Original Article

Digital Video Festivals and Mathematics: Changes in the Classroom of the 21st Century

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Abstract

This paper aims to present how video production is impacting the classroom, mathematics students and teachers in Brazil, as well as mathematics knowledge production developed with this media. Digital video Festivals with mathematical content are being implemented in Brazil, locally and nationally. One of them is Mathematics Education Digital Video Festival, organized by the Research Group in Informatics, Other Media and Mathematics Education, GPIMEM. In this century, video is earning space as a pedagogical approach in either face-to-face or distance education, even before the COVID-19 pandemic. Currently, considering social distance, the use of videos became an imposed reality to students and teachers. Students and teachers with different level of experience or age started to realize possible positive effects regarding the reorganization of the classroom by the presence of mathematical videos. However, other aspects provided negative effects: for example, inequalities in homes and mobile access impacted equal opportunity to all. This paper will summarize the use of mathematical video in the last century and discuss what is happening this century. We will revise some research developed, mainly in Brazil, that shows how the classroom does not fit in a parallelepiped model. Internet, videos and software combined are "things" that have agency and are co-participating in learning and teaching mathematics. The organization of festivals of videos have become important not only in Brazil but elsewhere in many formats either nationally or internationally, in a way to create challenges, exhibitions, cultural mix that aim to show mathematics applications to the general public. In particular, this article reports on parts of a qualitative research that investigated participants of the first edition of the referred national festival. As a result, we look for the comprehension of following the discussions of qualitative transformations regarding the use of videos in classrooms and mathematics knowledge production, as this new setting suggests that digital technologies arrived in XXI century to collaborate with learning. This article will be supported by a theoretical perspective on technology based on the notion of humans-with-media. In such a perspective knowledge is seen as being constructed by humans and different media and different artifacts. This article shows how such a perspective may help us to cope with the classroom of the XXI century, including the classroom that during the pandemic include students' and teachers' homes.

Keywords: activity theory, COVID-19, digital technology, humans-with-media, mathematical video

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I. INTRODUCTION

Borba et al (2016), Borba, Scucuglia and Gadanidis (2014) and Engelbrecht, Llinares and Borba (2020) have reviewed the literature on digital technology and mathematics education over the last decade. This period is within what they refer to the fourth phase of digital technology and mathematics education, a phase that is shaped by fast Internet. In the most recent of these papers, the writing of the paper has been transformed by the pandemic: Engelbrecht, Llinares and Borba (2020) argued that it was not adequate to publish a paper regarding the use of digital technology without an update to discuss the growing influence and the limitations of digital technology in mathematics education, as the Internet became the safer replacement for in-person (mathematics) education.

COVID-19 has already become “COVID-20” and “COVID-21” at least. It is not possible to predict what will become of mathematics education once the pandemic is over, but as Borba (2021) claimed, the home became an important component of education.

“If we consider a trend as an effort to find answers to a given issue, COVID-19 has pushed forward the agenda of the digital technology trend in mathematics education. With the need for social isolation, it became necessary to offer education to children and undergraduates at home.” (p. 4)

As the home and the Internet became important “participants” in education, it led to a transformation of the classroom from a parallelepiped, cubic one to one with a more complex topology that includes virtual space, leading to the evolution of different ways of producing the teaching and learning of mathematics:

“Having students expressing mathematical knowledge with videos, or doing research with videos, was not a solid trend in the literature. However, video production may be an alternative for education during and after the pandemic.” (Borba, 2021, p.5).

Given this transformation, it may be the case that the movement of having students and teachers becoming producers of video may continue to gain momentum worldwide. The movement, which has roots in Canada and Brazil, may spread out further, since GPIMEM studies on students producing mathematical videos, which started in 2008 (Borba, 2015; Domingues, 2015; Lacerda, 2015), have become of special interest in light of the pandemic. This research began with a set of studies, like the extension project Math+Science Performance Festival¹⁾ developed in partnership with Canada, the PhD thesis by Scucuglia (2012), and the Masters dissertation by Domingues (2014), in which GPIMEM tried to stimulate

1) <https://www.edu.uwo.ca/mpc/festival.html>.

video production in collaboration with Basic and Higher Education teachers and students.

In 2016, GPIMEM, Research group on Informatics, Mathematics, Other Media and Mathematics Education, started a large project called “Digital Video in Pre-service Mathematics teachers distance education”, E-licm@t-Tube for short²⁾. This project’s main objective was to understand possibilities for collaborative construction and use of video in pre-service mathematics teacher education of the Open University of Brazil (UAB), with implications for Basic Education Schools and face-to-face pre-service mathematics teachers education.

There have been a number of reviews on video use in mathematics education. Oechsler and Borba (2020) presented central aspects of the E-licm@t-Tube project and carried out an extensive research in which they classified video use in mathematics education into three types: i) recordings of classes, to facilitate analysis of and reflection on the teaching and learning process (reflection about pre-service teachers’ practice); ii) using videos available on educational social media in the classroom; iii) production of video by teachers and students. Regarding this review, Domingues (2020) stressed that other uses are also reported in research, such as when video is recorded as a means of registration/production of data, as well as its continuous use as technological instrument allied with other resources to mathematics teaching and learning. Domingues (2014) and Fontes (2019) discuss video and its technological evolution, from analog to digital. Ferres (1996) reviews the use of analogical videos in education.

E-licm@t-Tube has many subprojects which analyze aspects of video and its production process, from different theoretical perspectives. In this paper, we highlight one of these subprojects, the work of Domingues (2020), which intended to create and study the 1st Digital Video and Mathematics Education Festival. This was the first of many iterations: this year the fifth edition will be held.

This festival consists of an online environment (www.festivalvideomat.com) and a set of face-to-face events that take place every year (in 2020, these were held virtually as well). Currently, there are about 600 math videos on the website. A few of them have subtitles in English, such as “The Sea of Mud”³⁾ and “Infinity”⁴⁾. The website shows news, dates, announcements, guidelines for submitting works, and displays all the videos that have been submitted. The face-to-face event consists of lectures about mathematics education and videos, exhibition of the top-placing videos, and the award ceremony. This environment is both the locus of research, and at the same time is a virtual space for exchange, show and discuss mathematics ideas between students, teachers and the whole community outside the school. This project therefore encompasses both teaching research and outreach work.

In order to be accepted in the festival, a video must have mathematics ideas, which are evaluated by a jury composed of mathematicians, mathematics educators, artists and movie producers. Digital video, a main artifact within the fourth phase of digital technologies (Borba, 2014; Scucuglia, 2014; Gadaniadis,

2) Grants by CNPq (303326/2015–8 and 400590/2016–6). CNPq is one of the two funding agencies of the Brazilian Federal Government.

3) <https://youtu.be/YpCteGqjxd0>.

4) https://youtu.be/Z8E_QjnrCuU.

2014), is understood as a multimodal artifact that can express mathematics ideas through orality, writing, gesture, body expression and sound (Walsh, 2011).

The focus of this paper is on the research question “What is the relationship between mathematics videos, video festivals, and the new XXI century mathematics classroom?” To address this question, we will present our theoretical framework as it relates to public images of mathematics and perspectives about digital technology. Next, we will show examples of digital videos that were presented in the 1st Digital Video and Mathematics Education Festival and discuss the nature of the festival, closing with a discussion, anchored on data, about the ongoing transformation of the mathematical classroom.

II. PUBLIC IMAGE OF MATHEMATICS AND ARTS

Mathematics is often viewed and described as something difficult, boring, only accessible to a few people, impossible, and abstract to the point of horror (Enerst, 1995). This consensual image is observed in the social scope (Gregorutti, 2016) and may be related to negative student experiences (Gadanidis, 2010; Scucuglia, 2010). Many initiatives and research, in Brazil and in other countries around the world, aim to improve teaching and communication within the mathematics classroom, so as to understand or overcome negative experiences. Amongst these initiatives, research is carried out regarding mathematics teacher education, namely analyses of teachers’ attitudes in the classroom, in order to think about teachers’ behaviors towards some situations in this context, as well as ways to explain topics arising from students’ mathematics doubts (Santagata, 2011; Guarino, 2011).

Gadanidis and Borba (2006) developed research on arts and mathematics education. Videos produced in this way were named Digital Mathematical Performance (DMP) and can be understood as multimodal narratives produced in various digital media to express mathematics ideas through arts, such as videos, applets, music, etc. (Scucuglia, 2012). This research encompasses discussions regarding the public image of mathematics and mathematicians as they try to transform student experiences regarding mathematics (Gadanidis, 2010; Scucuglia, 2010).

Other research related to the social image of any discipline in schools uses the term “encapsulation of school learning”. Engeström (2002) reports a mismatch between regular education content and textbooks, and previous students’ knowledge outside the school environment. According to Engeström, it is common to observe teachers being tied to teaching materials which represent situations outside the real context, while focusing on content using tools like books, blackboard, orality and chalk. Loyally following a textbook, page by page, is seen by Skovsmose (2007) as “traditional teaching”.

In order to disrupt the context of the traditional teaching, many research initiatives are anchored on different trends of mathematics education that attempt to face such problems. Examples of these trends are mathematics modeling, ethnomathematics, digital technology in mathematics education, and problem solving. In this paper, we focus on initiatives related to the use of technology in mathematics teaching,

specifically on video production in mathematics classes.

The research group GPIMEM, to which the authors belong, has been investigating issues regarding the use of technologies in mathematics teaching for more than 25 years. From the beginning, GPIMEM developed a variety research and used a wide range of technologies, from classical software like Derive to online mathematics education in a country that spans nearly a continent. GPIMEM arrived in the fourth phase of the use of digital technology in mathematics education with a shift in focus to research on digital video and mathematics education. With the emergence of high-speed Internet, video has developed new possibilities, considering the ease of sharing and even producing videos using portable devices, like cell phones. It is at this point beyond doubt that these technological affordances of mathematics video are expanding the traditional classroom (Borba, Lacerda, & Domingues, 2017). We see new ways of teaching and learning, involving arts and in particular digital videos, as a means of actively changing a classroom that is continually being transformed by the Internet, and, in the last two years, by the pandemic.

III. HUMANS-WITH-MEDIA

This paper is built on the notion of humans-with-media (H-W-M), initially synthesized by Borba and Villarreal (2005). This construct has been transformed throughout the years, especially in recent years as it became clear that the transformation of the classroom is irreversible: the four-walls-and-a-roof classroom is now combined with YouTube, and instantaneous communication devices attached to cellphones have an active role when learning mathematics. The main principle of the construct of H-W-M is that knowledge is jointly constructed by humans and non-human media, such as computers. Humans are imbued with technology and technology is imbued with humans.

The H-W-M framework was created by the efforts of Borba (1993; 1999) to synthesize and build on the ideas of Tikhomirov (1981) and Levy (1993). In the 1990s, Borba and Villareal (2005) deepened Borba's (1993; 1999) ideas, developing the notion of thinking collectives and the reorganization of thinking following examples of mathematical approaches that enabled the creation of mathematical conjectures, which refers to thinking-with-technology and the construction of mathematical knowledge.

In this construct, media molds and influences thinking, leading to distinct qualitative analyses according to the media utilized in a mathematical investigation. Media, according to Oechsler (2018, p. 282), are defined as "resources utilized to the production of meaning. It can be material (instruments, tools, stuff) or immaterial (orality, writing, informatics, thinking) (Borba, 2009)".

Digital video is understood to be a multimodal media, as it allows students and teachers to reorganize their mathematical ideas and to express them in a different way from what is usually adopted in the classroom, using a different setting, script, clothes, orality, writing, software, sounds, and poems, among others. These ideas can be incorporated into a short video that allows people to pause and rewatch it, and that can reach a much larger audience than in a conventional classroom, when it is uploaded to the

Internet.

In GPIMEM, the H-W-M framework has been developed and understood as an activity system, which involves questions related to Activity Theory (AT), along the lines of the proposal by Engeström (1987). Engeström proposes a systemic and dynamic structure composed of six elements (subjects, artifacts, rules, community, division of labor and object) which are part of human activity, in a way that some elements mediate between the subject and the object, as the system looks to achieve a product. This system of collective activity is seen as a minimal unit analysis (Borba, 2016; Souto, 2016).

In AT, artifacts are responsible for mediations between subjects and objects, understood as instruments and signs, which can include machines, writing, orality, etc. (Souto, 2013). Note that, as in the H-W-M construct, Engeström (1987) understands that agency is associated with subjects. This leads Souto and Borba (2016; 2018) to suggest a fourth generation of AT, in which media assume roles beyond just mere artifacts, but are understood to have agency, as held by the H-W-M construct. Borba (2021) also expands on the famous diagram developed in the Helsinki school to argue for an activity role of both media and things in general. As shown in *Figure 1*, the diagram represents a reappraisal to systemic structure as a triangular representation, grounded in the work of Sannino and Engeström (2018) and reinterpreted by our research group.

We can also view this dynamically, as an animation (<https://igce.rc.unesp.br/#!/pesquisa/gpimem---pesq-em-informatica-outras-midias-e-educacao-matematica/animacoes/triangulo-sannino--engestrom/>) that shows the Internet as artifact, subject and community! This illustrates the presence of media in every element of the system.

In Borba (2021) the last step has been taken. With the pandemic the role of things that are not digital, like the home, join the Internet as a non-human with agency in knowledge production:

“We have collectives of home-parents-internet-student-teacher as the minimal unit of the collective agent who produces knowledge. Home and parents, things and humans, have added more to social inequality and to discussions about how to use digital technology in

Figure 1 *The H-W-M system. Note: Borba (2021).*

mathematics education.” (Borba, 2021)

In this paper, our focus is on digital video, produced many times using mobile phones by students and teacher. They made them collectively, before and after the pandemic, face-to-face, but also using different facets of the Internet. The festival was created as a locus to incentivize the creation of the interdisciplinary artifact: the mathematical artistic digital video. This artifact, once published on YouTube or another platform, also becomes part of other collectives of humans-with-media. These collectives are components in the overall challenge of changing mathematics’s public image.

In the research we are presenting on (Domingues, 2020), each participant was seen as an individual activity system. Each collective of humans-with-media was also seen as such a system, as well as the First Festival, and the organization team, so as to create a complex web of systems, aiming to analyze the tensions in this web that caused possible internal contradictions.

In AT, tensions can be understood as divergences of opinion, ruptures of ideas, or a way to solve some conflict. However, internal contradictions consist of structural tensions historically constructed. Tensions and internal contradictions can be seen as capable of stimulating the polarization or expansive transformation of the system (Souto, 2013).

According to Borba (2021), with the pandemic, the H-W-M construct must also embed the home as an artifact that has agency. Internet quality and home quality become fundamental to a collective producing knowledge. So, the collective consisting of teacher-students-with-Internet-video-home is now relevant to this new classroom.

But what is the relationship between videos, the festival, and the research by Domingues (2020) on one hand, and the new mathematics classroom in XXI century on the other, which we are proposing in this paper? We believe that to understand what stimulated students and teachers, what the necessary adaptations were, and what other aspects were necessary to produce video for a national festival, even as they were overwhelmed by other activities through their student practice, are all fundamental to understand the way that these students are learning, in a society that is dominated by quick mathematics answers to classical exercises.

Afterwards, we list and discuss, based on this theoretical framework, the challenges experienced by students to express mathematical concepts through video, and describe the way that this media molded the students and classroom, and was itself molded by the students and classroom, during this collective process of knowledge production and thinking-with-video.

1. A new classroom: video-with-mathematics

Domingues (2020) discusses the mathematical content displayed in videos from the festival, as well as investigating tensions and adaptations that emerged during the production of video, based on reports by

the participants. As mentioned before, this work constitutes a subproject of a larger research project; here, we present information on how participants produced and used videos.

Reports from participants show that video production should be viewed as something to be further explored in the classroom in the XXI century. For instance, Bruna says: “And no teacher has ever asked us to record a video for us to pass in class ... never asked for anything like that, no theater, or anything in the room”, and Marlene says: “I had never made a video, but I had a dream of doing it ... I already watched a video lesson to have another study tool” These examples demonstrate student’s search for more dynamic classes, classes different from the traditional “expository class”.

These discussions can be related to the Encapsulated Image of Mathematics presented in Costa (2017) and Engeström (2002): the compartmentalized, isolated and discontinuous form of Mathematics teaching, in which students’ prior knowledge outside the school environment is not considered: mathematical digital videos may be a way to break away from compartmentalization.

The production of a video, combined with the motivations and particularities of each student, favors the production of knowledge, as students study mathematics in order to understand the best way to explain certain content, as Gustavo reports:

“Well, first, it is necessary to understand the subject a lot, because that way it is easier to build a script to explain it in the best possible way. And it is also important to build this script by imagining yourself as a lay spectator ... a well-made video becomes an art that conveys different emotions that imply better and easier learning.”

In this new classroom that we are proposing and experiencing, in which videos are produced, students are concerned with the emotions and the language present in these videos, with recurring phrases such as “easy learning” and “relaxed”, among other aspects. The mathematical language expressed in a “less rigorous” and “relaxed” way, due to the plasticity of the oral and gestural communication present in the video medium, is seen as a positive factor by the students who produce videos, as in this dialogue:

Viviane: I think it is showing that math is also fun, that it is not just numbers, and it is not just notebooks and books, that there is a fun part in mathematics that nobody sees.

Gabriele: Until then when we have searched for mathematics-related videos on YouTube, it would only show those with images and a guy appearing, or a teacher and a picture behind.

Researcher: Just ... video lesson?

Gabriele: Mm-hm [meaning yes] ... and get away from the traditional of these videos, these traditional videos and bring something funnier, cooler.

Bruna: That's why the colorful scenery, the colorful clothes, to really draw the attention of those who are watching.

This relaxed language, just like the language of humor present in the lines “funnier”, “drawing attention”, “flashy scenarios and clothes”, according to Riani (2002), can be seen as a way to break barriers to start an involvement between people and a work.

These statements refer not only to the encapsulation of the teaching of mathematics (when it is reported, for example, that there is “a fun part of mathematics that nobody sees”), but they allow discussions about the Public Image of Mathematics to be touched on. According to Gregorutti (2016), such an image consists of a vision socially constructed by experiences with humans and communicational media that depict mathematics as something difficult, boring, punitive, stressful, abstract and belittling. In the analysis of these statements, we infer the attempt to escape from the traditional, in the sense of breaking socially constructed standards of the Public Image of Mathematics.

Therefore, this new XXI century classroom aims to give students freedom of expression, enabling them to talk about applied mathematics in everyday situations, in a “light” way for “lay” audiences, at the same time that it seeks to create involvement and engagement with different audiences who view various videos on social networks.

Domingues (2014) already pointed to the use of videos as a bibliographic source, which was in line with what Edérison says in the following excerpt:

Edérison: I for example am not a fan of reading, if I take a book and start reading ... I stop halfway, even if it is maths, that is something I like, I will stop halfway and I will not read it. So, I try to take part of videos that I can better assimilate the content with the video class, which, if you link the video class with the class the teacher has given in the regular classroom, you can better capture the content, so for me it's better that way.

This speech refers to the culture of study outside the classroom. It is well known that students seek to study by videos, since it has a multimodal structure with orality, gestures, symbols, representations and writing linked to software with dynamic aspects, in which the same explanation can be paused and replayed several times, in addition to making it possible to adjust the video playback speed to slow down when you don't understand something or faster to save time in sections you already understand.

This idea is developed further in another interview presented by Domingues (2020), about a video on the Fibonacci sequence, developed by a preservice mathematics teacher, Juliana. She emphasizes in her interview how a mathematical video may go beyond the regular classroom:

Juliana: ... I had very good experiences, from the staff: "Our Juliana, I saw your video!" A teacher came to talk to me ... My mother called me: "Juliana, I'm going to send it out to everyone from my work to enjoy your video now!" And she went from table to table at her work so that everyone could enjoy the video ... This is what I think is cool, my mother's boss commented on the video [YouTube]: "Wow, you showed that math is not just that math in the classroom, that it really is in everyday things."

When leaving the classroom and arriving in people's daily lives, the language of the video, being more flexible, allows for less mathematical rigor as compared to the written representation, since it uses other resources to expose certain explanations, as discussed in Domingues (2020). The use of colloquial language is something commonly seen on the Internet, and criticized by some teachers who defend the mathematical rigor and the detailed procedure of each step of each operation in the calculations.

Some mathematicians disapprove, for example, the use of songs to memorize formulas such as "go over there reversing the signal", but some participants, like Juliana, defend this freedom and spontaneity, since the producer of the video is concerned with the way in which the student will perform the operations in order to arrive at the correct answer, based on the idea that the people who view the video have already had contact with the basic concepts and origin of the addressed resources. The following excerpt shows this concern with the videos produced:

Juliana: ... I need a more accessible language, you can't have a mathematical rigor up there because I'm not going to reach people, you know? I need the boys to understand. So, when I went to make think about the script, I prefer to go back, go down a little bit to the level of the language of kids ... I think it's interesting for kids to know what the numerator and denominator are, but it is much more important that they know how to do the math, what they do with the top and what you do with the bottom [referring to numerator and denominator]. If you know what you do with the top and bottom it's all right for me you know?

At the same time that Juliana reports this plasticity of the video media and the less rigorous language, making an explanation more accessible, she emphasizes some qualitative transformations necessary to explain mathematics in a visual and aesthetic way as:

Juliana: ... I bought other things that didn't work out [to illustrate Fibonacci sequence], so like that. My initial idea, I studied Fibonacci, there was the pineapple, there was the cabbage, ... Then I said: wow, I'm going to buy everything at the market ... it's going to be a single trip, I'm going to buy all the fruits. I got there, I went to look

at the pineapples, no pineapple from the market I went to had the Fibonacci sequence... Then I looked at the cabbage, I said "Eder [a friend], let's take a cabbage. I put the cabbage in the cart when I went to record, I still recorded with the cabbage, but then... I cut the cabbage on the wrong side, so on the side I cut the cabbage it didn't have ... because I had to cut it the other way. ... Eder, I think I cut the cabbage on the wrong side because there is nothing here that looks like the photos I saw. Then I: yeah ... it was cabbage too.

This excerpt shows that everyday applications of mathematics, such as the study of the golden ratio, present in static photos or in graphic animations, may not be so simple to show in practical situations, through strategies such as handling a certain commodity in a video. Based on that experience, the student decided to modify her initial plans and use resource-mixing, showing a photo and handling the other product during her explanation in the video, as illustrated in *Figure 2*.

Note in *Figure 2* that the combination of static and dynamic elements was tailored to the explanation in the video. These transformations of didactical behavior, concerned about camera takes, the mode of exhibition of a product, and the feedback provided by the video to the producer can be comprehended as an agency of the video as a media. In other words, this power of mobilization has the power to modify practices and explanations, in a way to explore deeper potentialities of that explanation on video.

The evidence from the students' explanations also suggests that teachers or future teachers should review their practices, as in the excerpt that follows:

Figure 2 Video and QR code "Fibonacci". Note: video produced for the first festival available on YouTube. <https://youtu.be/1odXFKBmKew>.

Juliana: You are faced with that type of teacher, both in person and at a distance ... the teacher is very intelligent, he knows a lot, but he has no didactics. But he doesn't know how to explain, so I think this is a way: you need to learn and train to explain, you need to think how to explain ... From the video, for me, the greatest wealth is this ... having to think, studying a way of teaching, in the best way for those who are watching learn, understand and ... for me too, of course.

In this excerpt, the student comments that the video has the potential to train teachers' ability to explain. These signs may be associated with the intershaping relationship proposed by Borba (1993) and Borba and Villareal (2005) regarding H-W-M, since the media shapes the human being and the human being shapes the media, in such a way that both adjust themselves to produce mathematical knowledge. This is because, when receiving the video feedback, the teacher of the video class can reorganize their ideas, recording it again or editing some parts.

So far, we have discussed questions related to video potentialities and also video production potentialities for a video festival from Brazil, and have analyzed reports from the participants. As we have noted, we intended to modify paradigms when we realized that the students put some efforts to break up with the traditional classroom, as they tried to be more creative and didactic at the same time they tried to be less formal.

We discuss now aspects of this experience to teachers, and we aim to emphasize the tensions that carried out adaptations in this process of video production, which demonstrate the power of the action of this media in these systems of teachers and students producing video for the festival.

Teachers are responsible for supervising these processes of video production, either during their regular classes, with evaluation approaches, or in extracurricular sessions for those students who were interested. Teachers invited their students to produce video and to participate in the festival, being responsible for the submission of their video, as well as collaborating with correcting the script and sharing the video. Some teachers organized an evaluative movie session, where all the participants watched and evaluated their own videos and those of their peers.

Priscila, one teacher, supervised some groups of participants of the festival. Considering her excerpts, her motivation was to give students experience using technology:

Priscila: ... undergraduate student... he needs to have experience with technology, and if we do not promote moments in which they have those experiences inside our courses, he is not going to use it, afterwards.

When choosing video production, instead of other technologies, the teacher had to change the contents of the course. She proposed - and the students accepted - to do video production as the final assignment,

instead of a lecture, as she describes:

Priscila: Once I got a class that was taught at first by another teacher, and they had scheduled a seminar of History of Mathematics. They were extremely unmotivated, They don't like to be in Mathematics classes, they think it is boring. They were complaining, but I could not change the course content. I had to work with them, and then I suddenly remembered about videos.. Then I proposed to them to produce a video about the History of Mathematics, instead of preparing a lecture, a seminar. They liked the idea... we divided the class in groups. We had 21 students divided in 5 groups. Each group picked one theme, and the objective was to produce a video. I asked them to be creative. It could be anything... they were supposed to do what they wanted.

This report shows one briefly how the teacher changed the usual structure of the class to incorporate experiences with video production in groups of students with freedom and autonomy. The teacher experienced moments where the use of video transformed the way the students communicated their mathematical ideas:

Priscila: In the beginning, for instance, working on quadratic equations, the students borrowed one colorful pen: when you pointed a blue light on the display, it showed [the expression of a quadratic function], so it was interesting, but the way they recorded was not OK, so they filmed it again, in another way, they had to adapt during classes...

This report suggests that the video had action power, and created tension that was capable of totally modifying the initial idea, due to the effect of the action of the camera in the recording process.

Also on the topic of the power of the action of the camera, one group of students supervised by Priscila clearly demonstrated that video modifies and conditions the humans' means of expression, as illustrated by the excerpt below:

Bruna: ... and Gabi didn't want to appear on the video, she is shy, she didn't want to.

Gabriele [Gabi]: The point is they wanted to do that kind of video, and then I preferred to work behind the cameras.

Bruna: Cameras make us nervous, actually. For me, it was the camera... Knowing that I was being recorded, as we had to look at the camera to talk ... it was different.

Gabriele: So far, if we note that part of the video, it has some parts that they were looking

up, not at the camera, then I had to attract their attention to the camera. I was behind the camera trying to attract their attention (moving my arms).

These reports show us that the camera was not a simple artifact that capture images, sound and movement. It interferes with the people who have no experience with video recordings, influencing the way they act and making them nervous. Regarding Gabriele's shyness and not feeling comfortable on camera, it is portrayed on *Figure 3*, as they wear extravagant clothes and flashy accents in a way to utilize humor to present exaggerations (Domingues, 2020).

These students had to produce video as part of their grades for the course History of Mathematics, in a creative and funny way. Not all students submitted their video to the festival, due to tensions between the submission system, the teachers and the students, as it involved image-rights authorizations and restrictions on the total duration of the video (see Domingues, 2020 for more details).

There are many interesting videos on the festival website. Each of them have their particularities, either considering the final product or aspects of their development, due to the diversity of experiences of the students involved in the production. Watching the video and interviewing their subjects/creators, based on the theoretical framework adopted, was as a way for us to look for understandings of some aspects of the various systems that culminate with the festival.

One example of a type of video showing understanding of aspects of these systems is music parody with mathematical content, as shown in *Figure 4*.

This video was submitted to the Basic Education category and it shows how students express their mathematics ideas through music. In this way, the festival was open to new ideas that mixed mathematical content and arts.

Figure 3 Image and video QR code "Golden number". Note: video produced for the festival, available on YouTube. <https://youtu.be/7FENQTT3Sog>.

Scan the QR Code
to watch the video

Figure 4 Image and video QR code “Infinite”. Note: Video produced for the festival, available on YouTube. https://youtu.be/Z8E_0jnrCuU.

These videos and excerpts illustrate many potentialities of a new classroom, the one from the XXI century, with video production of mathematical content, focusing on active students of basic education and pre-service teachers. In other words, in the First Festival, teachers worked as supervisors and motivators of this process inside and outside their classrooms, shifting to different dynamics to supervise, share and evaluate these works.

But are these practices an isolated phenomenon? Are there other movements in the same direction, in mathematics, in other disciplines, or non-discipline areas, either intensifying in Brazil or elsewhere?

IV. NEW ELEMENTS TO CLASSROOM AND MATHEMATICS FESTIVALS AROUND THE WORLD

Our research group developed a survey of festivals while we were developing the third edition of our own festival in 2019. As Domingues (2020) defines it, the expression “festival” refers to cultural and artistic exchange. Using this definition, this author, when searching the Internet, found some Brazilian and international festivals that aimed to spread mathematics and its applications (daily or in other areas) to diverse audiences. Rock and roll concerts and concerts of other kinds were found in abundance. The initial search used the keywords ‘festival’, ‘mathematics’, and ‘mathematics education’. A more careful crossing of terms took us to terms like ‘mathematics festival’, which led festivals that had put together various common cultural activities with mathematical activities, such as challenges that involved mathematics, explanation of mathematics and art. Many times, such activities were not a whole event, but they were workshops or segments in a larger event.

Each mathematics festival has its own way to develop and approach mathematics. Such dynamics

could involve workshops, challenges, problems, magic shows, or short courses; on many topics, pure, or applied in some context; and aimed at members of the public of various ages. Those mathematics festivals are carried out in initiatives inside schools, universities or public spaces, like city theatres and museums, depending on which partnerships the organization committee was able to develop. Some festivals are open to the community as a whole, while others are restricted to some specific groups; some are free initiatives, or with only a nominal fee for submission, while some provide monetary support to directors, teachers and students. Festivals are organized by research groups, non-profit organizations, and public and private institutions; in some cases, the videos are developed in short courses. Some festivals migrate or are carried out in more than one city, state or even country.

Some of these workshops developed in these festivals had similarities with our type of festival and its Canadian roots, as students and teachers were invited to develop mathematical videos. As we invited one teacher in Brazil to become part of the jury for our own festival, we learned that he was organizing a students' video festival, with no focus in mathematics. This search, together with the literature review developed by Oechsler (2018), Fontes (2019) and Neves (2020), convinced us that having students and teachers making mathematical videos could be a relevant path to follow. In Brazil, in some places elsewhere, there is a movement to have students and teachers expressing their mathematics knowledge through videos. These festivals are a way to change the public image of mathematics, and the same time a locus for doing mathematics for this collective of humans-with-teachers-cell phones-software-music.

As a research group, we have been developing research in the festival we organize at the same time as teaching and doing outreach, all in the same project. We had no idea when the project began that ten years of research on videos and mathematics education, and five year of the festival, would become so important in the spring of 2020. As the coronavirus pandemic hit the world, many schools had to close, suspending face-to-face classes. Many of them opted for remote activities, in other words, virtual classes. Because of the diversity in access to Internet in Brazil, many models emerged, some with partnership with TV and teaching platforms. Some institutions opted to hold synchronous classes, others to hold asynchronous classes with online delivery of activities, or both.

This presented a new challenge to many teachers, one which is similar to the ones faced by teachers and students as reported in this paper. They had to produce and share video with their students, and had to learn to record, edit and act in front of the cameras in a remarkably short time. Students had also to find a way to learn by video, now produced by their teachers. This new dynamic, imposed by the pandemic situation, led to the emergence of negative effects such as conflicts and inequalities regarding access and resources, as well as to enable positive aspects, such as overcoming the barriers imposed by social isolation with the use of technology (Engelbrecht et al., 2020).

The fact is that before the pandemic, videos were already "invading" students' culture in every aspect of their life, except, or much less, in their school life. Due to the pandemic, the use of video may become more accepted by administrators and teachers. It is now necessary to think about proposals and dynamics

that enable the potentialities of this media regarding its use, production and sharing. Mathematical videos can create discussions, during or after some content is presented by the teacher, but the best relations reported by participants of the First Festival is how they learn as they produce a video. It seems like that changes in education, towards a more hybrid way will be inevitable (Engelbrecht, Borba, Llinares & Kaiser, 2020). Therefore, work with videos looks like an emerging trend is likely to grow fast. But, are festivals the solution for mathematics education? Not by far: a festival cannot resolve many of the problems raised in Borba (2021). For example:

“The amplification of the starkness of inequality under the pandemic cannot be ignored (except for those who believe that the Earth is flat and that hydroxychloroquine is a miracle cure for COVID-19), and the rise of the home office, associated with home schooling, confinement, and lockdown, may help many to think about philosophical issues regarding the role of “place” in knowing/learning and notions such as humans-with-media.” (p.14)

Quality of home, quality of Internet, and quality of device will be even more important in education throughout and after COVID-19-20-21. The agency of these artifacts will be relevant for education in general, but in particular for the production of mathematical videos. Their agency in collectives that produce mathematical knowledge is so important that there will be no decent mathematics education for all without the end of social inequality. On the other hand, actions such as these digital videos and mathematics education may help to also overcome social inequality, as they will help to spread the changing classroom to all.

In this paper, we discussed mathematics video production, as when video sharing in a festival, as an alternative to disrupt the encapsulation of the classroom, as a facet of the transforming classroom. We noticed that students produce mathematical knowledge when they study some content in order to express it with a video, which enables a new language with less rigor but with a clearer objective, as it stresses humor and getting students’ attention while emotional and aesthetical concerns are reconsidered. The excerpts presented in the last section suggest that making a mathematics video is not “just turning in a mathematics list of exercises”, for teachers and students. Video on the Internet reveals itself to be a tool for the teaching and learning of mathematics. Sometimes it can energize the form of students’ study, compared to other media such as textbooks, as they allow different ways of teaching in just one environment, qualitatively transforming knowledge production by thinking-with-video.

In light of all this, we aimed to discuss a mathematics education initiative in Brazil that tried to stimulate students and teachers in different states to produce video, in order to spread mathematics outside school, as it tried to disrupt the public image of mathematics. We have shown that this kind of initiative is a possibility of the classroom in XXI century.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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