Crenças de autoeficácia de professores que ensinam matemática no nível superior: marcas das tecnologias digitais no ensino emergencial remoto e presencial

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Resumo
O presente artigo objetivou investigar as crenças de autoeficácia dos professores que ensinam matemática no ensino superior da UNIFESSPA (Universidade Federal do Sul e Sudeste do Pará), analisando as suas relações com o uso das TDICs desde a modalidade de ensino emergencial remota à modalidade de ensino presencial. Foi aplicado um questionário de crenças de autoeficácia, que buscou investigar sobre as atividades desenvolvidas pelos docentes, sobre o uso TDICs, as experiências pessoais, o processo formativo inicial e sobre a formação continuada. Como resultados observamos que do questionário de crenças de autoeficácia, tivemos apontamentos de uma crença de autoeficácia moderada com indicativos das principais fontes das crenças sendo as experiências diretas seguidas da persuasão social e experiências vicárias. Por fim, incentivamos que para trabalhos futuros sejam adequadas, adaptadas, construídas e/ou desenvolvidas escalas de crenças de autoeficácia para melhor medir as relações intrínsecas e mais profundas entre os construtos investigados nesta pesquisa.

Palavras-chave: Crenças de Autoeficácia. Ensino de Matemática. Ensino Superior. Tecnologias Digitais da Informação e Comunicação (TDICs).

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Self-efficacy belief of university math professors: Marks of digital technologies on remote and in person teaching

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Abstract

This article aimed to investigate the self-efficacy beliefs of professors who teach mathematics in higher education at UNIFESSPA (Federal University of the South and Southeast of Pará), analyzing their relationships with the use of TDICs from the remote emergency teaching modality to the teaching modality in person. A questionnaire on self-efficacy beliefs was applied, which sought to investigate the activities carried out by professors, the use of TDICs, personal experiences, the initial training process and continuing training. As results, we observed that from the self-efficacy beliefs questionnaire, we had notes of a moderate self-efficacy belief with indications of the main sources of beliefs being direct experiences followed by social persuasion and vicarious experiences. Finally, we encourage future work to adapt, construct and/or develop self-efficacy belief scales to better measure the intrinsic and deeper relationships between the constructs investigated in this research.

Keywords: Self-Efficacy Belief. Math Teaching. Higher education. Digital Information and Communications Technologies (DICTs).

Creencias de autoeficacia de docentes que enseñan matemáticas en un nivel superior: marcas de las tecnologías digitales en la enseñanza de emergencia a distancia y presencial

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Resumen

El presente artículo tiene como objetivo profundizar en la creencia de autoeficacia de los profesores universitarios de matemáticas de la UNIFESSPA (Universidad Federal del Sur y Sudeste de Pará), analizando sus relaciones con el uso de las TIC, desde la enseñanza a distancia de emergencia hasta la enseñanza presencial regular. Habiendo aplicado un cuestionario sobre creencias de autoeficacia, el estudio tuvo como objetivo investigar las actividades desarrolladas por los profesores, el uso de las TIC, las experiencias personales, los procesos formativos iniciales y la formación continua. Los resultados observados en el cuestionario indican una creencia de autoeficacia moderada que se basa principalmente en las experiencias directas, seguida de la persuasión social y las experiencias vicarias. En conclusión, fomentamos el ajuste, adaptación y desarrollo de escalas de creencias de autoeficacia para trabajos futuros, con el fin de medir mejor las relaciones intrínsecas y profundas entre los constructos estudiados en esta investigación.

Palabras clave: Creencias de autoeficacia. Enseñanza de las Matemáticas. Enseñanza superior. Tecnologías Digitales de la Información y la Comunicación (TDIC).

Introduction

In the past 20 years, there has been a significant shift in how society consumes and disseminates information globally. This has made the speed and reach of digital information and communication technologies (DICTs) even more crucial in people's daily lives, both in their personal and professional spheres, as well as in education.

During this same period, the use of digital information and communication technologies (DICTs) in education, particularly in mathematics education, has been widely discussed by various authors in the field of Mathematics Education (ALMEIDA, 2000; BAIRRAL, 2018; BATISTA, 2016; BELINE and COSTA, 2010; BORBA and PENTEADO, 2012; BORBA, SILVA, and GADANIDIS, 2015; LÈVY, 1999; NETO, 2007; OBATA, MOCROSKY, and KALINKE, 2018; PEIXOTO et al., 2015; SILVA and GRACIAS et al., 2000; VALENTE, 1999). All these authors highlight that the educational field cannot remain indifferent to the changes that are occurring.

In this new context, the years 2020 and 2021 were marked by a pandemic caused by COVID-19. which drastically transformed how educational institutions managed digital information and communication technologies (DICTs). During this period, Brazilian institutions adopted an emergency educational model using digital educational resources, according to Portaria Nº 343. dated March 17. 2020. from the Ministry of Education. This model, which does not permanently replace in-person education, was (and still is) referred to by universities in the country as Emergency Remote Teaching, where classes occurred synchronously and asynchronously. This was the method and means that educational institutions found to maintain their activities in the face of social distancing imposed by the pandemic.

In particular, at the Federal University of South and Southeast Pará (UNIFESSPA), Resolution Nº 500. dated August 12. 2020. was published, which addresses the Emergency Academic Period (EAP). This approach caught many professors by surprise, as they suddenly had to adapt to the new challenges imposed by the situation and interact with DICTs more frequently and, in some cases, for the first time, engaging with a Virtual Learning Environment (VLE).

With the aim of investigating the judgment of the university's faculty regarding both in-person and remote teaching modalities using digital technologies, this article, arising from the master's research of one of the authors, seeks to present the procedures, data, and results obtained, and discuss how beliefs in self-efficacy were influenced by the use of ICTs, especially in the years 2020 and 2021.

To this end, the study utilized the construct of self-efficacy beliefs, grounded in Albert Bandura's Social Cognitive Theory (Bandura, 1997) and the research of Pinheiro (2018) and Coutinho (2020), among others.

It is important to highlight that some authors, such as Hodges et al. (2020) and Fuchs (2022), distinguish between Emergency Remote Teaching and Distance Education (EaD). However, Paiva (2020) views that the various terminologies for face-to-face teaching serve as defensive barriers due to the prejudice against EaD, even in Brazilian legislation. For this reason, we have sought to avoid using EaD-related contributions in the theoretical framework to avoid such conflicts, as it was not the focus of this research.

The research presented in this article is both qualitative and quantitative, as it involves textual data and the use of statistical tools for inferences about the investigated constructs (Creswell, 2010). It was conducted at the Federal University of South and Southeast Pará with faculty members who teach mathematics courses at the institution. The data collection instruments included a participant characterization questionnaire, a teacher self-efficacy beliefs questionnaire, and a qualitative questionnaire that complemented the self-efficacy beliefs questionnaire with personal responses.

To provide a solid foundation for the research topic, we present a theoretical framework and justify the novel nature of the study by the state of the art, as we did not find any research with the same content in the Capes Thesis and Dissertation Bank, although similar ideas helped guide our research process.

Theoretical Framework

As a starting point, it is evident that the research is based on Albert Bandura's Social Cognitive Theory (SCT) (Bandura, 1995. 1997. 2008a, 2008b), particularly concerning self-efficacy beliefs. Following this, the framework will address Digital Information and Communication Technologies (DICTs) and their role in mathematics education, as well as review research conducted on teacher self-efficacy beliefs and the use of digital technologies.

Albert Bandura's Social Cognitive Theory and Self-Efficacy Beliefs

Albert Bandura's Social Cognitive Theory, developed and disseminated by the Canadian psychologist Albert Bandura (1925–2021), provides a robust theoretical framework for understanding the individual's perception as part of a group or environment and the influences resulting from their interaction. Unlike other theories of human functioning, "social cognitive theory adopts the perspective of agency for self-development, adaptation, and change" (BANDURA, 2008a, p. 15). In this view, the agent actively influences their own functioning and life circumstances, being proactive, self-reflective, and self-organizing, rather than merely a product of their circumstances. As Bandura puts it

> Human agency encompasses several fundamental characteristics. The first of these is intentionality. People form intentions that include plans and strategies for achieving them. The second characteristic involves the temporal extension of agency through anticipation. This encompasses more than just making plans directed toward the future. Individuals set goals for themselves and anticipate the probable outcomes of prospective actions to guide and motivate their efforts in advance. Although the future cannot directly cause current behavior due to its lack of material existence, imagined futures, represented cognitively in the present, serve as current guides and motivators for behavior. Agents are not only planners and predictors but also self-regulators. They adopt personal standards, monitoring and regulating their actions through self-reactive influences. They engage in activities that bring them satisfaction and a sense of self-worth, avoiding actions that lead to self-censorship. People are not merely agents of action but also self-investigators of their own functioning. Through functional self-awareness, they reflect on their personal efficacy, the integrity of their thoughts and actions, and the meaning of their pursuits, making adjustments as necessary. Anticipatory thinking and self-influence are integral parts of this causal framework (BANDURA, 2008a, p. 15 -16).

Bandura asserts that individuals are not merely passive observers in their environments; they are both observers and active agents of the experiences they undergo and construct. While it is true that adverse and uncontrollable situations exist, the fundamental abilities of reflection, planning, anticipation, and evaluation are crucial in coping with life's challenges. These capabilities are significant in performing tasks and actions necessary to achieve one's goals (BANDURA, 2008a).

Coutinho (2020) argues that:

> Unlike theories that emphasize the role of environmental and biological factors in the development of learning and human behavior, Social Cognitive Theory (SCT) proposes an explanatory model in which human behavior results from a constant interaction between the individual and the environment (COUTINHO, 2020. p. 29).

The fact is that exploring one's own cognitions and personal beliefs, as well as evaluating and altering one's own behavior (and thought), is considered by Bandura to be the most distinctly human capacity since it is essentially exercised through self-beliefs (beliefs that a person has about

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themselves). According to Coutinho (2020), these self-beliefs play a fundamental role in human agency, as they allow individuals to "exercise self-control over their thoughts, feelings, and actions" (COUTINHO, 2020. p. 31).

At the core of SCT, this research highlights self-efficacy beliefs, which Bandura (1997) describes as personal beliefs about one's abilities to organize and execute the courses of action required to achieve specific goals. For Bandura, motivation, affective state, and people's actions are based on what they objectively believe they are capable of, making self-efficacy beliefs central to the investigation of this construct of human functioning. Regarding the valuation of this theme, Nunes (2008) points out that:

> These beliefs are very important, as they influence the choices of courses of action undertaken, the amount of effort exerted toward their goals, how long they will persevere in the face of obstacles and failures, their resilience to adversity, their patterns of self-impeding or self-supporting thought, the level of stress and depression experienced with environmental demands, and ultimately, the level of achievement they reach (NUNES, 2008. p. 30).

From Bandura's (1997) perspective, self-efficacy is seen as the individual's perception of their capabilities to perform a specific activity. According to Costa (2003), this perception refers to the beliefs that an individual has about their own ability to organize and execute specific and desirable actions to handle a variety of complex situations, including prospective ones, in order to achieve all their goals. Beyond these capabilities, this perception of self-efficacy has other influences on human behavior, such as "patterns of emotional and cognitive reactions, expected outcomes, anticipatory behavior, and constraints on one's own performance" (BARROS, BATISTA-DOS-SANTOS, 2010. p. 3).

Martínez and Salanova (2006) tell us that self-efficacy beliefs are constructed based on judgments of one's own capabilities. Thus,

> With the same capabilities, individuals with different beliefs may experience success or failure depending on these differences in beliefs. Therefore, self-efficacy is seen as personal beliefs; the individual exhibits high or low levels of self-efficacy according to their own judgments regarding their capabilities. In forming these judgments about their own abilities, the individual may consider various factors that contribute to the increase or decrease of their beliefs (BARROS; BATISTA-DOS-SANTOS, 2010. p. 3).

Thus, according to Azzi and Polydoro (2006), since these beliefs are intrinsically linked to specific domains, having high self-efficacy in one domain may mean the opposite in another.

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From the perspective of Social Cognitive Theory (SCT), self-efficacy can be viewed both from the perspective of human agency and, according to reciprocity, where the individual is allowed to influence and be influenced in their behavior (Barros & Batista-Dos-Santos, 2010).

The beliefs a person has about their efficacy arise from four main sources of influence (sources of self-efficacy beliefs): mastery experiences, vicarious experiences, social persuasion, and emotional (affective) and physiological states (Bandura, 1997).

According to Bandura (1997) and reaffirmed by Pajares and Olaz (2008), the most influential source of self-efficacy is mastery experiences, also called direct experiences by Pinheiro (2018) and success experiences by Coutinho (2020). These experiences are based on the individual's past behavior (Pajares & Olaz, 2008). Thus, when performing certain tasks or activities, people make interpretations and use their results to assess their capabilities for future actions, acting according to the beliefs formed in the process. According to Pajares and Olaz (2008)

> Results interpreted as successful increase self-efficacy, whereas those interpreted as failures reduce it. Of course, individuals with a low sense of self-efficacy often downplay their successes rather than changing their beliefs. Even after achieving a goal through persistent effort, some individuals continue to doubt their efficacy to make similar efforts (PAJARES; OLAZ, 2008. p. 104).

Regarding mastery experiences, Coutinho (2020) states that even with failure, the effects on self-efficacy are not always negative, as experiences of success over time tend to mitigate the impact of negative experiences. "Since the individual, based on various previous successes, may not let a temporary failure demotivate them" (COUTINHO, 2020. p. 32).

In any case, developing such (positive or negative) efficacy beliefs through mastery experiences involves not just adopting acquired habits but also developing the cognitive, behavioral, and self-regulatory tools essential for creating and executing appropriate courses of action to manage adverse life situations, constantly adjusting one's approach. For Bandura (1997), if people only experience easy successes, they begin to expect quicker results and are easily discouraged by failure. Therefore, to have a resilient sense of efficacy, one must overcome obstacles, recognizing that some difficulties and setbacks encountered throughout life are intended to teach that success generally requires continuous effort. Convincing oneself that they have what it takes to succeed enables individuals to persevere in the face of adversity and recover quickly from setbacks, becoming stronger (BANDURA, 1997).

The second way to build self-efficacy beliefs is through vicarious experiences provided by social models, that is, characterized by observing the performance of other individuals. This source is considered weaker compared to the former, according to Pajares and Olaz (2008), as it requires a social model to be observed, with similar situations and desired outcomes for the observer.

For Bandura (1997), seeing people achieve success in their courses of action through persistent effort generates, in the observer, a heightened sense of self-efficacy and belief in their ability to overcome similar tasks and activities. Similarly, observing others' failures can generate uncertainties about the observer's own abilities, directly impacting their motivation and self-efficacy beliefs.

Thus, watching similar social models can influence people's beliefs both positively and negatively. It is also worth noting that:

> When people perceive the attributes of models as very different from their own, the influence of vicarious experiences is significantly reduced. It is important to note that people seek out models who possess qualities they admire and abilities they aspire to. A significant model in an individual's life can help instill personal beliefs that will influence the direction and meaning that life should take (PAJARES; OLAZ, 2008. p. 105).

Another source of self-efficacy beliefs to consider is social persuasion or verbal persuasion (COUTINHO, 2020). This source generates self-efficacy from verbal judgments received from other people. According to Pajares and Olaz (2008), such judgments should not be confused with mere praise or motivational words. For social persuasion to effectively increase an individual's self-efficacy beliefs, it must involve positive judgments about the person's ability to perform specific tasks and activities, ensuring that the desired success can be achieved.

According to Pajares and Olaz (2008), "persuaders play an important role in the development of an individual's beliefs" (p. 105). Just as positive verbal judgments strengthen people's beliefs, the opposite can also occur, meaning negative persuasions can lead to frustration and weaken self-efficacy beliefs. According to Bandura (1997), it is more difficult to instill high self-efficacy beliefs through social persuasion than to strengthen them because unrealistically high beliefs are quickly contradicted by failed results.

The fourth source of self-efficacy beliefs is emotional (affective) and physiological or somatic states, according to Pajares and Olaz (2008). States such as anxiety, stress, excitement, fatigue, fear,

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increased heart rate, and mood, for example, also provide judgments about the person's abilities and beliefs.

Stress and tension reactions can be perceived as signs of vulnerability and low performance. In physical activities, fatigue and pain may be interpreted by the individual as weakness. Finally, mood also affects people's judgment about their beliefs, meaning that a positive mood enhances the perception of self-efficacy, whereas a negative mood diminishes it (Bandura, 1997). In general:

> When people have negative thoughts and fears about their abilities, affective reactions can reduce self-efficacy perceptions and trigger more stress and agitation, which contribute to inadequate and feared performance. One way to enhance self-efficacy beliefs is to promote emotional well-being and reduce negative emotional states. As individuals have the ability to alter their own thoughts and feelings, fostering self-efficacy beliefs can powerfully influence their physiological states (PAJARES; OLAZ, 2008. p 105).

It is important to highlight that the sources of self-efficacy are not directly translated into competency evaluations. The individual's judgment about the information that underpins these sources, as well as the rules of assessment and integration, are part of the interpretative basis performed by the person. "Thus, the selection, integration, interpretation, and recollection of information influence self-efficacy judgments" (PAJARES; OLAZ, 2008. p. 105).

Differentiation of Self-Efficacy and Other Mental Constructs

According to Pinheiro (2018), self-efficacy beliefs need to be differentiated from other mental constructs due to potential confusions in their interpretations. Among the concepts to be distinguished from self-efficacy are self-concept and self-esteem.

Since self-efficacy beliefs and self-concept have conceptual similarities, Pajares and Olaz (2008) state:

> Self-efficacy beliefs are cognitive judgments of competence, referenced by goals, relatively specific to the context, and future-oriented, and are relatively malleable due to their task dependence. On the other hand, beliefs related to self-concept are primarily affective personal perceptions, quite normative, generally aggregated, hierarchically structured, and oriented toward the past, which are relatively stable due to their sense of generality (PAJARES, OLAZ, 2008. p. 112).

According to Coutinho (2020), both self-efficacy beliefs and self-concept are related to the individual and personal characteristics of the subjects. In summary, "self-concept is a judgment about personal competence, while self-efficacy is a judgment about confidence in that competence"

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(COUTINHO, 2020. p. 36). Batista-dos-Santos (2010) describes self-concept as a result of the interaction between the individual and the environment, shaped by personal experiences from childhood and by the individual's self-view developed through experiences and feedback from close others.

Regarding self-esteem, Coutinho (2020) states that "this construct is much more related to feelings of self-worth, which may not be connected to the individual's capabilities" (COUTINHO, 2020. p. 36). According to Barros and Batista-dos-Santos (2010), although self-esteem and self-efficacy beliefs are closely related, they do not necessarily mean the same thing. The authors believe that self-esteem reflects what a person feels and thinks about themselves, and can be related to many aspects, both positive and negative, such as liking oneself and feelings of acceptance or rejection regarding one's way of being. In contrast, self-efficacy is seen as the belief in one's own capacity (BARROS and BATISTA-DOS-SANTOS, 2010. p. 05-06).

Understanding the differences between these constructs is crucial for grasping what self-efficacy beliefs are. Despite conceptual similarities, each contributes in its own way to personal beliefs and needs to be considered within its respective conceptual framework to perceive its influences on human behavior amidst the complexities of daily situations.

Digital Information and Communication Technologies in Mathematics Education

The use of Digital Information and Communication Technologies (DICTs) in education, particularly in mathematics education, has been a subject of intense discussion over the past 20 years. The literature presents various perspectives on the potential dangers as well as the contributions, challenges, and prospects of using digital technologies in the teaching and learning process (ALMEIDA, 2000; BELINE & COSTA, 2010; BORBA & PENTEADO, 2012; BORBA, SILVA & GADANIDIS, 2015; LÈVY, 1999; NETO, 2007; PEIXOTO et al., 2015; SILVA & GRACIAS et al., 2000; VALENTE, 1999).

Most of these authors highlight, in their own way, the importance and challenges of implementing technology in education. However, a common theme is that technology alone does not resolve the daily problems faced in classrooms. Additionally, authors such as Lèvy (1999), Borba and Penteado (2012), Valente (1999), Obata, Mocrosky, and Kalinke (2018), and Bairral (2018) advocate

for a philosophy regarding the use of DICTs in education that focuses not just on the advent of new technology but on how it can be manipulated, integrated, and appropriated within education as a whole, transforming from a mere tool into an object/space for (re)constructing knowledge.

According to Obata, Mocrosky, and Kalinke (2018), merely having technological equipment and teachers' access to it is not sufficient to ensure that teaching and learning are truly affected by technology. Furthermore:

> The "technological" aspect that characterizes the era we live in often highlights the understanding that society increasingly relies on technological apparatus to facilitate the dissemination of information and communication among people. Based on this understanding, we might ask: if this is the case, should the role of teaching simply be to manage the influx of information coming our way? But who provides this information? How is it produced? What kind of communication is possible in this technological world? Furthermore, how does the school experience this movement, or how is the school pulsating within this technological society? The school is alive, dynamic, and, as such, has the potential to change, given that it exists as an institution, carrying with it the complexities that permeate people's live (OBATA, MOCROSKY e KALINKE, 2018. p. 2).

Even though, according to the authors, there are no ready answers to these questions, the discussion about technology and education should always be maintained, so that research and discussions on the topic remain prominent. This ongoing discourse serves as a foundation, a source of concern, and an inspiration for further studies and debates, with the aim of contributing to education in academic institutions.

> So, what is technology? There can be various answers, but which one satisfies our educational curiosity? Batista and Mocroscky (2016) also question the use of technology, defining it as follows: "The use of technology by humans is something that has accompanied them since the moment man picked up a stick or a chipped stone and used it as a tool for his own benefit. (BATISTA e MOCROSCKY, 2016. p. 42).

According to Kenski (2008), the term "technology" extends far beyond what we typically think of as equipment and devices. As the author explains:

> We are very accustomed to referring to technology as equipment and devices. In fact, the term 'technology' encompasses much more than just machines. The concept of technology includes the entirety of things that human ingenuity has managed to create throughout the ages, their forms of use, and their applications (KENSKI, 2008. p. 20)

Technology encompasses everything we have at our disposal to facilitate and solve various human problems. Thus, equipment, instruments, resources, products, processes, tools, algorithms, among many others, can all be considered forms of technology.

Kenski (2008) asserts that, broadly speaking, technology equates to power, and there has long been a strong connection between knowledge, power, and technology "throughout all eras and across all types of social relationships" (KENSKI, 2008. p.14). According to the author, education also forms this link, serving as a powerful mechanism that connects knowledge, power, and technology. In other words:

> From a young age, a child is educated within a specific cultural and familial environment, where they acquire knowledge, habits, attitudes, skills, and values that define their social identity. The way they express themselves verbally, how they eat and dress, and how they behave both inside and outside the home are results of the educational power of the family and their environment. Similarly, schools also exert their influence over knowledge and the use of technologies, which mediate between teachers, students, and the content to be learned (KENSKI, 2008. p. 16).

The fact is that, despite all these connections, education and technology should never be viewed as separate entities. Batista and Mocrosky (2016), in their questions about what technology is, make an analogy to its use in the classroom and the potential to expand the range of didactic resources for teaching. According to this reasoning, any material used with the purpose of imparting knowledge to students can be considered educational technology. Therefore, the use of computers and their accessories is seen as technological tools that complement education. The use of computers and the internet has provided diverse methods of teaching and learning, becoming powerful tools for the democratization of education (BATISTA, 2016).

Another interesting way to view the relationship between education and technology is from the perspective of the socialization of innovation. According to Kenski (2008), for an innovative technology to be internalized, accepted, and used by others, it needs to be taught. Any discoveries and innovations in this regard must be communicated and learned. It is not sufficient merely to disseminate them; we must learn how to utilize these various technological resources, processes, and equipment.

It is noteworthy that, once such innovations are assimilated, they cease to seem like technology. As Kenski (2008) points out, their incorporation into our daily lives makes them invisible, becoming part of the knowledge and skills we use within our limits and needs.

However, what makes digital technology suitable for education? Borba, Silva, and Gadanidis (2014) provide a retrospective of what they term as the phases of digital technologies in mathematics education. They present four phases that overlap and integrate but show significant advancements between them. The first phase was characterized by the use of LOGO software and the adoption of computer labs in schools. The fourth phase, which we are experiencing now, involves improved access and speed of the internet. "Since then, the quality of connection, the amount and type of internet resources, have been enhanced, transforming online communication" (p.35). In this context, Kenski (2008) notes that:

> Most technologies are used as aids in the educational process. They are neither the object, nor the substance, nor the purpose of education. Instead, they are present throughout every stage of the pedagogical process, from the planning of subjects and curriculum development to the certification of students who complete a course. The presence of a specific technology can induce profound changes in how teaching is organized. For example, teaching a language solely based on textbooks and the teacher's pronunciation in lecture-based classes will differ significantly from the same teaching approach with additional support, such as dialogues, conversations, and communicative exchanges between students, along with the use of videos, cassette tapes, and interactive labs (KENSKI, 2008. p. 43-44).

In this way, it is evident that a reality to be understood and constantly debated is the pedagogical incorporation of technologies, especially digital technologies. This includes how to use technologies in the teaching and learning process and how teachers perceive the adoption of DICTs at all educational levels, along with the benefits and limitations that may arise.

Methodological Design

The methodology used for the research adhered to the mixed-methods approach (quantitative-qualitative/qualitative-quantitative), as outlined by Creswell (2010) and Creswell and Creswell (2018). This approach involves:

> […] a research approach that combines or integrates qualitative and quantitative forms. It involves philosophical assumptions, the use of both qualitative and quantitative approaches, and the blending of these approaches in a single study. Thus, it is more than just the simple collection and analysis of both types of data; it also involves using both approaches together, so that the overall strength of a study is greater than that of qualitative or quantitative research alone […] (CRESWELL, 2010. p. 27).

Generally, the research employed multimethod strategies (CRESWELL, 2010). This included a survey that provided a quantitative/numerical description of the studied events (variable of self-

efficacy beliefs), followed by a case study aimed at in-depth investigation of these events and processes related to the research (CRESWELL, 2010).

The research was an exploratory (non-experimental) study, as it aimed to understand and better grasp the research subject in relatively unexplored contexts (GIL, 1999). Its goal was to investigate possible correlations between self-efficacy beliefs and the judgments made by higher education Mathematics teachers, particularly in relation to the use of digital information and communication technologies in both remote and in-person teaching modalities, as well as their perspectives on their teaching roles.

The research problem focuses on the following question: *How do Mathematics teachers at the Federal University of South and Southeast Pará assess their self-efficacy in relation to the use of digital information and communication technologies in remote and in-person classes?* The specific objectives can be outlined as follows:

● Understand the relationship between teachers' self-efficacy beliefs and remote classes, including the methodologies adopted;
● Identify possible factors influencing teachers' self-efficacy beliefs regarding teaching mathematics using technology in remote classes;
● Compare teachers' beliefs in remote and face-to-face classes.

The research was conducted at the Federal University of the South and Southeast of Pará (UNIFESSPA), across all its campuses located in the municipalities of Marabá, Rondon do Pará, Xinguara, São Félix do Xingu, and Santana do Araguaia in the state of Pará. The participants were 13 professors from these campuses. The instrument used to achieve the research goals, and presented in this article, was a self-efficacy beliefs questionnaire for teachers, which was reviewed by expert judges in the areas of Portuguese Language, Mathematics Education, and Digital Information and Communication Technologies.

It is important to note that emails were sent to participants to inform them about the research's virtual page and the forms to be completed (Informed Consent Form - TCLE and the Research Form, which included the questionnaires and the characterization form) to ensure that they were participating in a legitimate study approved by the Research Ethics Committee in Humans of the Institute of Health Sciences of the Federal University of Pará (CEP-ICS/UFPA) under Opinion No.

5.325.872 and with the Certificate of Presentation for Ethical Appreciation - CAAE n.º 55833522.5.0000.0018.

Presentation of the Self-Efficacy Beliefs Questionnaire and Discussion of Results

This article primarily focuses on discussing the results, in accordance with the research theme and the title of this text, from the self-efficacy beliefs questionnaire administered to 13 (thirteen) faculty members at the Federal University of Southern and Southeastern Pará. To avoid disclosing the participants' names, the faculty members will be referred to as P1 to P13.

The questions in the odd-numbered items focus on face-to-face teaching, while the even-numbered items address emergency remote teaching. The items from Q1 to Q18 in Table 1 were categorized as follows: *those dealing with the activities developed by the faculty* (Q1. Q2. Q3. Q4. Q9. Q10. Q11. Q12. Q13. Q14. Q15. Q16); *those concerning the use of digital technologies* (Q5. Q6); *those related to personal experiences and initial formative process, known as direct experiences* according to Pinheiro (2018) (Q7. Q8); and *those related to ongoing professional development*, specifically continuous qualification in the area of digital information and communication technologies (Q17. Q18).

The responses to be marked were based on questionnaires using a Likert scale, following the frameworks of Brito (1996), Pinheiro (2018), and Coutinho (2020). Therefore, the items to be marked in the questionnaire correspond to: ( ) strongly agree ( ) agree ( ) disagree ( ) strongly disagree, as shown in Table 1. The scoring for these items follows the guidelines found in Tortora (2019) and Silva (2021). Specifically, the score assigned to each marked response ranges from 1 to 4. with 1 being "strongly agree," 2 being "agree," 3 being "disagree," and 4 being "strongly disagree." Thus, with scores ranging from 1 to 4 for each item, the minimum possible score for each participant's self-efficacy beliefs is 18 points (1x18) and the maximum is 72 points (4x18). The average score was 45 points ((18+72)/2).

After the questionnaire was administered, it was possible to tabulate the absolute (N) and percentage (%) frequencies to present the collected information in a compact form.

Table 1 Frequencies of Responses for Items Q1 to Q18 of the Self-Efficacy Questionnaire

Items	Responses	Frequencies	
		N	(%)
Q1. I believe I am capable of planning lessons or pedagogical activities that enable the learning of concepts of the subject(s) I teach to students in the face-to-face modality.	Strongly Agree	10	76.9
	Agree	3	23.1
	Disagree	0	0
	Strongly Disagree	0	0
Q2. I believe I am capable of planning lessons or pedagogical activities that enable the learning of concepts of the subject(s) I teach to students in the remote modality.	Strongly Agree	3	23.1
	Agree	9	69.2
	Disagree	1	7.7
	Strongly Disagree	0	0
Q3. I believe I am capable of conducting classes or pedagogical activities that enable the learning of concepts in the subject(s) I teach to students in the in-person modality.	Strongly Agree	11	84.6
	Agree	2	15.4
	Disagree	0	0
	Strongly Disagree	0	0
Q4. I believe I am capable of conducting classes or pedagogical activities that enable the learning of concepts in the subject(s) I teach to students in the remote modality	Strongly Agree	4	30.8
	Agree	6	46.2
	Disagree	3	23.1
	Strongly Disagree	0	0
Q5. I believe I am capable of using Digital Information and Communication Technologies for teaching concepts in the subject(s) I teach to students in the in-person modality..	Strongly Agree	3	23.1
	Agree	10	76.9
	Disagree	0	0
	Strongly Disagree	0	0
Q6. I believe I am capable of using Digital Information and Communication Technologies for teaching concepts in the subject(s) I teach to students in the remote modality..	Strongly Agree	4	30.8
	Agree	7	53.8
	Disagree	2	15.4
	Strongly Disagree	0	0
Q7. I am confident that the experiences during my formative process have influenced the development of my competence to teach Mathematics in Higher Education in the in-person modality.	Strongly Agree	6	46.2
	Agree	6	46.2
	Disagree	1	7.7
	Strongly Disagree	0	0
Q8. I am confident that the experiences during my formative process have influenced the development	Strongly Agree	0	0
	Agree	5	38.5

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Items	Responses		Frequencies
of my competence to teach Mathematics in Higher Education in the remote modality..	Disagree	6	46.2
	Strongly Disagree	2	15.4
Q9. I am confident that when I develop activities for the subject(s) I teach to students in the in-person modality and do not achieve the expected results, it affects what I think about my ability to teach mathematics..	Strongly Agree	3	23.1
	Agree	3	23.1
	Disagree	5	38.5
	Strongly Disagree	2	15.4
Q10. I am confident that when I develop activities for the subject(s) I teach to students in the remote modality and do not achieve the expected results, it affects what I think about my ability to teach mathematics.	Strongly Agree	2	15.4
	Agree	3	23.1
	Disagree	5	38.5
	Strongly Disagree	3	23.1
Q11. I am confident that students are interested in and engage with the activities proposed based on the subjects I teach in the in-person modality	Strongly Agree	7	53.8
	Agree	5	38.5
	Disagree	1	7.7
	Strongly Disagree	0	0
Q12. I am confident that students are interested in and engage with the activities proposed based on the subjects I teach in the remote modality	Strongly Agree	1	7.7
	Agree	7	53.8
	Disagree	2	15.4
	Strongly Disagree	3	23.1
Q13. I am confident that the college where I am a faculty member provides all the support necessary for the activities of the subject(s) I teach to occur satisfactorily in the in-person modality	Strongly Agree	6	46.2
	Agree	6	46.2
	Disagree	0	0
	Strongly Disagree	1	7.7
Q14. I am confident that the college where I am a faculty member provides all the support necessary for the activities of the subject(s) I teach to occur satisfactorily in the remote modality	Strongly Agree	0	0
	Agree	6	46.2
	Disagree	3	23.1
	Strongly Disagree	4	30.8
Q15. I am confident that I have the necessary equipment, connection, and software for the activities of the subject(s) I teach to occur satisfactorily in the in-person modality..	Strongly Agree	1	7.7
	Agree	7	53.8
	Disagree	5	38.5
	Strongly Disagree	0	0
Q16. I am confident that I have the necessary equipment, connection, and software for the activities of the subject(s) I teach to occur satisfactorily in the remote modality.	Strongly Agree	1	7.7
	Agree	5	38.5
	Disagree	4	30.8
	Strongly Disagree	3	23.1
Q17. I am confident that I seek qualified training in relation to digital information and communication technologies (DICTs) with the aim of using them in the activities of the subjects I teach in the in-person modality.	Strongly Agree	5	38.5
	Agree	6	46.2
	Disagree	0	0
	Strongly Disagree	2	15.4
Q18. I am confident that I seek qualified training in relation to digital information and communication	Strongly Agree	4	30.8
	Agree	5	38.5

Items	Responses	Frequencies	
technologies (DICTs) with the aim of using them in the activities of the subjects I teach in the remote modality.	Disagree	2	15.4
	Strongly Disagree	2	15.4

Source: Prepared by the author.

Table 1. of an illustrative nature shows how teachers responded to questions about self-efficacy beliefs and their own judgments regarding teaching mathematics in both teaching modalities. Looking at each of the questions above, there is a tendency, albeit "immature" observation of the data, for responses to be quite different, with lower percentages of agreement when it comes to the emergency remote teaching modality. Figure 1 and Graph 1 complement Table 1 as they provide a broader view of the direction in which the responses of teachers P1 to P13, regarding the presented questions, are trending.

The statistics conducted for the responses to the self-efficacy questionnaire items used corresponding values from 1 to 4 with the same distribution: 1. *Strongly Agree*, 2. *Agree*, 3. *Disagree*, and 4. *Strongly Disagree*. Therefore, the means, medians, and standard deviations (Figure 1), as well as the mean and median graphs (Graph 1), provide relevant initial information about the level of certainty of the beliefs of the surveyed teachers.

Regarding the self-efficacy beliefs of the teachers P1 to P13 in the study, and according to Tortora (2019) and Silva (2021), we consider that a participant has a low level of self-efficacy beliefs if their score is below 45 points, and we would describe this as a negative self-efficacy belief. Scores above 45 indicate a high level of self-efficacy beliefs, and in this case, we would describe the self-efficacy belief as positive. Following the recommendations from Tortora (2019) and Silva (2021), the closer the score is to the minimum score of 18, the less intense the self-efficacy belief is, and the closer it is to 72, the more intense it will be (Figure 2).

Figure 1 - Statistics of Q1 to Q18 from the Self-Efficacy Beliefs Questionnaire

Estatística Descritiva

	N	Média	Mediana	Desvio-padrão
Q1	13	3.77	4	0.439
Q2	13	3.15	3	0.555
Q3	13	3.85	4	0.376
Q4	13	3.08	3	0.760
Q5	13	3.23	3	0.439
Q6	13	3.15	3	0.689
Q7	13	3.38	3	0.650
Q8	13	2.23	2	0.725
Q9	13	2.54	2	1.050
Q10	13	2.31	2	1.032
Q11	13	3.46	4	0.660
Q12	13	2.46	3	0.967
Q13	13	3.31	3	0.855
Q14	13	2.15	2	0.899
Q15	13	2.69	3	0.630
Q16	13	2.31	2	0.947
Q17	13	3.08	3	1.038
Q18	13	2.85	3	1.068

Source: Created by the author using JAMOVI software.

Graph 1 - Scatter Graph of the Mean and Median Values, respectively.
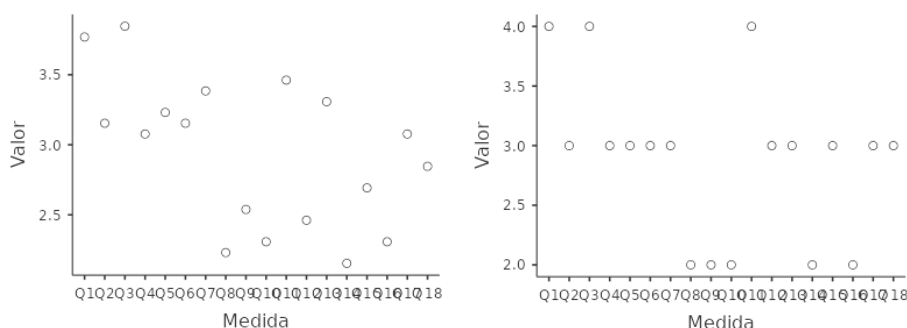
Source: Created by the author using JAMOVI software.

The central point is that, upon examining Graph 1, we get the sense that the perceptions the educators have about their abilities to perform their activities, i.e., their self-efficacy beliefs, seem to be affected and/or influenced by the fact that their activities and the use of digital information and communication technologies (DICTs) are so intense both during and after the emergency remote teaching (ERT) period. Most of the responses are concentrated in the areas between "Disagree" and "Agree," indicating a certain degree of insecurity among these educators regarding all the issues. However, when analyzing the standard deviation of each response (Figure 1), we observe that those with the smallest standard deviation values are responses where the means are close to 3, which corresponds to "Agree," and the even-numbered responses (corresponding to emergency remote

teaching and the use of DICTs) mostly have means consistently below those of the odd-numbered responses (in-person teaching). Recall that Bandura (1997), Costa (2003), and Barros and Batista-dos-Santos (2010) shed light on the various influences on self-efficacy beliefs, and in our case, there is the issue of the use of DICTs and ERT influencing the level of confidence in the self-efficacy beliefs of the research participants.

Regarding the self-efficacy belief scores for each educator, we follow the previously outlined procedures, where the self-efficacy belief strength for each educator is under the conditions of minimum = 18, maximum = 72, and average = 45. Thus, Table 2 and Graph 2 show the final scores for each educator, and we calculate the strength of their self-efficacy beliefs according to the values in Figure 2.

Figure 2 Scale of Teacher Self-Efficacy Belief Strength
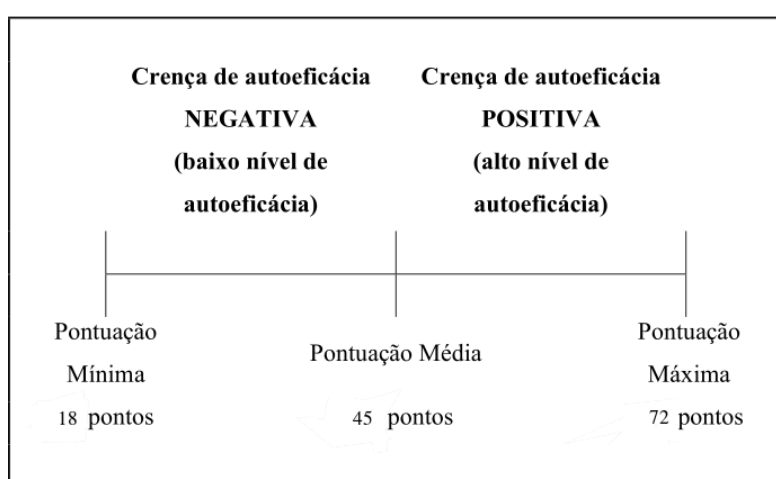
Source: Adapted from Silva (2021. p. 135)

Table 2 - Table of Scores and Strength of Teaching Self-Efficacy Beliefs

Professor (P)	score	Strength of Teaching Self-Efficacy Beliefs
P1	46	Positive Teaching Self-Efficacy Beliefs
P2	57	Positive Teaching Self-Efficacy Beliefs
P3	48	Positive Teaching Self-Efficacy Beliefs
P4	52	Positive Teaching Self-Efficacy Beliefs
P5	59	Positive Teaching Self-Efficacy Beliefs

P6	61	Positive Teaching Self-Efficacy Beliefs
P7	60	Positive Teaching Self-Efficacy Beliefs
P8	47	Positive Teaching Self-Efficacy Beliefs
P9	57	Positive Teaching Self-Efficacy Beliefs
P10	50	Positive Teaching Self-Efficacy Beliefs
P11	57	Positive Teaching Self-Efficacy Beliefs
P12	44	Negative Teaching Self-Efficacy Beliefs
P13	51	Positive Teaching Self-Efficacy Beliefs

Source: Prepared by the author

Graph 2 - Professor (P) Based on Their Score
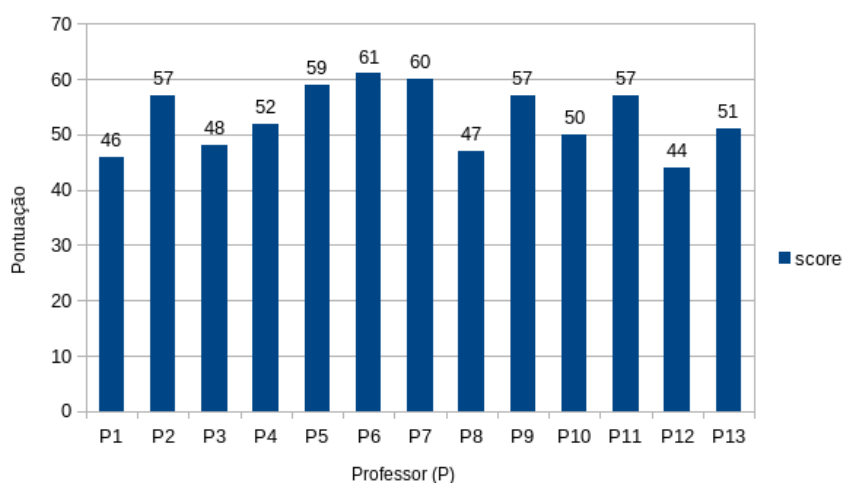
Source: Prepared by the author using LibreOffice Calc.

According to Table 2, most of the teachers' self-efficacy beliefs were positive, although the intensities vary significantly. Graph 2 provides a clearer view of these scores and offers a broader perspective on the intensity of each teacher's self-efficacy beliefs.

We observe that 5 (five) of them have scores very close to 45, meaning that those with scores lower than or equal to 50 have more moderate self-efficacy beliefs. Among these teachers, P5, P6, and P7 are closest to the maximum value, indicating that their beliefs are likely more positive than those of the other teachers.

Only teacher P12, according to Table 2, shows a negative self-efficacy belief, though it is very close to the central value, suggesting that this belief is more moderate.

These trends in individual self-efficacy beliefs are similar to the general statistics of responses shown

in Figure 1 and Graph 1 previously. This reinforces, in our view, that the teachers' self-efficacy beliefs are directly influenced by the teaching modality adopted in the PLE.

Final considerations

The main focus of this article was on teachers' self-efficacy beliefs regarding the use of digital information and communication technologies, from the perspective of both face-to-face and remote teaching modalities. The latter was widely used during the Emergency Remote Learning Period and was authorized by Ordinance Nº 343, dated March 17, 2020, from the Ministry of Education and Resolution Nº 500, dated August 12, 2020, from the Federal University of Southern and Southeastern Pará (Unifesspa).

Key references guiding this research include Bandura's Social Cognitive Theory (TSC) (1995, 1997, 2008a, 2008b), self-efficacy beliefs as described by Bandura (1997), Pajares and Olaz (2008), as well as studies by Pinheiro (2018) and Coutinho (2020). Regarding digital information and communication technologies (TDICs), the works of Almeida (2000), Beline and Costa (2010), Borba and Penteado (2012), Borba, Silva, and Gadanidis (2015), Lèvy (1999), Neto (2007), Peixoto et al. (2015), Silva and Gracias et al. (2000), Valente (1999), Obata, Mocrosky, and Kalinke (2018), Kenski (2008), and Batista (2016) were considered essential.

Our primary goal was to investigate the self-efficacy beliefs of higher education mathematics teachers, analyzing their relationships with the use of digital information and communication technologies, from the remote teaching modality widely and mandatorily employed during the emergency remote learning period to face-to-face teaching.

Considering the research problem and the initial objectives related to the self-efficacy beliefs questionnaire, we find indications of moderate to strong insecurity regarding the use of digital information and communication technologies (DICTs) in remote teaching, even after the Emergency Remote Learning (PER). This insecurity is significant, even extending to face-to-face teaching. Figure 1 provides a general overview of the responses from the questions labeled Q1 to Q18, showing that the central measure of responses is a value of 3, representing "Agree." Almost all response indicators in Table 1 show that the tendency towards positive self-efficacy is linked to face-to-face teaching. However, when considering the use of digital technologies, these beliefs diminish. This difference is more pronounced when examining remote teaching during the PER, where the use of DICTs was mandatory. Obata, Mocrosky, and Kalinke (2018) explain this behavior well, noting that

having access to technologies and various possibilities does not necessarily mean that teachers are prepared or willing to use them.

Many of these response trends differed between face-to-face and remote teaching modalities. However, the self-efficacy questionnaire alone was not sufficient to understand why teachers favored one modality over the other. Data from Q1 to Q18 revealed a moderate self-efficacy belief (Pinheiro, 2018; Coutinho, 2020). Responses related to activities (from planning to execution) remained between "Disagree" and "Agree," with responses closer to "Disagree" for remote teaching and "Agree" for face-to-face teaching. For items specifically discussing DICTs, teachers' responses were mixed, reflecting a duality between not believing that the use of DICTs was significant for their activities but using them out of obligation. This situation suggests that the level of confidence in their self-efficacy might be lower compared to those who actively wanted to use the tools.

To expand on the considerations of the Self-Efficacy Beliefs Questionnaire, Table 2 and Figure 2 show the strength of self-efficacy beliefs for each participating teacher. It is evident that most beliefs were positive; however, nearly half (5 teachers) had beliefs very close to the central value, reinforcing the moderation according to our adapted strength scale from Silva (2021).

In summary, based on the self-efficacy beliefs indicated by the questionnaire, we have the following hypotheses derived from the results: a) Most teachers recognize the importance of using TDICs (Digital Information and Communication Technologies), but there is still resistance to accepting these tools, despite their inevitability. According to Borba and Penteado (2012), Borba, Silva, and Gadanidis (2015), DICTs are increasingly intrinsic to society and are in constant technological development, especially in communication media; b) Even though most teachers had access to the internet and the minimum necessary infrastructure, responses indicated that they did not receive support from the institution; c) By preference, the majority chose face-to-face classes; d) Regarding continued professional development in the area of DICTs, few were willing to undertake such training.

As observed in the responses, direct experiences are likely one of the most prevalent sources of beliefs in a teacher's life, followed by vicarious experiences. Generally, teachers are from the same department, and even during periods of social distancing, it was still possible to consult colleagues about the progress of each other's classes. Another likely source is social persuasion, as we recall that classes took place during the PLE (Emergency Remote Teaching), and teachers were pressured to manage the abrupt situation they found themselves in (Azzi & Polydoro, 2006; Pajares & Olaz, 2008).

Finally, we propose future research based on the difficulties encountered during this study. Initially, the aim was to validate a self-efficacy beliefs scale, which would have provided more decisive support for our analyses and theoretical assumptions about the constructs and objects investigated.

We encourage readers to pursue similar research, including within this area, and to achieve what we were not able to complete.

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