
Teacher Education and Creativity: An Experience with Mathematics Undergraduates

Formação de professores e criatividade: uma experiência com licenciandos de Matemática

Jéssica Adriane de Mello¹

Marcus Vinicius de Azevedo Basso²

Abstract

This article addresses the creative process investigation of a group of undergraduates in Mathematics in teaching strategies elaboration. Seeking to understand how creativity can favor the construction of teaching knowledge, plans and portfolios of four undergraduates who developed teaching practice with sixth and seventh-year high school students were analyzed. Teaching practice took place in the context of the COVID-19 pandemic. The methodology was based on qualitative research and classified as a case study. The theoretical framework is anchored in studies from a constructivist perspective. The practice experienced by the group points to a creative process related to Piaget's reflecting abstraction process. The "creation cyclone" proposed by Borges and Fagundes contributed to the records analysis, making it possible to conclude that the evidenced creation process is continuous and can be expanded and improved.

Keywords: Reflecting Abstraction; Creative Process; Math Teaching; COVID-19.

Resumo

Este artigo aborda a investigação de processo criativo de um grupo de licenciandos em Matemática na elaboração de estratégias para o ensino. Buscando compreender como a criatividade pode favorecer a construção de saberes docentes, foram analisados planos e portfólios de quatro licenciandos que desenvolveram prática de ensino com estudantes de sextos e sétimos anos de um Colégio de Aplicação. A prática docente ocorreu no contexto da pandemia COVID-19. A metodologia utilizada foi baseada em pesquisa qualitativa e classificada como estudo de caso. O referencial teórico ancora-se em estudos na perspectiva construtivista. A prática vivenciada pelo grupo aponta para um processo criativo que está relacionado com o processo de abstração reflexionante de Piaget. O "ciclone da criação" proposto por Borges e Fagundes contribuiu para a análise de registros possibilitando concluir que o processo de criação evidenciado é contínuo e pode ser ampliado e aperfeiçoado.

Palavras-chave: Abstração Reflexionante; Processo Criativo; Ensino de Matemática; COVID-19.

Introduction

The construction of knowledge that allows a graduate student to interpret the world as regards their training as a teacher is a process that depends on many factors, including the

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¹ Ph.D. student in Informatics in Education at the Federal University of Rio Grande do Sul (UFRGS). Professor of the Colégio de Aplicação of UFRGS, Brazil. Email: jessicaadrianemello@gmail.com. ORCID: <https://orcid.org/0000-0003-3079-406X>

² Ph.D. in Informatics in Education from the Federal University of Rio Grande do Sul (UFRGS). Full Professor at the Institute of Mathematics and Statistics of UFRGS, Brazil. Email: basso.marcus@gmail.com. ORCID: <https://orcid.org/0000-0002-2312-9056>

relationship between theory and practice. In this sense, the Colégio de Aplicação and the Institute of Mathematics and Statistics of UFRGS have developed a partnership that has lasted more than two decades. Since the 2000s, students of the Mathematics Degree course enrolled in the Teaching-Learning Laboratory in Mathematics I and II subjects have been planning lessons with the collaboration of their teachers and the teachers of the Colégio de Aplicação. In addition, they teach Mathematics Advisory and Virtual Interaction Advisory for students of the Colégio de Aplicação do Projeto Amora (CAp-Amora), which covers the 6th and 7th years of the elementary school stage.

Being in the classroom and facing the reality of the school becomes an opportunity to exercise teaching activity in its entirety. In small groups, undergraduate students have their first experience as teachers in the third semester of the Mathematics Degree course long before they perform the mandatory internship that usually occurs near the end of the course. The undergraduate Teaching-Learning Laboratories promote teaching practice in the subjects of Mathematics Advisory, and Virtual Interaction Advisory taught at CAp-Amora, boosting the unity between theory and practice.

Considering the challenge of starting teaching practice at an early stage of the Bachelor's degree course, the students of the Laboratory I and II disciplines, who carried out their practices in the years 2020 and 2021, had to face the limits of communication virtually with the students of CAp-Amora due to the COVID-19 pandemic. The unfolding of the practice developed by a group of four undergraduate students who taught the Advisories in the pandemic context will be presented in this article.

Seeking to discover how creativity and innovation can favor the construction of teaching knowledge regarding the elaboration of strategies to teach mathematics, the theoretical framework is based on the studies of Borges and Fagundes (2016) and Piaget (1995).

Learning laboratories and teacher education

A study on the Learning Laboratories of the Mathematics Degree course at UFRGS was carried out by Basso (2003), in which the author sought to investigate whether the proposal for training future teachers of the course favored the development of conditions for elementary school students to learn Geometry. In addition, he sought to investigate whether the practice promoted pedagogical reflections, accompanied by changes, on the part of future teachers. Following the bias of teacher training, Moura (2013) investigated how the Laboratories influence the initial training of UFRGS Mathematics undergraduate students. In addition, it is worth mentioning the research by Copetti (2015), who sought to investigate the role played by the Laboratories in the training of undergraduate students from the point of view of the training teachers.

The realization of the Learning Laboratories implies the practice carried out at the College of Application through the Mathematics and Virtual Interaction Advisory Services. This type of experience lived by undergraduate students is what Josso (2004) presents as a

formative experience. For the author, the practice's organization, planning, and implementation promote "an action reflected a priori or a posteriori" (Josso, 2004, p. 143). In this sense, the training experience is the work of reflection on what happened, but it also consists of what happens before and during the activity undertaken. Similarly, Machado (2013), inspired by Josso's studies (2004), emphasizes that "experience includes reflection, that is, the process of consciousness through which the subject goes to transform what has been lived into experience is taken by the mechanisms that put them to think about what has been experienced" (Machado, 2013, p. 34). Thus, the experience allows the graduate student to carry out the practice, reflect on its developments and qualify it for an upcoming opportunity.

It is worth highlighting the context in which this experience is developed. The Mathematics and Virtual Interaction Assessments are components of the Amora Project curriculum, and the Mathematics undergraduate students teach these subjects in partnership with the teachers. For this, the undergraduates plan the activities and teach the classes in groups with the collaboration of the teachers. In the Advisories, CAP-Amora students carry out activities involving digital resources (software, games, applets, websites, videos) and analog resources (abacus, golden material, FracSoma) related to the mathematical contents belonging to the teaching plan of the grade. Classes are divided into groups of approximately 15 students, which allows undergraduate students to offer more individualized and qualified assistance. In the Virtual Interaction Advisory, each student can use the computer individually, which makes it possible for students to develop the activities proposed by undergraduate students according to the time they need, respecting their individuality.

From this experience, Mathematics students can learn the school's reality. This practice can promote reflection on the teacher's work, which favors the development of creative and transformative practice by applying theories that support teaching. For Barros, Silva, and Vásquez (2011), the teacher is a reflective practitioner, in which he mentally rereads his work and the situation organized and experienced by him through action-reflection-action. Thus, by applying teaching methodologies, planning, and verification of learning in a process of action-reflection-action, reveals education as a questioning practice in which the teacher does not end his reflection at the moment the class ends but continues to reflect and question himself on how he can continue with his classes.

The proposal of the Learning Laboratories reveals itself as an opportunity for undergraduate students to explore their creativity. In a context where student groups are free to develop their plans and build their practice, undergraduates find a path where autonomy, commitment, responsibility, and boldness become pillars for their teacher education. Concerning autonomy, students can choose the theme and approach of the classes they will teach, allowing them to make decisions and explore their creativity. In relation to commitment, undergraduates become more committed to the learning process by taking responsibility for their choices and decisions. They dedicate time and effort to research, experiment and improve their practices. They also develop responsibility concerning teamwork, and, finally, they develop boldness by experimenting with different methodologies

and exploring new pedagogical approaches. According to Gontijo and Fonseca (2020), the indication of creativity as a necessary competence for teacher education in official documents, such as the National Curriculum Guidelines for the Initial Training of Teachers for Basic Education, which establishes the Common National Base for the Initial Training of Basic Education Teachers (BNC-Formação), reinforces the importance of "making room for creative studies and practices to be systematically included in undergraduate courses" (Gontijo & Fonseca, 2020, p. 733).

Considering the relevance of the theme of creativity for the study of everyday changes, Justo (2001, p. 62) states that "the need to renew, transform and create has never been so imperative." In addition to deepening theoretical knowledge about creative processes, the author must "foster practices that can engender creativity in all planes of life and places of the subject" (Justo, 2001, p.72).

As for the practice developed by the undergraduates, it should be noted that the tool that provided communication between teachers and students was the use of technology. For Lévy (1999), the use of technologies becomes necessary to "consciously and deliberately accompany a change of civilization that deeply questions the institutional forms, mentalities and culture of traditional educational systems and especially the roles of teacher and student" (Lévy, 1999, p. 172). The relationship between creativity and the use of technology gave indications of another challenge that undergraduate students would face: the elaboration of activities that promoted the construction of knowledge of the students of the Amora Project strictly with the use of technology.

The landscape for practice due to the COVID-19 pandemic

The pandemic context required schools to intensify the use of digital technologies. In addition, teachers had to use these tools so that the student's learning process was not interrupted while social distancing was necessary. According to Borba, Souto, and Canedo (2022), teachers were forced to use social networks, virtual environments, and videos to teach. It is difficult to judge whether this was positive or negative, "but it is certain that the pandemic forced the use of digital technologies by practically everyone" (Borba et al., 2022, p. 28).

In this scenario, in the midst of a worldwide pandemic, undergraduate students carried out their practice at the Colégio de Aplicação. For this, they needed to overcome another challenge: communication with CAp-Amora students strictly by virtual means. In 2020, the UFRGS College of Application maintained its remote activities through the school's website, in which an activity for each subject was made available weekly. CAp-Amora students accessed the activity, performed the task, and emailed it to the teachers responsible. As the Mathematics and Virtual Interaction Advisors had different teachers for each semester, the alternative found for communication with students was the creation of an avatar that represented the group of undergraduate students responsible for the subject in that semester.

At first, the solution seemed unpretentious; after all, the purpose of creating the avatar was to prevent Amora students from being confused with the contact by email from different teachers. However, the unfolding of the practice by creating the avatar and how it interacted with the students provided a sequence of activities that indicates the potential of creativity in the construction of teaching knowledge. Borges and Fagundes (2016) recognize the transformations in the world and, specifically, in the school as potential problem generators, but that, however, from an optimistic perspective, "they can present themselves as elements of motivation for the development of creative and innovative solutions" (Borges & Fagundes, 2016, p. 243).

Having this context for developing the practice, a group of four undergraduates was responsible for serving students in the 6th year of elementary school. Using the Gacha Life tool, which provided the character's creation with the characteristics the group wanted, they created an avatar named Ellie. In addition, from an accessible language, intending to make the character closer to the students, they started the activities seeking to establish a bond with the students of CAp-Amora.

Methodological path

The research is qualitative, based on the studies of Bogdan and Biklen (1994). According to the authors, this type of research is characterized by the observation and attention of the researcher to all elements of the investigated environment and points to the importance that the researcher's concern is more focused on the process than the final product.

According to Moreira (2003), qualitative research is an alternative to research in teaching due to the potential to share similarities concerning the various types of research:

Qualitative research is a term that has been used alternatively to designate various approaches to research in teaching, such as ethnographic research, observational participatory, case study, constructivist phenomenological, interpretive, and cognitive anthropological. Each approach forms a coherent whole, encompassing internally consistent assumptions about human nature, society, the object of study, and methodology. However, they share many similarities and, for the sake of simplicity, are commonly referred to as qualitative research (Moreira, 2003, p. 22).

In order to outline the type of research addressed in this article, Ponte, Brocardo, and Oliveira's (2006) perspective regarding the case study was considered. According to the authors, a case study aims to know a well-defined entity, such as a person, institution, course, discipline, educational system, policy, or other social unit. It is focused on comprehending the entity's identity and characteristics that pique the researcher's interest by thoroughly examining the "how" and "why" of the entity in its entirety. In mathematics education, case studies have been used to investigate student learning issues, teachers' knowledge and professional practices, initial and continuing teacher education programs, curriculum innovation projects, new curricula, etc. Thus, the research methodology chosen was qualitative through the case study.

Ellie: The girl who dreamed of being a math teacher

By creating a character with the same age as the students and with a similar language, the group's objective was to seek the students identified with the character and were willing to interact with it. For communication, an email was created in which the identification was also related to Ellie, and this email was the communication channel for student feedback and question resolution.



Figure 1 – Introduction of Ellie's character
Source: Undergraduate group planning

To kick off the activities with the students, Ellie asked them to introduce themselves. In addition, the young teacher proposed a poll on the preference of what the students liked to do in their free time, with the options: watching series, playing video games, or listening to music. In addition to getting to know the group with which the undergraduates would work, the purpose of this first contact was to organize the construction of tables, graphs, and percentages from the survey answers.

The engagement of the group of undergraduates from the beginning of the Advisory Services indicated the promising work that undergraduate students would develop in their classes. According to Gontijo (2015), intrinsic motivation plays an important role, as the student's involvement in a particular activity affects their creative production "since in the creative process the combination of affective and cognitive aspects is observed" (Gontijo, 2015, p.16).

After this first contact, during all the weeks until December 2020, Ellie was the student's teacher in Mathematics Advisory and Virtual Interaction. Sixth-grade students sent emails about their doubts, assignment deliveries, and, sometimes, asking about the real identity of the young teacher. The students, creators of the character, continued to answer the students' questions, giving feedback on the delivery of the tasks, but without revealing Ellie's identity.

The file made available to CAP-Amora students presented various colors and elements, considering that this resource could potentially arouse interest in students to know

more about Professor Ellie and, consequently, to learn more about mathematics. The students were attentive to exploring the context experienced by the students to propose their activities. In the following clipping, Ellie presents a situation from her daily life for an initial approach to graphs.

Durante este tempo de distanciamento social, em que não estamos indo para a escola, minha mãe me deu a tarefa de organizar meu quarto inteiro. Guarda-roupa, gavetas, caixas, brinquedos e tudo mais. Enquanto organizava meus brinquedos, me deparei com um desafio bem interessante que gostaria de mostrar para vocês.

Eu tenho aqui vários blocos coloridos: azuis, vermelhos e amarelos. Eles estavam completamente bagunçados e eu fiquei me perguntando qual seria a melhor maneira de organizá-los.

Decidi, então, empilhar todos que são da mesma cor. E ficou assim:


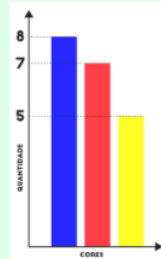


Figure 2 - Proposal for initial approach to graphs
Source: Undergraduate group planning

The activity of organizing the colored blocks was the strategy found by the group to explore the construction of graphs. Ellie records the coordinate axes in the same material produced, justifying why they were inserted and what they mean.

Vendo essas pilhas, percebi que dessa forma ficou muito mais fácil perceber quantos cubos eu tenho de cada uma das cores. Também percebi que posso construir um gráfico com essas informações!! Vejam só:



No gráfico ao lado, utilizei dois eixos para me auxiliar. O eixo que está na vertical representa as quantidades e o eixo que está na horizontal representa as cores. Assim, marquei no eixo vertical as quantidades de quadradinhos de cada uma das cores na mesma altura das barras de cada cor.

Figure 3 - Graph constructed based on the situation presented in Figure 2
Source: Undergraduate group planning

Over the weeks, the students explored more visual resources. Using the Canva tool, the group sought to reduce the amount of written text in the material made available to students and inserted more notes and reminders to signal important activity details.

After exploring the content of graphs and percentages for a few weeks, the students started new content. The context presented was that of curious Ellie imagining a world

without quantities and units of measurement. The task was an invitation for students to recognize the importance of this content.

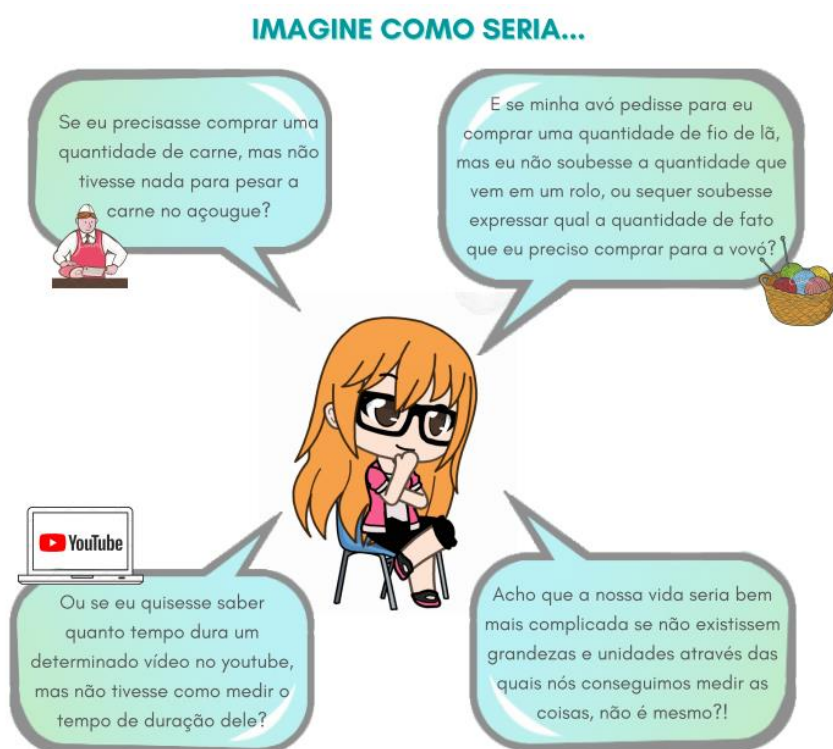


Figure 4 - Proposal for the initial approach to quantities and units of measurement
Source: Undergraduate group planning

In general, 6th-grade students remained engaged in Advisory activities. It should be noted that, as the end of 2020 approached, there was a drop in student deliveries, but this characteristic was perceived in all curricular components. In December 2020, Ellie said goodbye to the students by sending her last activity, not revealing her true identity and promising to return next year.

Video production with Ellie: New constructions and new challenges

In 2021, following the recommendations of the competent authorities, activities at the UFRGS College of Application continued remotely. However, since the beginning of the year, students have used the Moodle platform to conduct activities and interact with teachers.

Considering that, in the previous year, the undergraduate students had developed the work with sixth-grade students, the undergraduate students' group has started working with seventh-grade students in 2021 to continue Ellie's work. This class choice was due to the fact that the seventh-grade students at CAP-Amora included almost all the students from the previous year.

In order to qualify for the interactions developed in 2020, the undergraduate students responsible for Ellie decided to create a three-dimensional video animation for the character.

For the creation of Ellie's 3D image, the VRoid Studio software was used, and in this new version, a more adolescent image was proposed for the character. Once the new image was elaborated from the Wakaru application, Ellie gained voice and movement from inside her room to continue teaching Amora students. The video proposal prepared by the undergraduate students points to the commitment to qualify their practice using the available resources.

In March 2021, Ellie's first video was published on Moodle. The young teacher was presented recalling the work done in the previous year and resuming the content of percentage.



Figure 5 - Ellie appears in her first video
Source: Undergraduate group repository

The possibility of using videos as a didactic resource expanded the possibilities of work and allowed undergraduate students to create situations to teach mathematics more attractively. After all, in 2020, undergraduate students had three pages available to carry out their creations, while in 2021, in addition to the Moodle platform, the audiovisual resource could also be explored.

For Borba et al. (2022), producing videos with a pedagogical focus can potentially transform the classroom and Mathematics Education. For the author, the elaboration of videos puts students in a prominent place concerning the authorship, production, and communication of mathematical themes chosen by students according to their interests. Thus, "this practice has revealed the potential to go beyond the classroom, beyond school and academic contexts, by favoring that family members and friends of students and teachers become involved in the different stages of the video production processes" (Borba et al., 2022, p. 34).

In the context of the undergraduate students, elaborating videos with the protagonist Ellie required that the pedagogical work be organized with this bias. That is, the communication and constructions they would make with the students of CAP-Amora would be developed from the production of the videos. This resource provided more significant interaction between teachers and students, and it is essential to highlight the relevance of technology for teaching mathematics. As Borba et al. (2022) point out, "the diffusion of video

production by students, as well as the very relevance of the roles of Internet technologies in Mathematics Education, gained a new impetus with the advent of the COVID-19 pandemic" (Borba et al., 2022, p. 37).

The videos presented by Ellie to seventh-grade students sought to relate mathematical content to the daily lives of these students. Throughout the weeks of interaction with the students, the undergraduates identified one of the virtual games that were played by the class. Based on this information, they developed a video in which Ellie shared one of her favorite games: Stardew Valley. The young teacher presented in the video some moments in which she was playing, explaining the functioning of the game and its objective. From the game, Ellie explored the theme of increases and decreases using the quality of potatoes from her production as an example. Ellie realized they had quality standards for the sale of potatoes: gold, silver, and bronze. From the type of quality of the potatoes, she explored the calculations of additions and decreases.



Figure 6 - Ellie playing Stardew Valley
Source: Graduate group repository

In May 2021, the graduates ended their work with the Cap-Amora students as the university semester ended. Ellie said goodbye, saying she was thrilled with the opportunity to learn with the students and wished them to continue dedicating themselves to the activities proposed in the Advisories. In addition, the undergraduates completed a form in which they sought to know their opinion about the work developed in the Advisory Services during the period they were together. Ellie also asked for tips and suggestions so that she could be a great teacher in the future. The students answered the questions proposed by Ellie with great care, and their work was finalized without revealing their identity.

Creativity and innovation in the light of Piaget's theory

By seeking a theoretical perspective for the practical work that has been presented so far, what is desired is the dialog between theory and practice. In this way, the work developed

may favor future practices and indicate possible teaching knowledge built from the experience of creating Ellie.

Piaget's constructivist theory considers that knowledge is constructed through subject-object interaction. Thus, the subject acts on the object, but the object also acts on the subject. When understood by the subject, this action modifies the object of knowledge, resulting in an operation. For Piaget (1972):

To understand the development of knowledge, we must begin with an idea that seems central to me - the idea of an operation. Knowledge is not a copy of reality. To know an object or an event is not simply to look at it and make a mental copy, or image, of it. Knowing an object requires acting on it. To know is to modify, to transform the object, and to understand the process of this transformation and, consequently, to understand how the object is constructed. An operation is thus the essence of knowledge. It is an internalized action that modifies the object of knowledge (Piaget, 1972, p. 1)

In 1972, at a conference in the United States, in which the causes and mechanisms of creativity were explored, Piaget sought to unravel the creative process from his findings on intelligence in the field of Genetic Epistemology. For Piaget, intelligence is not configured as a copy of reality or represented in objects. For the author, intelligence would be configured as "a construction of the subject that enriches external objects. The subject 'adds' this dimension to external objects instead of extracting this dimension from objects" (Piaget, 1972, p. 13). Furthermore, Piaget maintains that "intelligence development is a continuous creation" (Piaget, 1972, p. 13). Thus, each stage of development promotes the emergence of new structures.

A study conducted by Parrat-Dayan (2001) on the creative process and its possible exceptionality covers the history of the concept of creativity, focusing on the main psychological theories and authors who have addressed this subject. For the author,

the maximum relationship between the concept of creativity and psychological theory can be found in Piaget's theory, in which intelligence is related to creativity. As intelligence is a successive construction throughout life, so is creativity (Parrat-Dayan, 2001, p. 121).

In 1977, Piaget published research on reflexive abstraction, stating that "a fundamental attribute of reflexive abstraction [consists in] deducing forms dissociated from contents" (Piaget, 1995, p. 285). Thus, reflexive abstraction does not deny the equilibration theory of cognitive structures but explains how the construction of knowledge develops specifically with human beings. Piaget divides reflexive abstraction into three parts: pseudo-empirical abstraction, "when the object is modified by the subject's actions and enriched by properties drawn from its coordinations" (Piaget, 1995, p. 274); reflexive abstraction itself; and reflexive abstraction, that is, when the subject becomes aware of his reflexive abstraction process. Piaget also summarizes that reflection, as a projection on a higher level of what was taken from the lower level, and reflection, as the reconstruction and (mental) reorganization of what was taken to the higher level, are part of reflexive abstraction.

Considering the period in which the undergraduate students were working on the Amora Project, building knowledge concerning teaching action, it is possible to perceive, from the activities proposed to the students and the records in the portfolio of the Learning Laboratory discipline, that they were in a constant process of reflexive abstraction. The fact that they are acting in the planning and teaching Mathematics to the students of Amora made it possible that, from the interactions with the students, the undergraduates removed qualities from this interaction, becoming a possibility for the subject to coordinate their actions and build something new. Becker (2001) describes that the subject turns to the environment, objects, and social relations, acquiring attributes no longer of the environment or objects themselves but of the coordination of their own actions.

Inspired by Piaget's theory, Borges and Fagundes (2016) elaborated on the "cyclone of creation" metaphor to illustrate the process of building the subject's knowledge about creativity and innovation. For the authors, creativity is related to the mental process of generating new ideas, and innovation is the execution of these creative ideas.

The "cyclone of creation" begins when curiosity turns into investigation. According to the authors, 'Everything begins when it 'touches the ground,' that is when the element that will trigger creation ceases to be just curiosity and is formalized as a question' (Borges & Fagundes, 2016, p. 247). From this, the creation process can be divided into four stages: 1) **Asking**: In this stage, the problem is identified, and the question that will trigger the investigation and possible creations is formulated; 2) **Knowing**: the subject seeks more in-depth information on the elements that make up the problem; 3) **Understanding**: it is deeply linked to knowing, "because the more one knows the object of research, the better one understands the problem and the solution to which one wishes to arrive" (Borges & Fagundes, 2016, p. 24); 4) **Creating**: it is deeply linked to knowing, "because the more one knows the object of research, the better one understands the problem and the solution to which one wishes to arrive" (Borges & Fagundes, 2016, p. 24). 247); 4) **Create**: It is configured when the novelty is created and validated. At this point, at which the invention is put to the test, the results of the creation are observed concerning its success and possible failures that can be improved. In this way, the moment of re-elaborations implies a new cycle of asking, knowing, understanding, and creating that can promote discoveries.

The mechanisms mentioned are present in the process of reflexive abstraction, which represents the essence of "acts of intellectual creativity" (Piaget, 2001, p. 15) and plays a fundamental role in the development of logical thinking. The axes present in the figure point to the three-dimensional nature of the cyclone, in which it starts at a level of complexity and, through the coordination of the subject's actions, advances to a higher level, elevated by reflexion. This cycle drives innovation and the process of progress to a new level of complexity.

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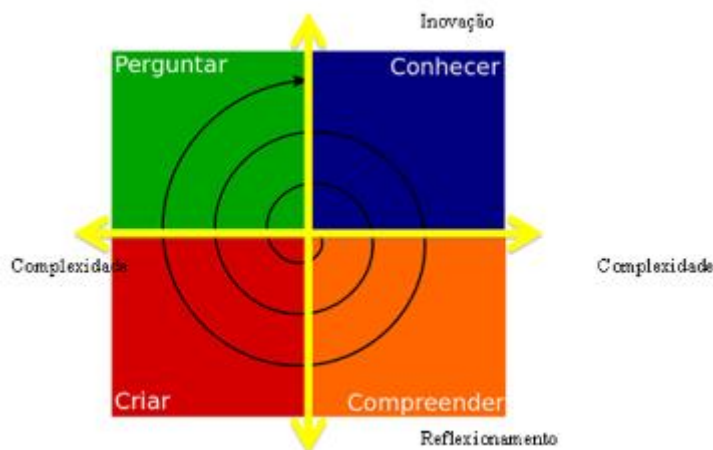


Figure 7 - The 'cyclone of creation'
Source: Borges and Fagundes (2016, p. 247)

The cyclone of creation, proposed by Borges and Fagundes, seeks to "illustrate how the creation of something new takes place in order to demystify this process and make it applicable in learning activities" (Borges & Fagundes, 2016, p. 248). From the illustration, it is possible to analyze the creative processes from the paths of asking, knowing, understanding, and creating that the undergraduates went through in the search to build knowledge related to classroom practice.

The construction of teaching knowledge from Ellie's creative process

The work developed by the undergraduate students in 2020 and 2021, based on the creation of the character Ellie, points to processes of knowledge construction that can be analyzed according to Borges and Fagundes' "cyclone of creation." This is because implementing the audiovisual resource in 2021 presents an essential advance concerning communication with CAP-Amora students.

When analyzing the records made in the portfolio of the Learning Laboratory discipline, it is possible to highlight notes made by undergraduate students that indicate the process of asking, knowing, understanding, and creating. In order to analyze these records, a selection of excerpts created by the group of undergraduate students in the 2020 and 2021 portfolios was made.

The starting point, the point where the cyclone touches the ground, is configured as the set of doubts that present themselves as a problem or, in the case of the students, the beginning of the work with the students of CAP-Amora. These doubts can be observed in the record "We reflect on the difficulties imposed by remote teaching, which does not allow us to closely monitor students, having them, for the most part, 'deal' with new content or concepts alone." This difficulty students encounter leads to the need to seek knowledge to overcome difficulties, which takes them to the stage of knowing.

The process of seeking to know the problem contributes to the group's decisions regarding the choice of content. Their portfolio states, "After an internet search, we decided how to start the content. We found some fascinating videos that made us reflect on the importance of having units of measurement to determine quantities of each of the quantities". In this way, undergraduate students learned about proposals already prepared and were able to organize their pedagogical practice.

From their understanding of the content of quantities of measures, the undergraduates, from the organization of the actions that would make the Advisories, began to structure an objective for the activities they would create. In the portfolio, they recorded "the goal of making them think about the importance of units of measurement and their standardization."

Finally, the creation process was completed with the elaboration of the activity in which Ellie appears asking a series of questions (Figure 4). In addition, at that moment, in 2020, the students' concern about the limitation of resources that could favor the learning of CAp-Amora students was perceived. The undergraduates recorded in the portfolio: "As we could not indicate the videos as a mandatory part of the task, we ended up creating sentences in which Ellie questioned the students about what a world without units of measurement would be like, and we ended up leaving the video as an extra activity."

When analyzing these portfolio records, it is observed that the undergraduate students experienced the process of pedagogical practice and sought to qualify their strategies through creativity. According to Borges and Fagundes (2016),

In this process of creation, it is possible to recognize the evolution of invention through reflexive abstraction, as described by Piaget. Reflection represents the levels of development of innovation, which are increased from reflections. Moreover, a question or problem triggers a new reflection, followed by moments of knowing, understanding, and creating (Borges & Fagundes, 2016, pp. 247-248).

For Piaget (1995, p. 282), "each act of reflexive abstraction involves a displacement and the use of coordinates already in action at the starting point, but with additions of new characteristics resulting from a construction, in this respect, creative." In this sense, what is observed in both the "cyclone of creation" and in reflexive abstraction is that the process allows the subject, from his action and the coordination of actions, to produce novelties. In the case of undergraduate students, the opportunity to act as teachers of CAp-Amora students provided the dialog between theory and practice and, consequently, through the processes of reflexive abstraction, the construction of knowledge regarding teaching. In addition, given the context experienced by undergraduate students due to the COVID-19 pandemic, creativity and innovation in the tasks developed provided new elaborations, which also constitute the knowledge related to the teaching experience.

Regarding the communication of undergraduate students from 2020 to 2021, it is possible to characterize the creation process according to the records in the portfolio. Seeking a way to present the records relating to the four phases of the "cyclone of creation" of Borges and Fagundes (2016), the following table was constructed:

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Chart 1 - Creative Process

Asking	Throughout the semester, we realized how challenging the teacher's role and the adaptation to distance learning are. Every time we were going to teach some content to the students, no matter how simple it was, we had to stop and think of a simple way to explain it or one that would actually be able to produce meaning for them. Combined with this, the creation of Professor Ellie became quite a challenge, as we also needed to explain as if we were their age and use the knowledge they possessed.
Knowing	The activities carried out also had to be well structured and creative to arouse the students' interest, which in this remote teaching modality required us to be even more committed. Due to our limited interaction with the students, we noticed difficulty in creating activities that were not hampered by the lack of teacher intervention during their development.
Understanding	Over time, as we became more familiar with the environment, we noticed our evolution in how we work with students compared to the beginning of the semester. We noticed the importance of noting the students' performance in the weekly activities in detail so that we would have an easier time attending to their doubts or mistakes. For us, it was delightful to see the development of the students throughout the semester, their excitement in working with Ellie and how much they excelled in their learning, and their ability to adapt to this very atypical year.
Creating	As Ellie was a success in the previous year, both with students and teachers, we decided to continue her story. However, with the possibility of using more excellent technology, in 2021, we had the opportunity to adapt the character to 3D form, as we could then create videos with the character.

Source: Elaborated by the authors

When analyzing the notes presented in the table, it is clear that, from the questions that appear in the questioning phase, the undergraduate students were able to go through the path of knowing and understanding, creating a new version of Ellie. It should be noted that some excerpts were chosen to compose the table to illustrate the phases, but that, however, the portfolios of 2020 and 2021 make up a broader version of the creation process experienced by future teachers.

Even though the table contains only a clipping of the undergraduate students' records, what can be seen is that the process of reflexive abstraction of these students was not limited to the creation of the character Ellie, as presented in the video production section of this article. This continuity in the creation process is configured in a way that refers to the epigenesis of Piaget's cognitive functions (1974) and the form of the "cyclone of creation." For Piaget (1995), "the characteristic of this spiral is thus to reach increasingly richer forms and, consequently, more important concerning the content" (Piaget, 1995, p. 277). From Ellie's three-dimensional creation, new challenges arose that demanded new knowledge. This knowledge allowed the students to understand the reality in which they were inserted. Based on this understanding, it was possible to develop new strategies to teach mathematics, and the creation of these novelties gave rise to new challenges, leading the process to a new cycle of asking, knowing, understanding, and creating.

Final considerations

Given all the difficulties encountered during the pandemic, virtual communication between teachers and students was established strictly. This type of communication was challenging for many teachers who were used to the school environment. However, the problem is more significant when faced with Mathematics undergraduate students who have never been classroom teachers and had to plan and deliver their classes in this context.

Concerning teacher training courses, the importance of curricula in fostering practices that encourage the elaboration of authorial and innovative proposals is highlighted. This challenge can trigger creative processes that will contribute to the construction of teaching knowledge. In addition, this type of practice can reframe the concept that undergraduates have about how the learning process takes place and, from this, seek strategies that qualify their teaching work.

In this article, it was possible to realize that creativity can promote the construction of teaching knowledge from the practice developed in the pandemic context. The creation of the character Ellie and the unfolding of the activities developed with the students of CAP-Amora point to a creative process that is related to Piaget's process of reflexive abstraction. The "cyclone of creation" proposed by Borges and Fagundes (2016) contributed to the analysis of the records of the graduate students' portfolios, making it possible to conclude that the creation process is continuous, can be expanded, and improved according to the actions and coordination of actions of the subject.

The dialog between theory and practice, proposed when presenting undergraduate students' experience with theory, provided subsidies for analyzing the experience. In addition, it was possible to realize the potential of the creative process in the construction of teaching knowledge. Finally, what is expected when sharing this type of experience is that this article has the potential to trigger new questions, in which the search for new knowledge is necessary in order to generate new understandings, leading, in turn, readers to new elaborations.

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