attitude of the teacher regarding their creativity in the classroom. This is initially and empirically seen as fundamental for the creation of a favourable locus for the promotion of creativity. The teaching performance can favor the maintenance of an environment "[...] that gives the student a chance to have creative experiences" (Oliveira & Alencar, 2008, p.300). In this way, we can think of creative teaching as an act, in which the teachers allow the creativity to emerge as activities that involve the teachers with the students and with the DT. It is important that teachers use their and students' creative potential in classes. They can lead themselves and their students to acquire strategies, that allow them to deal with challenges and unforeseen events, including those related to working with DT. In the meantime, the teacher may be surprised by the students' reactions, once he will possibly be able to involve the students in activities, in which the students find the opportunity to show themselves and their creative potential with DT. Therefore, Barreto and Mitjánz Martinez (2007) confirm the need to work with teachers to implement a pedagogical practice and academic guidance based on the assumptions of creativity and innovation, through a permanent program of continuing education. The data obtained by these authors also reinforce the need for investment in educational processes that encourage the updating of the creativity of teachers in their education, both initial and continued.

Thus, we researched this update by the technological, pedagogical and mathematical dimensions, during an extension course, in a continuing education process with mathematics teachers. We observed the aspects that involve creativity in the interaction of these

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professionals with technological innovations, so that they could create activities using them. We aimed to make it possible for teachers to learn by doing, disregarding use by use and seeking innovative action, especially for those who create and develop it. For this reason, we believe that, due to the constant changes and challenges brought about by the advent of DT, the initial education alone becomes promptly insufficient. It confirms the need for a willingness for continuous learning throughout life (Pedrosa, 2005).

In this research we investigate the creativity of the teachers when planning and developing activities that may, in some way, favor the opportunity of the students to constitute mathematical knowledge with DT. We analyse the process of construction of mathematical activities looking for emerging possibilities of creativity from DT. The idea is to investigate "**how does the work with current and/or unknown Digital Technologies occur in a process of Cybereducation with mathematics teachers in creativity perspective?**".

In the sequence, we theorize the concept of creativity through authors, who deal with this theme, in order to constitute a construct that leads us to plot this theoretical perspective considering the work with DT. In other words, we seek to characterize what we call technological creativity.

Theorizing Technological Creativity

"The mankind has always been creative. In fact, we can even say its creativity is what distinguishes it from other animals and that makes of it human" (De Masi, 2005). Thus, since the invention of fire, the wheel, the word, the symbols, the seed, the iron, the industry, among others things, until the creations of televisions, computers, cell phones, tablets and smartphones, our evolutionary development had been only possible because an inexhaustible flow of intellectual flashes occurred. So, the act to innovate is among the best qualities of human behavior (Kraft, 2005). However, restructuring teaching has been a constant challenge for those who believe that education should consist of human potential updating moments. Aiming for the challenges to be overcome and for this promotion of creativity in the educational system to occur, we believe it is necessary, among other things, to invest in the education of the teachers.

In this way, Oliveira (2010) points out that the teachers' education in 21st century still falls short of current needs. As Delizoicov, Angotti and Pernambuco (2002) emphasize, the contemporary world challenges, particularly those related to the transformations that school education goes through, affect directly teacher education courses traditionally established and disseminated show signs of exhaustion. That is, in many situations of initial education, social transformations are not being directly incorporated, discussed and reflected. Initial education has shown signs of exhaustion for a long time, not only because of the departure from social and school reality, but also because of pre-conceived and reproduced educational attitudes that dialogue with the idea of reproduction (Bourdieu & Passeron, 2014). In this context, in the last decades, there has been concern the search for answers about the difficulties of

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teaching and learning and, thus, many questions have been raised in relation to the performance of the teachers in the classroom.

With the advent of technologies, teachers are still charged for methodological innovations with the use of technological equipment that is being inserted in the school environment. According to the Common National Curricular Base (BNCC), among the general competencies for Education Basic is General Competency 5, which is presented as:,

> Understanding, using and creating digital information and communication technologies in a critical, meaningful, reflective and ethical manner in the various social practices (including school ones) to communicate, access and disseminate information, to produce knowledge, to solve problems and to exercise protagonism and authorship in personal and collective life (Brasil, 2018, p.9).

Notwithstanding, BNCC also provides, among the specific skills/habilities of mathematics teaching for the final years of Elementary School: "Using mathematical processes and tools, including available digital technologies, to model and solve every day, social and from other knowledge areas problems, validating strategies and results" (Brasil, 2018, p. 265).

Thus, more and more, the creativity of the teacher when working with DT is a fundamental element in the educational process, because of the need to update the school and the demand from a society in constant transformation (Mourão & Mitjáns Martinez, 2006). As result, teachers are being charged to form creative citizens, who need to learn how to work with technologies. However, how would it be possible to fulfil these expectations, if teachers were not educated to do so? Is there education in this specific area, that is, creativity? We understand that a possible and indicated way forward is the general and continuous education of the teacher, taking inspiration from the innovations that occur on daily basis and seeking to update themselves to seek both creative alternatives in relation to the teaching and learning processes and to know how to interact with Digital Technologies, giving pedagogical meaning to what is produced.

This reveals the importance of "learning to learn" in the teacher education process. Relating theory and practice with creativity and work with technologies so that the teacher's *praxis* can be constantly updated (Vanini, Rosa, Justo & Pazuch, 2013). We understand that working with DT in education constitutes a set of possibilities and proposals to seek a new direction together with the school's educational community. Furthermore, in the classroom context, new practices, new possibilities and new ways of constituting knowledge can be materialized, contributing to the education of both teachers and students. Thus, we seek creativity in the movement resulting from the intentionality of looking (Bicudo & Rosa, 2010), that is, when we think about Cybereducation with mathematics teachers (Rosa, 2015, 2018), we are conditioned to the intentionality of this teacher when they are being with DT, acting and forming themselves while working with them. It is a "[...] form/a(c)tion that deals with and considers DT as media that participate or should participate effectively in the production of mathematical knowledge" (Rosa, 2015 p. 65). In this perspective, it is

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important that the teacher does not work with Digital Technologies in a mechanical or technical way, that they do not seek a reproduction of what they do in the classroom simply using DT for its mere use, as if the technological resources were to be used only as auxiliary to teaching and learning.

According to Rosa (2015, 2018) and Rosa and Pinheiro (2020), teaching and learning, when performed with DT work, can enable the enhancement and broadening of the understanding of mathematical concepts, in such a way, it allows to conceive being-with, thinking-with and knowing-how-to-do-with-DT. Those acts are considered relevant to the creation process with DT. We affirm this, because we understand that these acts (being-with, thinking-with and knowing-how-to-do-with-DT) can produce something, that will potentially be evaluated as creative. Thus, in the act of creating, the

> [...] "Being-with" [...], being cognitive [...], or "being cybernetic" [...], "Thinking-with", that is, thinking mathematically with the virtual environment [and] [...] the "Knowing-how-to-do-with-TD", based on actions that reveal the existence of the executing cybernetic being's interaction. It is not just any action, but the intentional act of acting, the agency, that is, the action with will and sense of accomplishment. (Rosa, 2008, p.32).

Therefore, we seek the "creative being" act, with the will and sense of accomplishment, and their expression in the movement of knowing-how-to-do-with-DT (Rosa, 2015, 2018), which provides a reflection on doing knowledge and the its constitution. Its constitution can be able to updating the technological, pedagogical and specific (mathematical) domain. Thus, we envision acts that allow the teacher being-with-DT through the identification of the available technological resources with themselves, thinking-with-DT through investigation, for example, and knowing-how-to-do-with-DT through an intentional movement during the creation of mathematical activities with technological resources. "These actions are only carried out due to the human beings' intentionality, which are behind their realization. Intentionality is a decisive factor for the agency [...]" (Rosa, 2008, p.135) and, in our view, it is what causes the creative potential to appear and is what allows those activities created by teachers to possibly be considered creative. This is because the intentionality is linked with agency, which goes beyond participation and activity alone, covering both (Murray, 1997). It is an action with will and sense of accomplishment (Rosa, 2008, 2015, 2018). This movement to go further through an intentional doing with interaction, will, reflection and realization of possibilities, overcoming reproduction and limitations, meets what we consider to be the way in which the creative potential is updated.

The use of technologies in the teaching and learning processes can provide the possibility of a new action and a new posture in the educational environment. This searching for a new thing is directly linked to creative potential. We consider that all people have creative potential, because according to Neves-Pereira (2007, p.15), "[...] we are all creative, at least in potential". In the same way, Winnicott (1975, apud Sakamoto, 2008), Vygotsky (1987) and Ostrower (1987), consider that this creative potential is innate and inherent to mankind, that is, for us, everyone is born with this potential.

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We understand creative potential as a "Potency, characteristic of what is potent, of what has the strength to be, that brings with it the potential to become" (Bicudo & Rosa, 2010, p.24). In addition, these authors point out that potency has several meanings and specify two, covered in the philosophy dictionary (Mora, 1994) in which it considers potency:

> [...] a) the power that a thing has to produce change; b) the potentiality that dwells in something to pass from one state to another. This last meaning is more important for the philosopher, because it allows us to understand *physis*, that is, what springs up and has the strength to keep being. Thus, the reality of what exists physically can be explained in ontological and metaphysical terms, without needing any resource to separate the "being" and the existing in the world. (Bicudo & Rosa, 2010, p.24)

When we reflect about creative potential as the possibility of producing changes and that every human being has this potential, we will not dissociate creativity from being, that is, everyone has the potential to be creative, however, keeping each one creative in their own way. The creativity can only be evaluated or observed, if this potency is updated. This means that for there to be creativity, there is a need for act. Like this,

> Act, which updates the potency, encompassing the movement to advance what happens. It includes a certain operation. The act is understood by the change. This movement is important in Aristotelian philosophy, because it means carrying out what exists potentially, while potentially existing. With this movement, the being passes from the power of being to the act of being. It is an update process. Thus, the change of an object is the transition from a state of potency or potentiality to a state of act or actuality (Bicudo & Rosa, 2010, p. 24).

We can think about creativity as a human resource, as a potency that we all have and that can be updated in different degrees and dimensions, according to the experience lived in the mundane reality of each one. In this way, we understand creativity as the way for everyone to be creative, based on the movement to update creative potential. In other words, creativity will only exist, if there is a movement of the creative potential aiming for the potency, which is no longer just a possibility and becomes an act of being.

> In logical terms, what appears in the mundane reality is the updated, so that, following an inductive path, the act is a reality of being prior to potency. Following the path of inductive logic, the potency can only be recognised for the current, for what is or for whathas already been updated (Bicudo & Rosa, 2010, p. 24).

The simple fact that we have the creative potential does not mean that we have creativity in all our actions. The existence of creativity occurs with the updating of creative potential. If that does not happen, we can think of a virtual creativity "[...] in such a matter that, what virtually may become is already real in potential; in the sense that there is a possibility of what is in potential, becoming, existing" (Bicudo & Rosa, 2010, p. 25). In other words, the fact that we all have creative potential means that we already have a virtual creativity, which may or may not be updated, that is, becoming, happening. This creativity will only occur, if the materialization that may emerge from the updating of this potency to become effective.

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> For a virtual thing to update itself, and Deleuze speaks of potential almost as a synonym, it is always to create new divergent lines, which correspond without similarity, to the virtual multiplicity. In this respect, updating is always a creation, something new, that is happening, coming into existence. However, it is not a romantic vision of creation, because, at the limit, it is always a double of something, it is the origin of its maggot, which becomes carnal and material through updating (Bicudo & Rosa, 2010, p. 30).

Thinking about creating activities, we are envisioning the possibility of updating the teachers' creative potential, so that we can observe the process and the product that emerges from the materialization of the virtual creativity of those involved. Thus, more than anything new, we believe that in view of technological evolution (which occurs more and more rapidly and generates countless possibilities with digital resources), creativity is materialized through activities that may be current. However, we can notice, in the theories of creativity, the importance given to the knowledge of the "creative being" aiming for updating their creativity. This is important, because creativity does not emerge from anything. In order to justify it, there is the concept of "dominance" found in the Theory of Investment in creativity (Sternberg & Lubart, 1995), in the Component Model of creativity (Amabile, 1996) and in the theory proposed by Csikszentmihalyi (1999), called Systems Perspective. Other authors, such as Feldhusen & Goh (1995) and Lubart (2007) also consider that creativity cannot occur without a domain of the area of knowledge.

The domain refers to what is recognized in the area of knowledge, subjectively. In addition, in our view, it does not mean that in order to be creative, the individual has to "dominate", in the sense of totality, the area, but it is important that they recognize information, their knowledge, in and from the area in which they work/study. Also, it is important that they are willing to expand the boundaries of that domain, relating the information and knowledge already revealed in the culture of the area, to which the domain is related.

Thus, when we talk about creativity in the processes of teaching and learning of mathematics with technological resources, we are aiming at the concept of Cybereducation **with** mathematics teachers (Rosa, 2015, 2018), no longer that education **of** teachers or **for** teachers (Nacarato, 2005), but a form/a(c)tion **"with"** teachers, which can contribute to the expansion of the domain regarding the mathematical, pedagogical and technological dimensions of the individuals in education. In this way, what would be the necessary domain for mathematics teachers to create activities with the potential to be judged as creative? What is the mathematical domain necessary to be creative in the teaching and learning processes with Digital Technologies? What are the necessary elements, in pedagogical domain, to think about potential practices to be considered creative? What is the necessary technological domain to be creative in the teaching and learning processes with Digital Technologies?

All questions regarding the domain are within the scope of the need, which points to the subjective side of the possible answers. Therefore, there is no single definition of the necessary and specific domains for each area thinking about creativity, there is no recipe for being creative. In this way, we understand the domain as a non-current and subjective

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relationship of information and known existed and recognized by each individual. This information, as well as known, concerns the areas involved in the act and can generate ideas that update the creative potential of each teacher/student. Our understanding returns to what we believe it can raise, that is, new ideas will emerge. We consider that, when one constructs a product (in the case of the education proposed by us, constructing a mathematical activity that will be worked by students of the investigated teachers), mathematical ideas should be sought and constructed. Supporting this theoretical point of view, we work based on a constructionist perspective.

Constructionism is a learning theory developed by the mathematician Seymour Papert, which is based on the constructivist theory that was developed by Jean Piaget, but which goes further, because Papert not only read Vygostky and revealed clearly this influence, when he embraces and discuss the social dimension of Constructionism. In this way, according to Piaget, people construct knowledge, as they interact with the object of knowledge and suffer an action from it. Papert, on the other hand, assumes that knowledge is constituted by people and proposes, through Constructionism, that the act of educating is through the creation of situations and engaging activities that enable students to construct a product (Papert, 1994).

Facing today´s technological possibilities for creation of diverse personalized resources, the theory proposed by Papert (1994) has the potential to contribute to teachers when thinking about DT activities. Constructionism aims to constitute knowledge based on the development of a product like these activities from teachers or games from students, for instance. “Constructionism postulates that learning takes place especially, when the apprentice is engaged in constructing a product of personal meaning (for example, a poem, a model or a website), which can be presented to other people” (Maltempi, 2004, p. 3). Through the involvement of students with the digital resources available in our society, we envision that by enabling the creation of infographics, videos, texts, tables, presentations, images, among other resources with DT, the teacher can generate the opportunity to update the student’s creative potential and favor the constitution of knowledge. In this way, by studying these resources and creating their own products, students will also be able to advance in terms of education through the dimensions postulated by Cybereducation.

Thus, we believe that teachers can think on activities with TD that generate the opportunity for students to constitute the maximum learning with the minimum teaching (Papert, 1994), that is, activities that provide opportunities for the student to create something aiming for learning with DT. In this way, Maltempi (2004, p. 265) states that “[...] learning must be an active process, in which students ‘get hands-on’ in the development of projects, instead to be attentive to the teacher’s speech”. However, it is necessary to involve the student, because only ‘hands-on’ can promote repetitive activities and actions, “[...] which are characterized as head-out, when the student is not involved with them, because the objectives and resolutions are given by a third person” (Rosa, 2004, p. 45). Thus, when we think on this theory as a way to go further in the construction of activities, we want to promote teaching

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for creativity, in which the creative potential includes both teacher and student, and those involved in these teaching and learning processes project a probable attractive environment to everyone.

Perhaps, when each one constructs a mathematical activity and it has constructionist characteristics, the amplitude of the mathematical domain with DT, for example, is able to point out what each individual considers creative. Furthermore, when each one thinks about technological creativity, we are respecting the domain of each one. However, even with this respect, the judgment of the presentification of technological creativity will also be made in a subjective way, considering the domain of the one who judges, in mathematical, pedagogical and technological terms. Thus, when we think about the use of DT in the school environment, we envision a type of creativity (technological creativity) that can emerge from activities produced with DT, considering updated and exploring the technological resources available for the teaching and learning processes. This perspective of environment enables several paths that lead beyond what is already known. For us, the technological creativity is understood as an act, a change that updates the creative potential, encompassing a movement to advance what is thought. Creativity emerges from an updating process in which, with this movement, the potential creative manifests itself from what is updated differently from what is recognized subjectively. However, for technological creativity to emerge, there is a need to materialize these possibilities, therefore, it is important that teachers seek to go beyond-knowing-how-to-do-with-DT aiming for these possible acts with Digital Technologies can occur and, when it done, an act of creation can be analysed as technological creativity.

In this way, we consider that going-beyond-being-with and thinking-with-DT is to create activities that enable the student to be-with-DT and think-with-DT (Rosa, 2008). Also, provoking them to know-how-to-do-with-DT aiming for the teacher, at the time of the activity in conjunction with students (Rosa, 2008), also seeks to expand their domain during this act, being able, moving to go further in the next activities. We believe that going-beyond-knowing-how- to-do-with-DT, through agency, that is, action with will and sense of accomplishment, can be built by the relationship between the domains from teachers and students. Perhaps, the agency expands the possibilities of overcoming the challenges, not only from the "creative being", but also from the use of Digital Technologies. We believe in interaction and creation using different DT and giving meaning to digital resources as participants in the process of constituting mathematical knowledge.

Nevertheless, we define technological creativity in the mathematical educational context as: **the act of updating products and/or processes with DT, which have not yet been updated, using for this the intentionality of going-beyond what is subjectively recognized in the mathematical, pedagogical and technological dimensions, in order not to reproduce wholly or partially what is updated.**

Methodological procedurality in favor of technological creativity

Investigating, in a qualitative perspective (Bicudo, 2011), the creativity from the work

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with Digital Technologies in the mathematical classes, we agree with Winicott (1975) and Alencar & Mitjanz Martinez (1998, 2007) who believe in the creative potential innate[3] to all human, because everybody has the ability to create, produce, transform, enhance and act with the environment and experience it, in front of their needs since their birth. In this way, we corroborate the idea of Sakamoto (2008) when she mentions that children, adolescents, adults and the elderly are potentially creative, because each stage of human development has its particularities, which can point out specific creative aspects.

The technological innovations increasingly present in schools and in the development of children in the 21st century bring a need for everyone's creativity. This fact provokes teachers into the application of these resources in their classes. Thus, it is important for the teacher to experience moments of interaction with the technological resources, aiming for being-with, thinking-with and knowing-how-to-do-with-DT (Rosa, 2015, 2018). In addition, we consider this experience as a relevant factor that can contribute to the development of creative potential of the human being, who aims to use DT in their teaching activities.

In this way, our action aimed the production and analysis of data. We seek the expressions, ideas, reflections and actions of/from the research participants aiming observation of their creative potential. During moments and activities that included technological, mathematical and pedagogical aspects, we intended to perceive the fomr/a(c)tion provided during the realization of a continuous education course based on Cybereducation with mathematics teachers.

The extension course "Cybereducation with mathematics teachers: technological creativity in the planning of activities" was announced through a folder and certified by the Extension Department of the Lutheran University of Brazil. It was proposed as an instrument of data production for this research. The course aimed to generate the opportunity for mathematics teachers from Basic Education to experience interaction with DT inserted in their school environment and directing their use of DT to the teaching and learning processes of mathematics. In this way, we developed a continuous education, in this specific case, in service and blended. It had as theoretical support the conception of Cybereducation. This approach, according to Rosa (2008, 2015, 2018), aims to work with DT as a media of constituting mathematical knowledge, disregarding the mere use for use of DT. In the same way, this approach does not defend simply the use of technologies as support and/or aid. Instead, we implemented a proposal for teacher education - involving technological, pedagogical and mathematical aspects - which would take up work with DT, in the teaching and learning processes of mathematics from the perspective of being-with, thinking-with and knowing-how-to-do-with-DT (Rosa, 2015, 2018). The DT are effective participants of these processes and not auxiliars.

[3] When it is said that someone has innate conditions, it is like saying that this person was born with conditions to perform something, or that they have innate capacity, they were born with potential, that is, we can associate innate with being born with.

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Through this proposal of continuing education, we elaborate situations in which it was possible to discuss the constitution of mathematical knowledge using DT, whose mathematical approaches were emerging from the situations experienced at each meeting. Thus, we thought of a structured course by a total workload of 40 hours. These 40 hours were divided into seven face-to-face meetings, totalizing 28 hours, and 12 hours through distance activities, divided into four topics, using the Moodle Virtual Learning Environment. We prepared the schedule by inserting thematic topics chronologically between the dates of the face-to-face meetings.

This intercalation is justified by suggesting the reading, reflection and discussion of previous materials, which were made available in the virtual environment on the theme that would be addressed in the face-to-face meeting. Thus, we structured the virtual environment with materials and forums that would allow participants to interact in relation to the theme adopted in each meeting. The meetings were developed with themes, that are involved in the scope of Cybereducation with mathematics teachers: work with Digital Technologies, the theoretical construct of the concept of Cybereducation, Cybermathematics, Constructionism and Instructional Design.

Thus, before the thematic approach specified for each face-to-face meeting, the participants had access in the virtual environment to the material. The material was texts, videos and hyperlinks about the topic. In addition, a forum was created in this environment in order to offer the possibility to discuss and reflect about the theme of each meeting by the course participants.

In the meantime, achieving the proposed objectives, the semi-presential course was carried out with two groups of a total of thirty teachers. At first, the course was conducted with eleven mathematics teachers from the Presidente Castelo Branco State School, located in the municipality of Lajeado, in the state of Rio Grande do Sul. Of these eleven, only eight authorized and committed to participate in this research. The others, despite having participated in some meetings, did not commit to attend due to the responsibility they had with other schools, because they would not be able to follow all activities. 19 teachers participated in a second version of the course, which took place with teachers from different schools in the municipality of Estrela, located in Rio Grande do Sul. They are teachers with degrees in mathematics or pedagogy and work in elementary school.

The criterion for choosing these teachers was the fact that the schools, in which they teach do not use DT or underuse their resources, either because they do not have the necessary equipment, or because of a lack of knowledge or interest. Some schools, in fact, had already received DT before the data production period (August to November 2015) from government agencies through state and federal government programs and projects, such as: the *RS Mais Digital* program and the *Province São Pedro* program, from the State Education Secretariat (Seduc); and the National Educational Technology Program (ProInfo), from the

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Ministry of Education (MEC). Among the technologies found in the schools, we can highlight, in addition to computers, tablets and digital whiteboards, smartphones that most teachers already had. The importance of having digital technologies present in the school environment is due to research with current technologies, that we aim to propose to mathematics teachers in their work environment. In addition, another factor that interfered in the choice was the ease of access to teachers and the interest of the management team, both from the Education Secretariat of Estrela and Lajeado, making the schools space available and organizing a structure of the formative process. Thus, we enable the participants of the research to have experiences in their work environment, considering the potentials and challenges, arising from the DT and present in their daily lives.

The DT used in the course were owned by the schools, the exception was the teachers' smartphones and the equipment used to record data for this research. The resources used at the Presidente Castelo Branco State School, for example, were an uBoard Portable Interactive Whiteboard (Auction FNDE 42/2010), teachers' tablets (distributed by the Ministry of Education/FNDE, through auction 81/2011) and diversified models and brands of smartphones with Android systems, because these were private acquisitions of the teachers.

Creativity in the Construction of Mathematical-Activities-with-DT

Our movement to take a look at the work with DT from the perspective of creativity, in a process of Cybereducation with mathematics teachers, who teach mathematics in Basic Education, aims to analyse the process of creating mathematical activities. It seeks to understand the acts that can update the creative potential of those involved and, consequently, enable the teachers "to go beyond the limitations of each one", involving the mathematical, pedagogical and technological dimensions of Cybereducation. This latter dimension under the perspective of being-with, thinking-with and knowing-how-to-do-with-DT (Rosa, 2015, 2018). Thus, our data are characterized as descriptive, in order to reveal the expressions and movements of work-with-DT when the teachers construct mathematical activities during their participation in the extension course called "Cybereducation with mathematics teachers: technological creativity in the planning of activities."

When we noticed that some teachers updated their pedagogical, technological and mathematical domains and tried to use this information to reflect and produce their activities with different perspectives from the reproductions initially thought, surprising us with their products. With that, we consider analysing what we call "Technological Creativity: mathematical, pedagogical and technological aspects", as the emerging category of this study. In this way, we present the first activity of one of the participating teachers:

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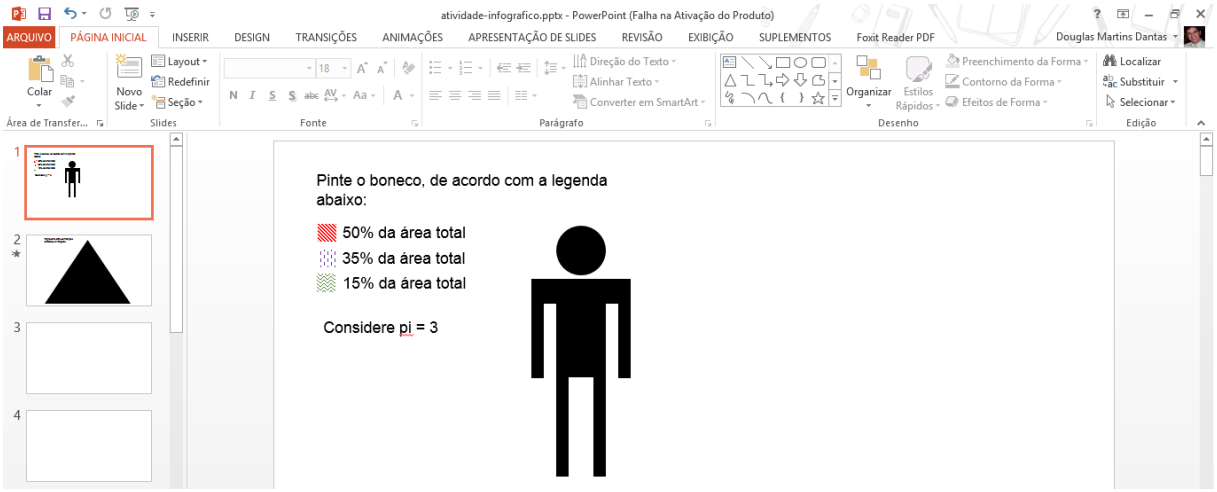

Figure 1 - Activity sent by teacher Jaqueline: area calculation for understanding the infographic[4]

Source: research

The activity developed by teacher Jaqueline[5], carried out in a school of the municipality of Estrela, uses the Power Point[6] software and articulates the three prominent dimensions of the Cybereducation conception (the mathematical, the pedagogical and the technological dimensions (Rosa, 2015, 2018)). Regarding the mathematical dimension, we understand that solving this activity implies mathematical concepts as fraction, percentage, area calculation and graphic representation of information (Figure 2). These concepts are usually discussed separately and as an example, we can mention textbooks, which typically address those concepts in separate chapters. In addition, many teachers and school curricula adopt linear teaching of content, what may often not promote the interrelationship among these mathematical concepts. When the teacher represents these different concepts together in the constructed activity, she does not use the reproduction of what is found in several textbooks. Furthermore, another interesting aspect is that the student will have to calculate the areas of the figures present in the humanoid[7] for resolving the activity. In our opinion, this will prepare the student to understand the idea of some infographics, which work with the measurement of areas to display information treated in different forms and formats. Thus, we identified the teacher's agency (Murray, 1997), because when she creates her activity, mathematically, there is an action with will and sense of accomplishment at the moment when she generates a humanoid with intertwining of the concepts, often presented in a watertight way. She goes further, through intentional doing, with interaction, will, reflection (in relation to imagine how the activity will be resolved) and realization of possibilities,

[4] The translation of activity is: paint the doll, according to the legend below. 50% of the total area, 35% of the total area, 15% of the total area. Considering Pi (π)=3.

[5] All data presented in this study, such as the use of the participants' names, were authorized through a free and informed consent form.

[6] "Microsoft PowerPoint is a program used to create/edit and display graphic presentations, originally written for the Windows operating system and ported to the Mac OS X platform" (Wikipedia, 2018).

[7] "What resembles human forms". (Priberam, 2013)

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overcoming reproduction and limitations. Jaqueline meets what we consider to be the way, in which creative potential is updated.

Jaqueline, in our view, updates her creative potential, because she creates new lines diverging from what is common, from the classic. She mixes contents in order to work them in unison, corresponding them without similarity, generating a virtual multiplicity, that is, multiple resolutions in different orders. In this aspect, the updating is always a creation and Jaqueline updated her knowledge in a mathematical-activity-with-DT. She created something new (at least for her) and that is happening, coming into existence (Bicudo & Rosa, 2010). Nevertheless, it is not a romantic vision of creation, because, at the limit, it is always a double of something, it is an activity, in our view, interesting, but which may have been generated in similar ways by several other teachers. However, Jaqueline's creative movement stands out in our eyes and arouses our interest in working with this teacher's Cybereducation, as we understand her creator and creative potential.

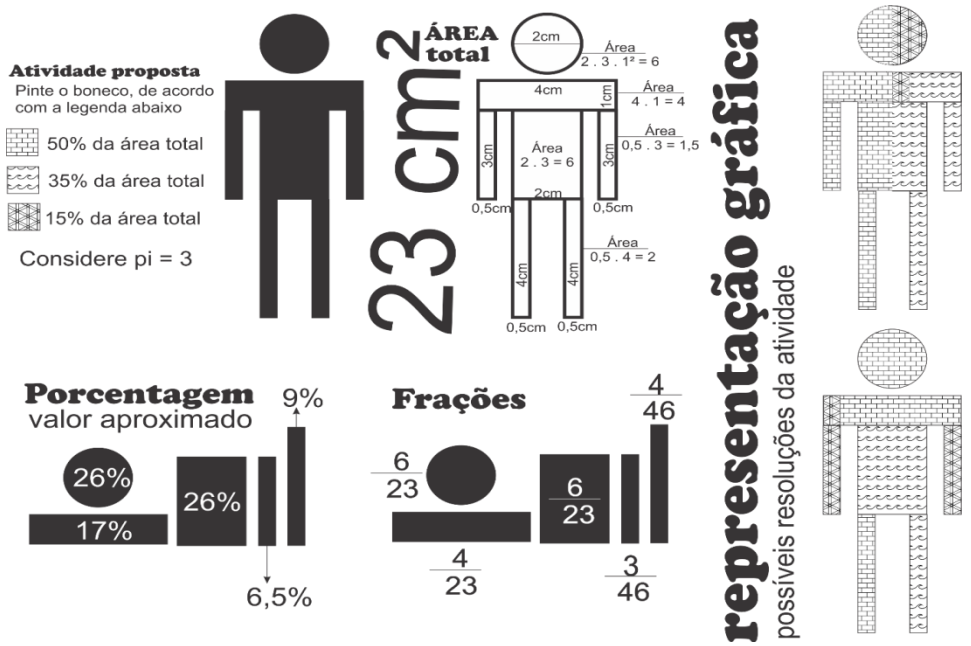

Figure 2 - Resolution of the activity proposed by the teacher, in an infographic format, presenting some mathematical concepts that may arise.

Source: research.

Furthermore, the aspects presented are intertwined with technological knowledge in the means that the teacher does not indicate any value for geometric shapes (Figure 3). Thus, the student, who is going to solve the activity constructed by Jaqueline, will have to use the measurements presented by software. This act, expressed in the movement of know-how-to-do-with-DT (Rosa, 2015), can be seen in the need of identifying the measures provided by the software. Also, this act is related to the creating act of the activity, allowing, in a consonant way, a reflection on doing and constituting knowledge able to update the technological and mathematical domain. Thus, we envision an act, which allows the students, through the activity, being-with-DT when they thinking-with-DT. These actions are only

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carried out due to the intentionality of human beings that is revealed when they act, due to the "Movement of perceiving itself in the world, with the world, launching itself to perception. This, in our view, enables the production of knowledge and this can be expressed in the construction of other things, that is, objects, artifacts, actions, situations, worlds, concepts" (Rosa, 2018).

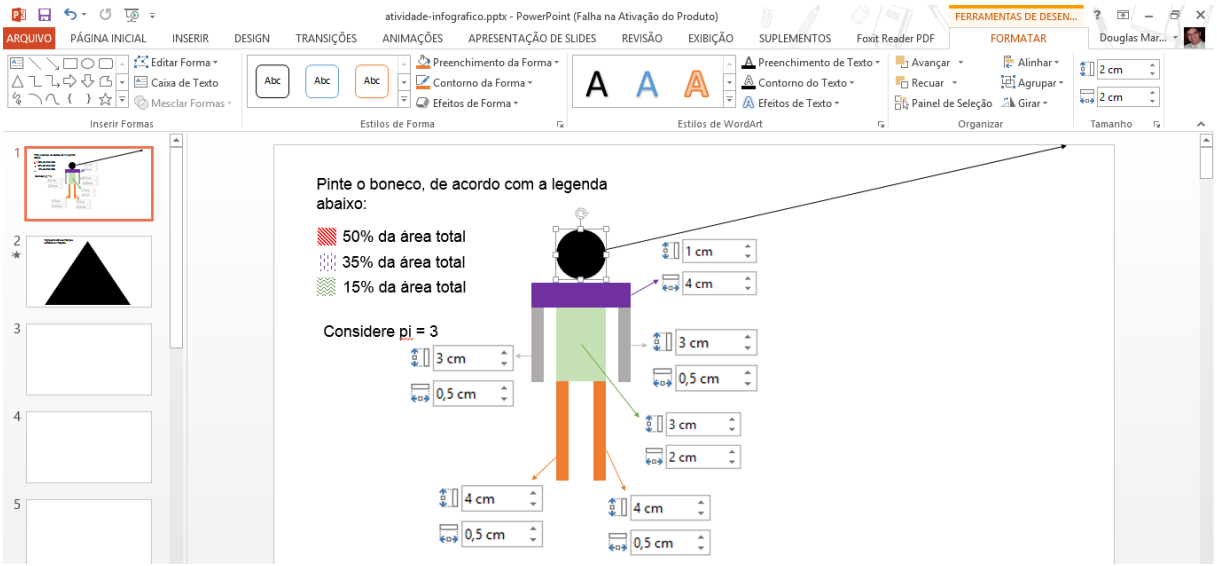

Figure 3 - Display of the problem data found using the Power Point shape measurement feature.

Source: research

We can also notice that this activity allows a variety of solutions, depending on the path that the student decides to carry out. In other words, there is a "pedagogical going beyond" that abstracts the idea of a single solution (Figure 3), which goes beyond closed questions of thought and that allows for something more in terms of cognitive processuality. Therefore, as it contains these characteristics in the activity, we can evidence the teacher's intentionality to create an activity, in which the student has to be-with, think-with and know-how-to-do-with-DT.

When Jaqueline requests this type of activity, she demonstrates to have expanded her pedagogical and technological domain. It can be perceived when Jaqueline recognizes the concept of infographic and how some infographics are elaborated and interpreted by her, for they are based on the areas of geometric figures. In this same perspective, we consider that the teacher is in a movement of going beyond from what she has already known and experienced.

Another highlighted activity that shows technological creativity in terms of Cybereducation is related to basic geometry concepts. However, the activity of teachers Maria Isabel and Íris provokes reflections that going beyond what is commonly seen, although, in a glance, we can believe, that the activity is simple and not creative. So, through their activity, the teachers embark on the idea of doing with students and propose the activity of building newspaper advertisements with geometric shapes and specific dimensions (Figure

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4).

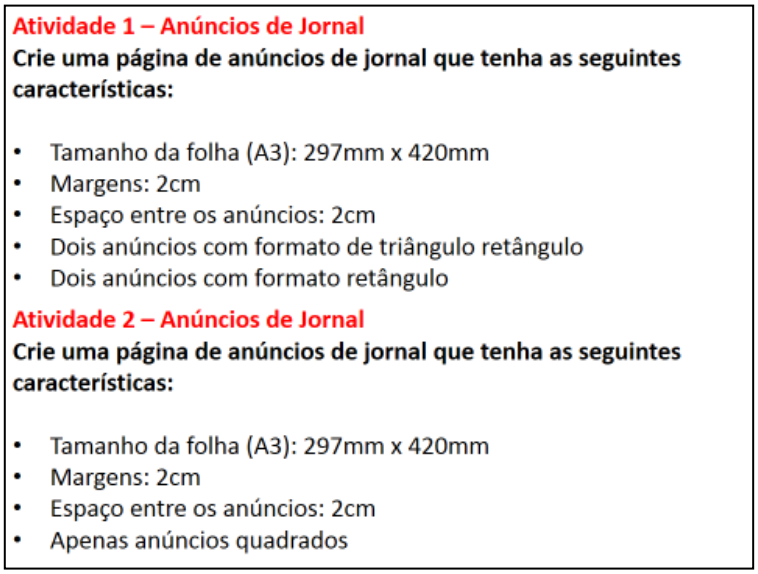

Figure 4 - Geometric thinking activities[8].
Source: research

The activity of creating advertisements can be evaluated as technological creativity, because it can update the creator and creative potential of the teacher and of their students, concurrently, in the development of this activity. Because the teachers knowing-how-to-do-with DT, they expand their domain, using their interaction with others (fellow teachers and students) in the process of creating the product. This, for us, also shows a process of Cybereducation with students, as Rosa (2015, 2018) points out that knowing-how-to-do-with-DT is manifested by intentional actions carried out with the world, with myself and with others. Thus, the development of the activity promotes the constitution of mathematical knowledge through a pedagogical proposal that can be carried out together (Rosa, 2008), interacting in the same context with the digital blackboard, the teacher and the students.

In addition, when aiming at the construction of a product, the proper activity highlights an aspect of Constructionism (Papert, 1994), once it suggests the construction of a product: an advertisement page, like in a newspaper. This product can be made through several identities (being-with) that can be chosen, when launching into an act with the intentionality of creating, that is, acting to construct the product (advertisements). However, what does specificity this product have? If so, which advertisement should be developed? Advertisement for what? Identified with whom? With me? With the group? With mathematic? With the school? The potential creator and creative can be updated in different ways. Thus, pedagogically, there is a "going beyond", which is not confined to closed questions again, but refers to a radical opening in terms of product development. Thus, we can being-with-TD, in this creation, plugging into Power Point or a text editor, such as

[8] Translation of activity: Activitiy 1 – Newspaper Ads - Create a newspaper ad page that has the following characteristics: Sheet size (A3): 297mmX 430mm; Margins:2cm; Space among ads: 2cm; Two ads with right triangle shape; Two ads with rectangle shape. Activitiy 2 – Newspaper Ads - Create a newspaper ad page that has the following characteristics: Sheet size (A3): 297mmX 430mm; Margins:2cm; Space among ads: 2cm; Square ads only.

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Microsoft Word, or image editing software, among other resources that allow the creation of shapes and measurement visualization. When plugging in the way of construction in the Power Point, we carry out the activities proposed by the teacher (Figure 5).

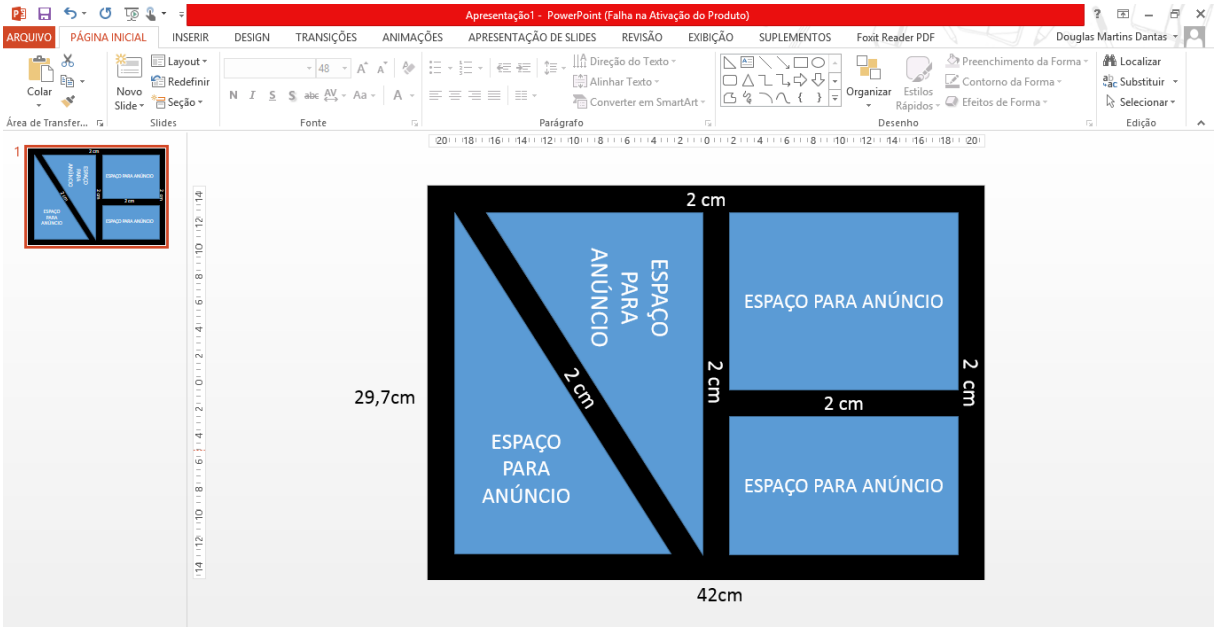

Figure 5 - Resolution of Activity 1 of newspaper ads – an ad with two triangles and two rectangles.

Source: research

When carrying out activity 1, of newspaper advertisements (Figure 5), we can notice that the product from the creative act updates the creator potential and enables the expansion of mathematical domains with regard to the notion of space and geometric shapes. However, when carrying out activity 2, we must notice the teacher's intentionality in provoking students to think about the area of flat figures, because due to the dimensions of the A3 sheet (29.7cm x 42cm) and the demands of 2 cm margins, you cannot complete the sheet with square advertisements only. This is because, the sheet area (1,247.4 cm^2), if filled only with squares and regardless of the quantity and size of the squares designed for the advertisements, will have always a rectangular surplus, once it is not a perfect square. In this point of view, this product, originating from the creative act, enables a fruitful mathematical reflection, so as not to be considered a reproduction, in order to promote a further reflection on areas, ceasing to be just acts already updated, for example, calculation areas using formulas. Therefore, mathematically, an activity that initially did not seem to go any further, causes an update of unusual knowledge when thinking about the area of flat geometric figures. According to Bicudo & Rosa, (2010), in logical terms, what appears in the mundane reality is the updated, that is, what was shown seemed to be mathematically known, so that, following an inductive path, the act of solving the activity showed the reality of being, prior to the potency of the activity. Following the path of inductive logic, the potency could only be known from the actual/current, what is or what has already been updated. That is, only after the resolution of

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the activity built by Maria Isabel and Íris. With this, we believe to have elucidated how the work with current and/or unknown Digital Technologies is shown in a process of Cybereducation with mathematics teachers in the perspective of creativity, in the way of going beyond the known and the updating of the creator and creative potential.

Final considerations on potency

We concluded, through this investigation, that the work with current and/or unknown Digital Technologies in a process of Cybereducation with mathematics teachers, on the perspective of creativity, showed itself in a movement to update the creator potential and the creative potential of the investigated teachers, expanding the subjective domain of those involved in this form/a(c)tion process. Thus, taking for example the activities brought up in this article and constructed by the teachers participating in the research, we could evidence that teachers update their creative potential.

The Jaqueline's virtual creativity, in the midst of the Cybereducation process, is manifested. She creates an activity in a new line of reasoning, diverging from what is common, from the classic. She thinks and develops an activity that mixes mathematical contents, in order to work them in unison, generating a virtual multiplicity of answers, that is, multiple resolutions in different orders. Jaqueline creates and updates her knowledge in an activity-mathematics-with-DT, a new product, at least for her, and which materialized itself, came into existence (Bicudo & Rosa, 2010) in the context of what Mathematics Education requires, that is, thinking mathematically. The updated creative movement in Jaqueline's mathematical-activity-with-DT shows us that Cybereducation as a process can contribute so that the creator and creative potential of teachers is updated, comes to the fore. Also, the activity of teachers Maria Isabel and Íris shows the updating of their creator and creative potential. The creation of an activity that seems to be simple and not very innovative provokes reflections that go beyond what is commonly seen. Purposely inserting elements of mathematical reflection updates their creative potential, because, in addition to not being something easy to do, it invests in the reflection of why, that is, for the student, the questions "why is it not so simple to do the assignment?" and "what am I doing wrong?" bring an interlocution with the teacher and they can embark on the idea of doing it with students and can propose the activity of building newspaper ad regardless of the quantity and size of the squares designed for the advertisements with geometric shapes and specific dimensions.

We aim for teachers starting to look for their form/a(c)tion, planning, generating the opportunity for the student to do, participating with them in the constitution of knowledge and learning from the student during the development of the activity. We need to bring students to think about problems and solutions. We do not seek activities that make students reproduce or are limited to mechanical procedures. Thus, we believe that teachers, when launching an act with the intentionality of updating the creator and creative potential, do not have the need to know-how-with-DT to propose activities with technological resources.

It is important that teachers give to their students the opportunity to think and, for that,

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they should not give the student everything ready, so that, they just reproduce or can do what their teachers are limiting. Acting in this way, we believe that teachers going beyond their limitations, giving to their students the opportunity to discover, seek information, surprise in their actions, learning from them and being able to go beyond what teachers, books, memorization and imitation activities could offer. Thus, in our view, students will also be able to learn from the interaction and teachers can benefit from students' actions by being with the intentionality of looking at the updating of the creator and creative potential of the students and update themselves together. In this way, the work with current and/or unknown Digital Technologies in a process of Cybereducation with mathematics teachers, on the perspective of creativity, proves to go beyond the known, go beyond closed problems, go beyond infinitely limited possibilities when thinking mathematically, go further in the search for updating the creative potential of the teacher and the apprentice, go further in updating the creative potential, in terms of discovering and creating products, whose characteristics respect the subjective identification of the individual and go further when working with DT, not mechanically, but, as a way of being-with, thinking-with and knowing-how-to-do-with-DT in favor of a fruitful and creative Mathematics Education.

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