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The relationships between creativity and working with digital technologies that are revealed in the mathematics education literature

Las relaciones entre creatividad y trabajo con tecnologías digitales que se revelan en la literatura de educación matemática

Les relations entre la créativité et le travail avec les technologies numériques révélées dans la littérature sur l'enseignement des mathématiques

As relações entre criatividade e o trabalho com tecnologias digitais que se desvelam na literatura de educação matemática

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Abstract

This article aims to identify relationships between creativity and work with digital technologies in literature focused on Mathematics Education in the Portals of the Brazilian Digital Library of Theses and Dissertations, in the CAPES Catalog of Theses and Dissertations, in the CAPES Periodicals Portal and in the Proceedings of the International Congress on Mathematical Education and the International Mathematical Creativity and Giftedness Conference, thirty-eight publications were selected. Of these, information such as title, author/year, definition of creativity, research question or objective and relationships between creativity and technology were collected and categorized. From the analysis, we identified that: (i) the potential of digital technologies for the development of creativity lies in facilitating the articulation of ideas, the opening of perspectives, the opportunity to take risks and collaboration; (ii) that teaching mathematics with digital technologies for creativity is linked to work that promotes contexts of

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exploration, experimentation, access and sharing of knowledge; and, (iii) that creativity in the construction of activities with digital technologies is related to pedagogical innovation, learning opportunities and the suitability of the experience of using technology for the teaching objective. Furthermore, we highlight as research gaps the understanding of how the development and expression of teaching creativity occurs when working with digital technologies in the classroom and the need to deepen the study of the teaching creative process with these technologies.

Keywords: Creativity, Creativity in mathematics, Digital technologies, Mathematics education, Research mapping.

Resumen

Este artículo tiene como objetivo identificar relaciones entre creatividad y trabajo con tecnologías digitales en la literatura enfocada a la Educación Matemática en los Portales de la Biblioteca Digital Brasileña de Tesis y Disertaciones, en el Catálogo de Tesis y Disertaciones de la CAPES, en el Portal de Periódicos de la CAPES y en las Actas del Congreso Internacional de Educación Matemática y de la Conferencia Internacional de Creatividad Matemática y Superdotación, se seleccionaron treinta y ocho publicaciones. De estos, se recopiló y categorizó información como título, autor/año, definición de creatividad, pregunta u objetivo de investigación y relaciones entre creatividad y tecnología. Del análisis identificamos que: (i) el potencial de las tecnologías digitales para el desarrollo de la creatividad radica en facilitar la articulación de ideas, la apertura de perspectivas, la oportunidad de asumir riesgos y la colaboración; (ii) que la enseñanza de las matemáticas con tecnologías digitales para la creatividad está vinculada a un trabajo que promueva contextos de exploración, experimentación, acceso e intercambio de conocimientos; y, (iii) que la creatividad en la construcción de actividades con tecnologías digitales se relaciona con la innovación pedagógica, las oportunidades de aprendizaje y la idoneidad de la experiencia de uso de la tecnología para el objetivo docente. Además, destacamos como vacíos de investigación la comprensión de cómo se produce el desarrollo y expresión de la creatividad docente cuando se trabaja con tecnologías digitales en el aula y la necesidad de profundizar en el estudio del proceso creativo docente con estas tecnologías.

Palabras clave: Creatividad, Creatividad en matemáticas, Tecnologías digitales, Educación matemática, Mapeo de investigación.

Résumé

Cet article vise à identifier les relations entre la créativité et le travail avec les technologies numériques dans la littérature axée sur l'enseignement des mathématiques dans les portails de la Bibliothèque numérique brésilienne de thèses et de mémoires, dans le catalogue de thèses et de mémoires du CAPES, dans le portail des périodiques du CAPES et dans les actes. du Congrès international sur l'enseignement mathématique et de la Conférence internationale sur la créativité et la douance mathématiques, trente-huit publications ont été sélectionnées. Parmi celles-ci, des informations telles que le titre, l'auteur/l'année, la définition de la créativité, la question ou l'objectif de recherche et les relations entre la créativité et la technologie ont été collectées et catégorisées. De l'analyse, nous avons identifié que: (i) le potentiel des technologies numériques pour le développement de la créativité réside dans la facilitation de l'articulation des idées, l'ouverture des perspectives, la possibilité de prendre des risques et la collaboration; (ii) que l'enseignement des mathématiques avec les technologies numériques pour la créativité est lié à un travail qui favorise les contextes d'exploration, d'expérimentation, d'accès et de partage des connaissances; et (iii) que la créativité dans la construction d'activités avec les technologies numériques est liée à l'innovation pédagogique, aux opportunités d'apprentissage et à l'adéquation de l'expérience d'utilisation de la technologie à l'objectif pédagogique. En outre, nous soulignons comme lacunes de recherche la compréhension de la manière dont se produit le développement et l'expression de la créativité pédagogique lors du travail avec les technologies numériques en classe et la nécessité d'approfondir l'étude du processus créatif pédagogique avec ces technologies.

Mots-clés : Créativité, Créativité en mathématiques, Technologies numériques, Enseignement des mathématiques, Cartographie de recherche.

Resumo

Este artigo tem como objetivo identificar relações entre a criatividade e o trabalho com tecnologias digitais na literatura voltada à Educação Matemática nos Portais da Biblioteca Digital Brasileira de Teses e Dissertações, no Catálogo de Teses e Dissertações da CAPES, no Portal de Periódicos da CAPES e nos Anais do *International Congress on Mathematical Education* e da *International Mathematical Creativity and Giftedness Conference*, sendo selecionadas trinta e oito publicações. Destas informações como título, autor/ano, definição de criatividade, questão ou objetivo de pesquisa e relações entre criatividade e tecnologia foram coletadas e categorizadas. A partir da análise, identificamos que: (i) o potencial das tecnologias digitais para o desenvolvimento da criatividade está em propiciar a articulação de ideias, a abertura de perspectivas, a oportunidade de assumir riscos e a colaboração; (ii) que o ensino de matemática com tecnologias digitais para a criatividade está atrelado a um trabalho que promova contextos de exploração, experimentação, acesso e compartilhamento de saberes; e, (iii) que a criatividade na construção de atividades com tecnologias digitais se relaciona com a inovação pedagógica, com as oportunidades de aprendizagem e com a adequabilidade da experiência com a tecnologia ao objetivo de ensino. Além disso, destacamos como lacunas de pesquisa a compreensão de como se dá o desenvolvimento e a expressão da criatividade docente na atuação com tecnologias digitais em sala de aula e a necessidade de aprofundamento no estudo sobre o processo criativo docente com essas tecnologias.

Palavras-chave: Criatividade, Criatividade em matemática, Tecnologias digitais, Educação matemática, Mapeamento de pesquisas.

The relationships between creativity and working with digital technologies as revealed in mathematics education literature

In the context of the 21st-century technological and scientific innovation, which brings changes to various spheres of society and affects different aspects of our lives, including creativity, it becomes essential to consider both practically and theoretically the role of digital technologies (DT) in creativity. Digital technologies influence how people learn, work, produce, and interact with the world. At the same time, the role of creativity in technological development must be examined, as society and individuals also shape new technologies and ways of utilizing them (Gangadharbatla, 2010; Henriksen *et al*., 2016).

Considering the impact of technology on learning and education geared toward developing creativity - especially in teacher training and practice - we are interested in the relationships established in Mathematics Education (ME) research between creativity and DT in the educational context.

In referring to creativity, we acknowledge its multiplicity of definitions in the literature but adopt here, in line with Glăveanu (2014), the view of creativity as an action engaged by multiple actors (individually or in groups) that explores the possibilities of the cultural world (both symbolic and material) and leads to the generation of artifacts appreciated as new and useful by oneself or others.

Numerous studies have discussed these relationships within the scope of education, including works by Loveless (2007); Burkhardt and Lubart (2010); Henriksen *et al.* (2016); Vilarinho-Rezende et al. (2016); Rezende (2017); Borges and Fleith (2018); Habowski and Conte (2019); and Vilarinho-Pereira and Fleith (2021). Notably, Loveless (2007) provides a literature review on creativity, new technologies, and learning, while Vilarinho-Rezende *et al.* (2016) reviewed publications from 2004 to 2014 that evaluated the implementation of technologies in educational contexts and their effects on creativity development. Overall, these studies concluded that DT foster creativity development.

Some features of DT that facilitate creativity development, highlighted by Loveless (2007), include their provisional nature, enabling users to make changes, experiment with alternatives, and preserve traces of idea development; interactivity, which allows users to engage at various levels of interaction and feedback; access to vast amounts of information locally and globally; speed and automation, which support storage, transformation, and display of information, enabling users to read, observe, question, interpret, analyze, and synthesize information at higher levels.

Henriksen *et al.* (2016) emphasize two aspects of the relationship between creativity and technology in education. First, technologies offer new contexts and tools for creative production, providing multiple ways to construct, represent, communicate, and share knowledge, thus creating opportunities for creativity development. Second, since human creativity drives technological advancement and the ways technologies are used, educators' creativity becomes vital, particularly in designing ways to integrate technology into teaching, as most digital resources are not originally designed for educational purposes.

However, Burkhardt and Lubart (2010) warn that experiences with technologies may also hinder creativity development. For example, internet search tools provide rapid access to infinite information but risk limiting users to widely accessed content, compromising originality, which is essential for creative expression. Furthermore, the reliability of this information cannot always be guaranteed. In this regard, Loveless (2007) and Vilarinho-Rezende *et al.* (2016) argue that simply incorporating technological resources into pedagogical practices is insufficient; they must be used contextually and aligned with specific objectives.

Concerning ME research, Pitta-Pantazi *et al.* (2018) note that while many studies have explored the impact of technology on mathematical understanding, few have examined its influence on developing creativity in mathematics. Advancing this field requires identifying relationships between creativity and working with DT in teaching and learning mathematics. Thus, this study addresses the question: what relationships between creativity and working with DT are identified in studies on this topic in the context of Mathematics Education?

This article is structured as follows: first, we present the methodological approach for constructing and analyzing the *corpus*; next, we provide the analysis of the results, which converge into four categories representing the main relationships between the topics discussed; finally, we offer concluding remarks and research perspectives.

Methodological Approaches

To identify the relationships between creativity and working with digital technologies (DT) in Mathematics Education (ME) research, we mapped theses, dissertations, articles, and book chapters discussing this topic. To encompass both national and international research, we defined the search fields as the Brazilian Digital Library of Theses and Dissertations (BDTD), the CAPES Theses and Dissertations Catalog, the CAPES Journal Portal, and the proceedings of the *International Congress on Mathematical Education* [4](ICME) and the International

[4] To learn more: https://www.mathunion.org/icmi/conferences/icme-international-congress-mathematical-education. Last accessed on: 10/06/2022.

Mathematical Creativity and Giftedness Conference (IMCGC)[5]. Using the adopted protocol, during our search on October 6, 2022, we selected studies available in full text in Portuguese, English, or Spanish. Following this approach, the earliest study identified was from 2005, and the most recent was from 2020.

ICME was included due to its significance in the international ME research landscape and its dedicated working group on creativity. It is important to note that the proceedings[6] of this event, organized around Topic Study Groups (TSG) and Discussion Groups (DG), do not provide full articles but rather reports and minutes of lectures and discussions conducted at each edition. Additionally, books covering topics discussed at the event are published.

Through thematic searches in the available proceedings[7], we identified the formation of working and discussion groups on creativity starting with ICME 11. This justified our focus on this event from that edition onward. Regarding ICME 13, we discovered the publication of the ICME-13 *Monographs*[8] book series by SPRINGER, which includes three relevant books: *Mathematical Creativity and Mathematical Giftedness* (2018), *Uses of Technology in Primary and Secondary Mathematics Education* (2018), and *Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues* (2018).

Moreover, to foster continuity of the work initiated at the event, participants in the study and discussion groups on creativity are encouraged to join the *International Group for Mathematical Creativity and Giftedness* (MCG)[9]. This group organizes the *International Group for Mathematical Creativity and Giftedness Conference* (IMCGC)[10]. We found proceedings for the IMCGC editions of 2011, 2014, 2015, 2017, 2019, and 2021. Additionally, we identified a book publication, Creativity and Technology in Mathematics Education (2018), developed from discussions held during a mini-symposium on Creativity and Technology at the 2014 IMCGC and other contributions on the topic.

Table 1 summarizes the search terms used in each database and the number of selected works, considering each step of the corpus-building process.

[5] To learn more: https://www.igmcg.org/conferences. Last accessed on: 10/06/2022.
[6] Available at: https://www.mathunion.org/icmi/publications/icme-proceedings-and-publications. Last accessed on: 10/06/2022.
[7] ICME 2 (1972); ICME 6 (1988); ICME 8 (1996); ICME 10 (2004); ICME 11 (2008); ICME 12 (2012); and ICME 13 (2016).
[8] Available at: https://www.springer.com/series/15585/books?page=1. Last accessed on: October 6th, 2022.
[9] To learn more: https://www.igmcg.org/home. Last accessed on: October 6th, 2022.
[10] Proceedings available at: https://www.igmcg.org/conferences. Last accessed: October 6, 2022.

Table 1

Identification of the Search Base, Keywords, and Number of Materials Selected at Each Stage. (Authors, 2023)

Search Base	**Search Terms**	**Initial Search**	**Refinement**
BDTD	creativity and technologies and mathematics	180	2
CAPES Thesis and Dissertation Catalog	creativity AND technologies AND mathematics	26	0
CAPES Journal Portal	criatividade and tecnologias and matemática OR creatividad and tecnologias and matemática OR creativity and technology and mathematic.	948	14
Event	**Search Terms**	**Editions**	**Selected Papers**
ICME	"*creativity*" e "*technology*"	ICME XI (2008); ICME XII (2012) e ICME XIII (2016).	0
IMCGC	"*technology*"	VI (2011), VIII (2014), IX (2015), X (2017), XI (2019), XII (2022).	1
Book Title	**Search Term**	**Initial Search**	**Refinement**
Mathematical Creativity and Mathematical Giftdeness (2018)	"*technology*"	1	1
Uses of technology in primary and secondary mathematics education (2018)	"*creativity*"	1	1
Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues (2018)	"*creativity*"	2	2

It is interesting to note in Table 1, particularly in the searches conducted in CAPES portals for journals and theses/dissertations, the significant number of works identified in the initial search. This is due both to the search engine inspecting the keywords in pre-textual elements (title, abstract, and keywords), which allows for capturing research from other areas involving TD, and to studies that reference the term creativity but do not focus on the subject matter or define the specific concept of creativity assumed in their studies.

Furthermore, it is important to mention that the dissertation by Dantas (2015) was not accessed through the thesis and dissertation repositories but via the website of the university where it was conducted. This was possible because we became aware of this dissertation through the article by Rosa and Dantas (2020).

Selective reading of titles and abstracts led to the exclusion of duplicate works, studies that, while addressing DT and mentioning creativity, focused their research on other themes, and works where creativity was considered a consequence or result of a tool or approach without being assessed or defined. As a result, 38 studies were selected, listed in Table 2 and identified as T1 to T38.

Table 2

Identification of Research and Corpus Composition. (Authors, 2023)

Identification – Author(s) (Year)	Types of Research
T1 - Cox, Harper e Edwards (2018); T2 - Tassel, Stobaugh e Maxwuel (2018); T3 - Madden (2018); T4 - Redmond-Sanogo, Stansberry, Thompson e Vasinda (2018); T5 - Flores, Park e Bernhardt (2018); T6 – Davis, Phillips e Kulm (2018); T7 – Watson e Enderson (2018); T8 - Dickman (2018); T9 - Milner-Bolotin (2018); T10 - Szymanski (2018); T11 - Gerson e Yu (2018); T12 - Abramovich (2018); T13 - Sriraman e Lande (2018); T14 - Vidakovic, Dubinsky e Weller (2018); T15 - Champlain, DeBlois, Robichaud e Freiman (2018); T16 - Fellus e Biton (2018); T17 - Manuel (2018); T18 - Essonier, Kynigos, Trgalova e Daskolia (2018); T19 - Kynigos e Kolovou (2018); T20 - Daher e Anabousy (2018); T21 - Trgalová, El-Demerdash, Labs e Nicaud (2018).	Book Chapters
T22 - Aqda, Hamidi e Rahimi (2011); T23 - Karadag, Martinovic e Birni (2015); T24 - Supriatin e Boeriswati (2019); T25 - Fatimah (2019); T26 - Velikova e Petkova (2019); T27 - Fitriasari, Octaria e Sari (2020);	Conference Papers
T28 - Yushau, Mji e Wessels (2005); T29 - Idris e Nor (2010) ; T30 - Contreras (2013); T31 - Yildiz, Baltaci e Demir (2017); T32 - O'byrne, Radakovic, Hunter-Doniger, Fox, Kern e Parnell (2018); T33 – Rosa e Dantas (2020); T34 - Daher e Anabousy (2020); T35 - Vaz e Junior (2020).	Journal Articles
T36 - Oliveira (2016)	Thesis
T37 - Dantas (2015) T38 – Neri Junior (2019)	Dissertation

After selecting and organizing the *corpus* for analysis, following the steps outlined by Creswell (2010), we proceeded with reading and re-reading the studies, noting general perceptions and revisiting the research objectives. Key aspects of each study were described in a structured form prepared by the researchers, including title, author/year, definition of creativity, research question/objective, and relationships between creativity and working with technology. Subsequently, we began the coding process, organizing the materials into groups. Initially, the exact terms used by the authors were employed. Given the volume of data, these terms were later synthesized by grouping similar topics.

Based on this, we present our results and discussions in two parts: the first identifies the conceptions of creativity, the TD used, and the topics of interest in these studies. In the second, we highlight the main findings regarding the relationships between creativity and the use of TD, considering the teaching and learning of mathematics.

Results and Analysis

Before discussing the relationships between creativity and TD (Digital Technologies), we find it relevant to present some of the most cited concepts of creativity and the TD used. This choice of structure considers the multiplicity of conceptualizations for creativity and the TD being implemented in educational contexts.

In these studies, something creative typically meets the criteria of novelty or originality and usefulness, relative to the contexts explored. Since creativity is contextual and situational (Glăveanu, 2014), studies exploring students' experiences with TD and the development of creativity analyze aspects of creativity revealed during the learning process. Students demonstrate creativity in the solutions they propose, the construction of these solutions, and the paths they take to solve or formulate problems, relationships that have garnered attention in mathematics education (Brolezzi, 2015; Pitta-Pantazi *et al.,* 2018).

Based on various conceptions of creativity, publications often highlight aspects related to the product, process, person, environment, or the interaction between these elements in the emergence of a creative product. The criteria of novelty or originality and usefulness are addressed with differing nuances.

For instance, some studies focus on the interaction between opportunities (environment) and students' sensitivity (T4, T11, T15, T16, T31). T31, for example, defines creativity as the process of being sensitive to difficulties and information gaps, enabling students to make assumptions, test, revise, and reaffirm hypotheses, and communicate results—often tied to problem-solving. T11, on the other hand, considers creativity a construct based on students' choices in making sense of and solving problems, shaped by aesthetic sensitivities such as simplicity, visual appeal, connection, symmetry, elegance, and ease of understanding, leading to new results, at least for the students themselves.

T16 also associates creativity with choice, dependent on knowledge, options, and experiences that allow for new connections. Here, creativity relates to combinatorial thinking, where students combine known elements in new ways, imagining, altering, and creating something new for themselves.

Other studies emphasize creativity emerging from interactions with others and the environment. T18 and T19, for instance, identify the social dimension of creativity in exchanges or negotiations between creators, leading to co-construction of new, enriched perspectives. T8 focuses on creative collaboration, distributed among actors and objects, exploring roles in supporting and integrating novelty.

Criteria like novelty or originality and utility strongly characterize the perspectives on creativity in mathematics, linked to problem-solving and problem formulation (T1, T3, T5, T7, T11, T12, T13, T14, T24, T29, T30, T31). These perspectives consider creativity as the potential to create original solutions, formulate new problems, and/or appropriately reframe existing ones. For instance, T5 defines creativity as the student's attitude toward generating new solutions or details in the context of a task, presenting original work supported by previously learned concepts. T29 describes it as the ability to analyze a given problem in various ways, identify patterns, similarities, and differences, produce multiple ideas, and decide on an appropriate method to tackle mathematical problems. Similarly, T14 highlights the importance of combining or reorganizing ideas, applying techniques or approaches to deal with unknown information, creating new objects, gaining insights, and formulating new questions.

Regarding problem-solving and problem formulation, we also highlight the analysis of creativity-related skills identified by Guilford (1950): flexibility, fluency, originality, and elaboration (T11, T17, T20, T21, T22, T23, T24, T29, T31). Fluency is understood as the quantity of different correct ideas/responses on the same subject in a task/problem. Flexibility involves changing perspectives, strategies, or transforming an idea within the task resolution context. Originality is measured by how rare (different from the usual) the response or procedure is compared to others given for the task. Elaboration is seen as the ability to redefine a problem to create others by modifying one or more of its aspects.

Thus, we observe a multiplicity of understandings and aspects of creativity focused on in the research analyzed, leading us to seek relationships between creativity and working with TD (digital technologies) based on what each study understands as creativity. In other words, the discussions undertaken in the analyses do not reflect our understanding of creativity and technologies but rather what we found in literature.

In pursuing and deepening research exploring creativity and working with TD in mathematics teaching and learning contexts, we highlight the variety of TDs presented in the articles. Particularly noteworthy is the use of dynamic geometry software (DGS) (T1, T3, T5, T9, T11, T14, T23, T25, T26, T30, T31, T34, T36), especially *GeoGebra and Geometer's Sketchpad*. Other studies, such as T2, T16, and T24, analyze TD without specifying a particular technology, basing their discussions on TD in general. Some studies use various technologies depending on resource availability and the interests of those involved in their analyses. For example, T33 mentions portable interactive whiteboards, tablets, and smartphones, along with software like PowerPoint, Word, and image editors. Similarly, T28 and T29 reference computers, calculators, and DGS. Another technology highlighted (T18, T19, T21) is the c-book, a computational environment in an e-book format that includes dynamic tools, customizable data analysis mechanisms, and supports asynchronous collaborative design of pedagogical resources.

Additionally, *Python* programming environments (T5, T14); video editing software like Macromedia Flash (T4, T27); websites such as CAMI – Virtual Problem-Solving Community (T15, T17) and MESE – Mathematics Educators Stack Exchange, a Q&A platform for mathematics students (T8); 3D printing (T10, T35); graphic calculators like Wolfram Alpha (T12, T13); interactive spreadsheets like Excelets (T7); virtual learning environments like Second Life; applications such as Paper Pool (T20); computers (T22); and animation apps like Stop Motion (T32) are mentioned.

From the questions and/or objectives of the research analyzed, we identified four areas of interest. The first focuses on the potential of digital technologies (DT) for fostering creativity in mathematics. It includes studies reflecting on mathematics learning with DT, emphasizing the role and contributions of different technologies to creativity. These investigations analyze situations involving problem-solving and mathematical tasks using DT, presented as essays or secondary data analyses (T10, T13, T14, T15, T16, T28, T29, T35) or through the observation of mathematics learners, such as primary and secondary school students (T22, T23, T24, T36), mathematics undergraduates (T1, T5, T20, T30, T31), and members of a virtual community (T17). Only in study T6 is the analysis based on the learning experiences of undergraduates in an activity involving music and mathematics in a virtual simulation environment.

The second area examines the potential of DT in teaching mathematics to foster creativity. These studies, conducted within teacher training programs (T2, T9) or presented as essays and secondary data analyses (T4, T8, T12, T21), discuss the role of DT in creativity, evaluating methodologies, practices, and teaching activities in mathematics education involving DT.

Creativity in mathematics through problem-solving with DT represents another focus of the studies. This includes investigations on creativity in mathematical problem-solving contexts with DT, whether involving mathematics undergraduates (T3, T34) or primary and secondary school students (T11).

Finally, the fourth area concerns creativity in designing activities and resources with DT for mathematics teaching. This includes studies addressing creativity in the development of educational activities and resources with DT for mathematics teaching, focusing either on the constructed activity (T3, T7, T25, T26, T27, T33) or the process of creating the activities (T18, T19, T32, T37).

Beghetto (2017), concerning creativity in teaching and learning processes, distinguishes three interrelated forms of creativity in teaching: teaching about, for, and with creativity, each having distinct pedagogical objectives and knowledge bases. In summary, teaching "about" creativity aims to promote understanding of the creative phenomenon and its field of study; teaching "for" creativity aims to develop students' creativity; and teaching "with" creativity aims to teach in a creative manner.

Reflecting on the objectives of the research studies in the *corpus*, based on Beghetto's (2017) distinctions, we identified that teaching for creativity, specifically teaching with DT for creativity, has received more attention compared to creativity in teaching with DT. Additionally, we found no studies focused on teaching about creativity with DT. Based on these areas of interest and aiming to shed light on the key findings regarding the relationship between creativity and working with DT in these studies, we constructed four analytical foci, which we will discuss next: the potential of DT for creativity in mathematics; teaching mathematics with DT for creativity; creativity in mathematics with DT; and creativity in teaching mathematics with DT.[11]

TDs' Potential for Developing Creativity in Mathematics

In this section, we aim to highlight, based on our analysis *corpus*, the potential of students' experience with digital technologies (DT) for the development and expression of creativity. Research points out potential characteristics of DT such as dynamism, interactivity, connectivity, and processing power, which open up possibilities when dealing with problem-

[11] The analyzed publications may address issues related to more than one theme.

solving and mathematical task scenarios, enabling the performance of different actions: a) of an exploratory and experimental nature, such as experiencing and modifying situations; testing conjectures; verifying ideas; visualizing and relating different representations of objects; simulating reality; as well as b) accessing and sharing information. These actions are associated with the possibility of opening up to different perspectives of thinking and acting; the need to relate information and ideas; the opportunity for students to take risks, allowing themselves to make mistakes and encouraging new attempts, as well as fostering opportunities for collaborative creation.

The potential to allow students to see mathematical objects from different perspectives, to test and experiment, is related to the emergence of creativity, mainly by contributing to the articulation of different ideas, concepts, and representations, enabling new perspectives and actions when facing a situation, producing different responses, and varying solutions. Here, creative mathematical thinking is assumed as an intellectual activity that generates new ideas or responses in a non-routine mathematical situation, and the generation of these new ideas demonstrates fluency, flexibility, originality, and elaboration skills.

According to T21, the digital resource referred to as c-book could promote fluency and flexibility by providing students with an environment where they can explore the relationship between geometric situations and algebraic formulas while benefiting from feedback that allows them to control their actions and verify their conjectures. Feedback would enable the production of different and varied situations (flexibility) and assist in breaking the mental fixation we have on representations.

Additionally, the c-book would provide not only digital resources to explore geometric and algebraic aspects of loci studied separately but also what they call communication between dynamic geometry tools and algebra environments, *Cinderella* and *EpsilonWriter*, respectively, which would allow students to experimentally find the algebraic formula corresponding to the geometric locus generated uniquely; this feature would contribute to the development of original approaches by students (originality).

Focusing on the study of flexibility in problem formulation, based on a presented mathematical situation, both by observing different types of problems and different strategies for proposing problems, according to T20's analysis, the use of the *Paper Pool* app is related to the manifestation of greater flexibility in the types of problems. Only students who used the resource proposed problems about something specific (the speed of the ball), and this is due to the presence, in the app's interface, of this component of the presented situation. Therefore, the contribution of DT would relate to influencing the understanding of the mathematical situation, as manipulating the app's interface, which shows the different components of the situation, would facilitate the visualization of the relationships between its components, thus offering more means to vary the problems proposed.

Research T11 analyzes the creativity expressed in the aesthetic choices students make during problem-solving and states that in the SGD, "as students interact with geometric figures and graphs, they naturally make and test conjectures, choose what to construct, what to search for, what to perceive and pay attention to, based on their own imaginations, aesthetic sensibilities, whims, and mathematical thinking" (Gerson & Yu, 2018, p. 352). That is, it is an environment that enhances aesthetic sensibilities through visual interaction and provides students with an environment where they have the freedom to make choices, which is related to allowing them to change perspectives at will, dragging different points, segments, and figures, paying attention to different properties, such as side length, angle, measure, orientation, and symmetry, which can lead them to changes in perspectives or organization of thought in new ways during problem-solving.

T34, when analyzing the flexibility involved in problem-solving with DT, assuming that this refers to changes in ideas and approaches in solving a problem, states that the role of using *GeoGebra* in solutions evaluated as flexible was to assist in advancing the resolution through repetitive modifications, consisting of conditions/characteristics that the solver would change from the first solution onward. In this sense, the tool mainly supported the successive verification of various consequences of conjectures, primarily facilitating the measurement of areas related to a specific consequence.

Working with digital technologies (DT) is also associated with reformulating and recreating, in other words, combining to create something novel. According to T16, the use of *GeoGebra* by students when dealing with constructing proofs of mathematical properties enabled the expression of creativity and authorship when they combined different mathematical ideas to build their proofs using the technology, and through “[...] acts of bricolage, of choice and reasoning, they created mathematical representations” (Fellus & Biton, 2018, p. 522), which were appreciated as unique and innovative by other students. In this study, creativity (in the act of creating a proof) is associated with the combinatorial activity of what is already known and experienced to produce new forms of knowledge representation, occurring when a person imagines, combines, modifies, and creates something.

The opportunity to create and test, enabled by various DT such as data collection and analysis software, automatic response systems, computer simulations, and dynamic geometry software (DGS), allows students to explore mathematical ideas. This is related to what research T9 calls “[...] the reduction of the cost of failure,” as these technologies “allow students to experiment, make mistakes, reflect [...], make changes and try again” (Milner-Bolotin, 2018, p. 257). According to this research, making mistakes is an inherent part of developing creativity. Assuming that creativity involves thinking of new ideas, devising new approaches, stepping off the common path, and eventually taking risks and overcoming obstacles, it argues that this can be achieved if students feel safe to fail and have ample opportunities to try again.

T1, focusing its analysis of creativity on the search for *insights* [12]related to opening new perspectives for existing problems that enable a solution or illuminate a new approach or strategy, states that working with DGS allowed the students, involved in creating an interactive kaleidoscope, to adopt the insight of one of them that they could use not only symmetry but also reflection in the model. This led them to an experimental strategy (which resulted in a solution considered new and useful) where they decided to use reflective symmetry tools in the DGS and examine their results in the model they were building. According to the authors, this was made possible by the technology when they realized that once they had conducted an experiment, if the result did not align with their conceptual perceptions/images, they could revise their work.

[12] According to the author, it would be the thinking or reasoning responsible for the "turn" from impossibility to solvability.

Also attentive to the reversibility potential of DT, we find T10, for whom computational design tools allow users to create and modify their projects without physically creating the product, which they relate to a low risk testing environment. “Objects created in the virtual world can be modified, destroyed, and recreated with a few keystrokes, providing freedom for creativity and idea testing in a safe environment” (Szymanski, 2018, p. 329). In other words, using these DT enables students to test and fail multiple times, which not only fosters learning something new with each interaction but also implements improvements to the product being created. Furthermore, 3D printing would extend this potential by enabling the creation of low-cost prototypes, as “the ability to quickly print a prototype part and test it in the solution provides immediate real-world feedback to students, which also opens the door to creativity as challenges and innovative ways of thinking about the problem emerge from the ability to physically see and manipulate parts of the model” (Szymanski, 2018, p. 338).

For T20, the flexibility in strategies for proposing problems, for instance, varying the data and asking about a general mathematical object or relationship, or varying the data and asking about a specific mathematical object or relationship, is related to the use of DT “[...] due to its potential to facilitate reworking the same process or example, it helps to review what was done, what worked, and what didn’t. This will allow the student to decide which strategy to use for proposing future problems” (Daher & Anabousy, 2018, p. 246).

In this way, we understand that revisiting the process, enabled by DT, can help students reframe errors, reducing the sense of failure often associated with them, which frequently leads students to give up on the activity. Opportunities thus arise to encourage students to take risks, experiment with possibilities, and engage with the task, with this encouragement stemming from the experimentation made possible by DT. In this sense, according to Mann (2006), the fact that students can take risks by testing different possible responses may lead them to solve problems in various ways, propose new mathematical questions, and develop original strategies.

The collaborative aspect is cited in T8 and T10, referring to the fact that DT allows users to share and communicate ideas. T8, analyzing the pathway of how a question was answered in the MESE[13], associates problem posing and solving with creativity, assuming that raising new questions and possibilities or looking at old questions from a new angle requires creative imagination. In light of this, it asserts that collaboration was made possible through the site's potential to facilitate discussion, allowing multiple actors and objects to participate in the creative act. In this case, this included members of the field interacting jointly by sharing and/or responding to questions and the convergence of research sources that contributed to answering the question.

Research T10 involved the group creation of prototypes, where students iteratively developed, tested, and documented their success or failure to overcome the deficiencies in the created products. According to the study, this process could enhance mathematical understanding and creativity. It highlights that sharing virtually created objects allowed them to be manipulated, viewed, tested, and commented on by others, which benefited the creator by providing a better understanding of the content. This is also tied to the notion of social validation, determining whether the product is novel, useful, or valuable.

Thus, we see that working with DT for creativity development is related to the access and sharing of different perspectives enabled by DT—whether working simultaneously and in the same place with others (such as in synchronous remote interaction or in the classroom) or accessing information or perspectives previously shared at another time and place (such as in online repositories, websites, Wikipedia, and others). These opportunities foster creative collaboration.

From the analyses conducted by these studies, it becomes evident that the potential for developing creativity through working with DT in mathematics teaching and learning lies in what they provide for exploration, experimentation, access, and sharing. That is, the discussion on the potential of DT for creativity in mathematics underscores the importance of the experiences enabled by DT.

[13] Mathematics Educators Stack Exchange, a platform where individuals interested in teaching and learning mathematics can raise new questions and engage collaboratively with others who share their interests.

Mathematics Teaching with DT for Creativity

In the previous section, we emphasized aspects of creativity in mathematics that studies indicate benefit from working with or experiencing DT in mathematical learning, such as the potential to connect multiple representations of abstract concepts, ask new questions, link abstract mathematical concepts, apply these concepts to new contexts, and communicate and critique mathematical ideas. What becomes evident is that the contexts for working with DT to foster creativity are not just any context.

According to the analyzed *corpus*, the proposed work in mathematics teaching with DT, aiming to develop creativity, is intrinsically related to the type of tasks/methodology involved. These include problem-solving and problem-posing contexts (T1, T5, T10, T7, T17, T20, T30); investigative, exploratory, open tasks/problems of varying complexity levels (T21, T7); contexts involving collaborative work requiring discussion and negotiation (T1); problems reflecting real-world experiences, allowing diverse solutions and perspectives (T2, T10); and problems not automatically solved by the software but where the role of technology is essential (T12). These are contexts that enable learners to create during the process of learning mathematics: creating a problem, a new pathway to solve a problem, a new solution, or a new understanding. Such experiences help students reorganize and expand their thinking, which can be amplified by working with DT through exploration, experimentation, access, and sharing.

In this sense, T2, while discussing a theoretical framework for developing tasks that offer opportunities for students' creative thinking, argues that these tasks should involve four elements: cognitive complexity, real-world learning, technological integration, and engagement. According to this research, the integration of technology with the other three components should not merely serve as a complement but significantly support the efficient execution of the task, recognizing that "Technology, combined with critical thinking, student engagement, and real-world learning, offers opportunities for students to produce new products to solve authentic problems" (Tassell *et al.*, 2018, p. 74).

T21 identifies characteristics of situations or problems that have the potential to engage students in activities that promote creativity, including open and challenging problem formulation and solving contexts where students are seen as active problem solvers and learners, and social interactions are fostered during the resolution process.

The proposal of collaborative activities involving interaction and idea-sharing is observed by T5, who notes that creativity emerges when, by engaging in an activity with DT and dealing with concepts, students activate prior learning and form new connections that lead to solutions relevant to the given context. This research analyzes that in this type of activity, supported by DGS, students construct shared understanding within their small group and with the whole class.

With this perspective, T14 discusses a pedagogical approach that encourages exploration, collaboration, and discussion, allowing students to use technology to explore reflective thinking and imagination. This approach inherently establishes opportunities for developing creative thinking. In such an approach, students typically work in small groups on activities that explore new mathematical concepts by performing tasks (e.g., writing computer programs or constructing geometric figures), making observations, reflecting, discussing, and negotiating within their groups about what to write as responses for a given "exploration." According to these authors, this supports creativity by encouraging students to reflect on their thoughts and build new mental structures, as the interactions with peers and the instructor can lead to individual insights.

Thus, the studies indicate that what matters for fostering creativity is the type of experience proposed with DT. In this sense, T9 states that DT should be used to support student-led investigations that promote meaningful engagement with mathematics. T13 also highlights the importance of considering the type of questions posed when working with DT, emphasizing that while DT offers multiple possibilities, simply using multimodal software to display multiple representations does not necessarily lead to deeper understanding, insights, or creative action.

Negative aspects of working with DT in mathematics teaching, noted by T12, include the reduction of manual calculation skills and the ease of creating function graphs without understanding their behavior. The authors draw attention to how manual calculations can yield deep insights that provide students with valuable learning and comprehension opportunities.

Thus, they advocate for a complementary role in manual calculations alongside the possibilities offered by DT.

For T12, this dichotomy between positive and negative aspects of technology in mathematics teaching demands strategies that ensure problem-solving outcomes do not solely rely on computational tools for tasks that could be performed manually. Instead, these strategies should introduce problems that motivate conceptual understanding, development, and insightful inference through working with technology.

Reflecting on this, we agree with Loveless (2007), who states that access to digital resources alone does not generate creativity, but rather the promotion of learning environments that offer opportunities and contexts that support creativity. In this regard, Henriksen *et al.* (2016) emphasize that teaching with technologies to foster creativity involves enabling new forms of constructing, representing, communicating, and sharing knowledge, providing opportunities for creative outcomes by and among students. They consider creativity as a *continuum,* wherein fostering creativity in everyday actions generates more opportunities for significant ideas to emerge.

Our review corroborates these authors by affirming those contexts conducive to developing creativity—specifically those involving mathematics teaching and learning supported by experiences with DT—would encourage creation, reflect qualities of exploration and experimentation, allow risk-taking, reframe errors, and enable students to engage with tasks, reflect, and be flexible. Furthermore, they would value collaborative work, allowing students to advance their learning by producing and demonstrating new knowledge that is both useful and appropriate for the situation in which it is applied and serves as a foundation for new learning.

Creativity in Mathematics with DT

Focusing on creativity in mathematics with DT, studies T3, T11, and T34 investigate creativity in the context of problem-solving with DT. Study T3 considers creative activity to be evident when a student manipulates their construction (of a solution), searching for patterns, structure, or invariance, and makes choices: “[...] the application of a familiar mathematical idea [...] in a new context [...] provokes students to reevaluate and extend their own mathematical meanings" (Madden, 2018, p. 101). Thus, "[...] problems are places where information gaps become evident; when students experience this gap, in the presence of tools to deepen investigation, there is the potential for the expression of their creative ideas in new ways to solve problems [...]", which is referred to as "[...] mathematically creative action using technology" (Madden, 2018, p. 93).

According to this author, a solution evaluated as creative and impossible without technology occurred when a student, after using algebraic relationships to generate sets of three random points to test semicircle criteria, verified "her configuration through a visual geometric representation, [...] she devised a way to leverage *Fathom's* numerical resources to geometrically represent three unit circles to determine if her simulation worked correctly, a move that highlights competence and flexibility in representation" (Madden, 2018, p. 103).

In T11, DGS provides students with the freedom to make choices, and the interactions between choice and aesthetic sensitivities make these environments rich for studying creativity in mathematics. It also points out that aesthetic sensitivities are activated both by the representations on the computer screen and by students' actions as they interact with and act upon these representations to create symmetry, form, structure, collinearity, visual appeal, orientation, and order. These sensitivities were observed whenever "[...] students shifted perspectives or organized their thinking in a new way [...]" (Gerson & Yu, 2018, p. 365).

Study T34, in turn, identifies those participants who demonstrated flexibility in solving a problem with the help of *GeoGebra* performed a sequence of actions in the creative process consisting of conjecturing, specializing, verifying consequences with technology, and generalizing. According to this study, creativity is observed through modifications made (conditions/characteristics altered from their initial solution) that led participants to new and different solutions, aiding the flexibility of the creative process, with technology providing support, especially in the successive verification of their conjectures' consequences.

We observe that these studies converge in their notions of creativity in mathematics with DT, linking it to the expression of new ways to solve problems and/or presenting new and distinct solutions to these problems through the efficient and appropriate use of experimentation, visualization, and verification capabilities offered by DT.

Creativity in Mathematics Teaching with DT

Concerning creativity in mathematics teaching with DT, research has been dedicated to investigating the creativity present in the construction of activities and teaching resources with DT for mathematics teaching, focusing on the characteristics of the activity and the process of creating these activities.

Regarding the first focus, study T3 asserts that teachers, when creating learning sequences for their students, did so creatively, aiming to expand their mathematical knowledge. According to T3, in this process, they were able to think about "[...] creating conditions for students [to have] access to important mathematical ideas and resources to enhance that access," meaning that "[...] teachers have been dealing with mathematical problems and tools to generate solutions that are new and useful, that is, creative" (Madden, 2018, p. 119).

According to T3, an activity planned by the teacher with DT is considered mathematically and technologically creative when it involves students in a combination of different exploratory and expressive experiences; allows for multiple solution paths and presents a new technological approach; or when the activity is cognitively demanding and involves a non-routine mathematical context. Additionally, the study highlights that, by considering teachers as designers of these activities, the introduction of new DT can represent a creative act as it introduces something new, useful, and uncommon compared to previous practices.

In T7, tasks produced with the integration of *Excelets* were analyzed based on their potential for fostering creativity and promoting learning. By focusing on the appropriate use of technology and methodologies that encourage exploration and integration of content in the context of creativity, tasks were considered creative when they provided opportunities for students to explore and learn while encouraging independent problem-solving within the mathematical context presented in the *Excelet.*

Similarly, study T33 highlights aspects of creativity in mathematical, pedagogical, and technological dimensions, defining the term “technological creativity” in the educational and mathematical context as “[...] the act of updating products and/or processes with DT [...] using the intention of going beyond what is subjectively recognized in the mathematical, pedagogical, and technological dimensions [...]” (Rosa & Dantas, 2020, p. 124). This research envisions a type of creativity that may emerge from activities produced with DT, considered updated and exploring technological resources for teaching and learning processes, thus enabling diverse paths beyond what is already known (Rosa & Dantas, 2020, p. 9).

From this perspective, it considers that the creativity of one of the participating teachers manifests when “[...] she creates an activity along a new line of reasoning, diverging from what is common, from the classical. She thinks and develops an activity that mixes mathematical content, [...] generating a virtual multiplicity of responses” (Rosa & Dantas, 2020, p. 18), thereby producing something new, at least to her. Another activity is analyzed as technologically creative because pedagogically it goes beyond, not being “[...] confined [...] to closed questions” (p. 17) and is marked by the teacher's intention “[...] to enable fruitful mathematical reflection, so as not to be considered a reproduction” (Rosa & Dantas, 2020, p. 18). In other words, creativity in this study is recognized when a new or different way of presenting and reflecting on mathematical content through DT emerges, as well as when there is pedagogical innovation in how this content is approached.

Also linking creativity to the use of *GeoGebra* for working with mathematical content, study T25 considers as creative the activities built using the potential of this technology and, aiming to introduce new content, offered students opportunities to perform procedures in new situations and develop problem-solving skills, understanding, establishing connections, and making generalizations. Similarly, in T26, the proposal was to integrate *GeoGebra* into a problem-solving situation to analyze creations through the variety of software options, the construction of new and unexpected connections between concepts, and the integration of technology into the solution—offering new ways to visualize parts of the problem's solution, representing an innovative approach, or identifying new spheres of application for *GeoGebra applets*, methods, and configurations.

Thus, these studies identify that creativity in constructing activities with DT relates to the experience in terms of students' learning conditions; involving content in a non-routine, unconventional, or non-classical manner; and innovation in pedagogical practice and the use of technology.

Concerning research focused on the creativity of the process of creating activities with DT, studies T18 and T19 analyze the collaborative creation of pedagogical resources, such as c-books, designed to foster creativity in students' mathematics learning. The resources developed are considered creative based on criteria of novelty, usability, and appropriateness, according to the characteristics and functions of the c-books defined by the group's objectives for the resource.

According to T18, the design process is characterized by social creativity as it involves collaborative “[...] collectives of educational designers with different activity systems, backgrounds, and personal and professional concerns, supported by appropriate technology, which can bring new and alternative ideas, solutions, and implementations” (Essonnier *et al.*, 2018, p. 231). Considering the cultural variables guiding the design of one of the c-books, this study evaluates how time constraints, personal concerns, curriculum standards, and the various profiles and interests of developers influenced decisions during the resource design process.

Similarly, study T19 highlights that diversity in areas of knowledge, perspectives, and cultures was an important factor in driving social creativity, which was enhanced through exchanges and discussions. The role of technology was to facilitate communication and coordination among different perspectives. As teachers negotiated emerging mathematical constructions, they were challenged to reflect and reconsider their beliefs and practices related to what constitutes a challenging and creative mathematical activity, thereby expanding their learning. Similarly, study T32, which explores creativity in creating animations using the *Stop Motion* app, although not premised on collaborative creation by future teachers, states that collaboration among those who chose to work in groups was a vital element in the process of creating the activity. Overcoming challenges such as using tablets and the app was facilitated by support, trust, and interpersonal connections.

Focusing on the creative processes of teachers in constructing activities with DT, T37 considers these processes as acts of reproduction, acts of individual intentionality toward DT leading to technological creativity, and acts inherent to technological creativity. According to the research, these three approaches to working with DT "[...] were revealed through updates in the creative potential of the individual, with the emergence of creativity expanding the subjective domain of those involved [...] in terms of the mathematical, pedagogical, and technological dimensions perceived as a whole" (Dantas, 2015, p. 250).

These studies identify the emergence of collaboration as a mode of working in designing educational resources and as an important element of the creative process. Considering the collaborative creation experience, various factors influencing creativity with DT are noted, including different experiences, backgrounds, objectives, and personal and professional interests.

Reflecting that mathematics teaching encompasses not only the planning of teaching activities but also classroom teaching practices, we identify a gap in research focused on investigating creativity in mathematics teaching with DT concerning the analysis of creativity demonstrated by teachers when teaching mathematics with DT in terms of their classroom practice.

In relation to teacher training aimed at creative teaching and fostering creativity, studies highlight the importance of experiencing creativity during training by experimenting with and creating activities using DT. For instance, study T19, which involves mathematics teachers in all stages of the activity creation process, seeks to provoke reflection on the possibilities and tasks to be proposed, as well as the changes in mathematical content and classroom practices triggered by the presence of technology. Beyond studies focused on creating activities with DT, research such as T1 and T5 emphasizes that for teachers to understand the meaning of creativity, particularly in mathematics, it is necessary to create opportunities for them to experience it and reflect on this experience. According to T7, "[...] preparing teachers to experience mathematics in a creative way for themselves as learners, and then transpose that learning as teachers, is crucial to developing an understanding of creative pedagogy" (Watson & Enderson, 2018, p. 210).

Also supporting the importance of teachers experiencing moments of interaction with technological resources, T33 argues that teacher creativity can be one of the critical elements needed to contribute to the construction of current strategies and activities in teaching and learning processes. Relating this to teaching practice, T9 understands teacher creativity as the potential to expand their pedagogical repertoire by identifying students' learning difficulties and devising (new) pedagogical approaches to help students overcome these difficulties. While some digital resources can be employed in this process, their use must be deliberate and purposeful. Thus, in agreement with Henriksen *et al.* (2016), particularly in the context of mathematics teaching and learning, we understand that since technologies enable new and creative pedagogical practices, educators need to develop their own creativity to teach and learn effectively (to explore the potential of these technologies). Achieving this requires training aligned with this objective.

Conclusions

Aiming to answer our research question—what relationships between creativity and the work with DT are highlighted in studies on this topic within the scope of Mathematics Education, we identified the following main themes of interest in the analyzed corpus: Potential of DT for creativity in mathematics; Teaching mathematics with DT for creativity; Creativity in mathematics with DT; and Creativity in the teaching of mathematics with DT.

Most studies focus on the potential of students' experiences with DT for developing and expressing creativity. They point out that actions such as exploration, experimentation, access, and sharing, carried out through various DT in mathematics teaching and learning contexts, contribute to the development of creativity, primarily linked to: (i) enabling the articulation of information and ideas; (ii) opening perspectives for action when facing a problem or situation; (iii) encouraging risk-taking by reframing mistakes; and (iv) fostering collaboration.

Thus, contexts for working with DT to foster creativity are not arbitrary but are those that, supported by experience with DT, promote creation, reflect qualities of exploration and experimentation, encourage risk-taking by reframing mistakes, and allow students to engage with tasks, reflect, and demonstrate flexibility. Moreover, they should value collaborative work to enable students to advance in their learning, producing and manifesting new, useful, and appropriate knowledge both within the immediate situation and as a foundation for future learning. In this sense, the studies highlight teaching contexts with DT that involve problem-solving and problem-posing, as well as investigative, exploratory, open, and collaborative practices and methodologies.

We understand that these studies associate creativity in mathematics with DT with the efficient use of the potential for creative expression and that creative action can occur in the interaction between students, teachers, and DT. These interactions facilitate cognitive and aesthetic choices.

In the realm of creativity in teaching mathematics with DT, we identified that creativity in designing activities with DT is related to pedagogical innovation, a teaching action with DT that is considered new, useful, and uncommon compared to previous practices. It is also tied to the reasoning and mathematical learning opportunities that the DT experience offers students, as well as the extent to which this experience aligns with and supports the teaching objective and pedagogical intentionality.

Regarding the process of creating activities and pedagogical resources with DT, the collaborative aspect is evident, linking exchanges and discussions to opening new perspectives. This process is influenced by a multitude of factors, including training, curricular standards, personal and professional objectives, and interests. Additionally, teachers' experiences with technological resources in creating activities are highlighted as a formative action aimed at fostering creativity in teaching with DT.

We observed that these studies emphasize the discussion of how DT and working with them in mathematics teaching can enhance students' creative development in mathematics. However, there is a lack of investigation into teachers' creativity in their pedagogical work with these resources. Specifically, in the analyzed sample and the languages consulted, there are no studies focusing on teacher creativity in their classroom practices with DT in mathematics teaching. We, therefore, underscore the need for research focused on developing creativity in teachers' work with DT, particularly addressing the social, physical, and cultural aspects and factors that influence it. This research could support the development of actions within teacher training and public policies, fostering the integration of DT into creative and creativity-focused teaching and learning processes in mathematics.

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