ELICITING YOUTH DIGITAL MATHEMATICS STORIES: THE IMPACT OF A DIGITAL MATHEMATICS STORYTELLING SUMMER CAMP EXPERIENCE

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This research report analyzes the process of engaging 18 youth in urban emergent communities to enact Digital Mathematics Storytelling to explore their mathematics identities. The youth, in grades 7-11, engaged in the process of crafting and sharing their digital mathematics stories within two week long summer camps. Using a Participant and (Re)design Research Methodology, the research team explored how the constructs of Digital Storytelling, Mathematics Identity, and Storytelling can help us better know how to craft experiences that connect to youth knowledge.

Keywords: Equity, Inclusion, and Diversity; Design Experiments; Informal Education; Technology

Objectives

During the COVID-19 pandemic, many urban emergent school districts[1] in the United States of America, already dealing with racial and socioeconomic segregation, were overwhelmed with how to support the health and safety of their students and communities, while also responsible for their students' academic learning. Because of this context, research projects based within school settings had to either switch to a completely remote model or completely disconnect from the school context.

Our research team delt with the dissonance of our urban emergent partner schools having to engage in a much more stressful version of teaching by enacting a community-based approach, creating our own external summer camp experiences to invite youth to work with and co-create ways to enact Digital Mathematics Storytelling together with us without having to burden school and teaching partners. In particular, our summer camps hoped to create community-oriented spaces for thriving mathematics conversations, particularly for youth from urban emergent communities, after a year of remote learning that isolated many young people from their school communities. While our other work focuses on the actual stories and learning that young people enacted when engaging in Digital Mathematics Storytelling, this paper focuses on the ways our research team were able to plan, augment, and enact two week-long summer camps to best serve and learn from 18 youth, aged 12-17, in the wake of the COVID-19 pandemic. The objectives of this research study involved: (1) developing a protocol for Digital Mathematics Storytelling through Participatory (Re)design Research and (2) understanding how youth might see the construct of storytelling as connected to their own mathematics identities.

[1] The term urban emergent signifies communities in large cities, but not as large as metropolitan areas such as New York or Los Angeles. These urban emergent communities, however, encounter the same scarcity of resources and historical issues of segregation (Milner, 2012).

Theoretical Perspectives

Non-white children in urban emergent communities are often positioned in ways that do not allow them to craft their own mathematics identity. In particular, while students in urban emergent communities live mathematically rich lives, they are provided few opportunities to connect their out-of-school mathematical knowledge to in-school mathematics tasks that are often based on white, middle-class lifestyles they cannot relate to (Civil, 2009; Nasir & de Royston, 2013). For instance, when a student shares about the intricate proportional reasoning she witnesses in the kitchen as her mother and aunts prepare multiple dishes in unison, she positions them not only as holders of culinary knowledge, but also of mathematics knowledge. However, scaling up this approach of connecting out-of-school mathematics knowledge to in-school mathematics learning has been difficult because (1) family and community mathematics often operates socially, involving storytelling and group problem solving, while school mathematics is often positioned as internal knowledge measured individually (D'Ambrosio, 1985; González et al., 2001; Powell & Frankenstein, 1997), and (2) exploring students' home and community mathematics knowledges asks for even more labor from already overworked teachers.

Community Funds of Knowledge

One approach to address this issue of connecting out-of-school mathematics to in-school mathematics is through *funds of knowledge*, which honors families, communities, and the knowledge they bring to classroom mathematics. This community-based approach to mathematics teaching recognizes that "the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual's functioning and well-being" are mathematically rich resources (Moll et al., 1992, p. 133). A child's motivation to learn mathematics, thereby increases based on the increase in connections they make between two types of mathematics: (1) the mathematics they see in their families and communities and (2) the mathematics they experience in the classroom (Aguirre et al., 2013; Civil, 2016; González et al., 2001).

Within most urban and urban emergent communities, mathematics knowledge exists within social discourses such as storytelling (Turner et al., 2009). However, in the mathematics classroom, mathematics is treated and assessed as individual knowledge with little social interaction (González et al., 2001). For instance, Turner et al. (2012) detailed how well-meaning elementary teachers who were not from a Latinx community created a contrived mathematics activity around buying and selling *raspados* (shaved ices) at a community stand, but they did not ask children nor community members to share how mathematics conversations actually take place at the *raspado* stand. Surface-level attempts like this create harm by tokenizing children's cultures and imposing foreign values. In this case, the teachers imposed a value of capitalistic efficiency–getting the most *raspados* for your money, rather than connecting to community values (Bright, 2016).

To be successful, a community funds of knowledge approach to mathematics teaching must invite family and community members into the learning experience (Moll et al., 1992). These experiences help mathematics educators become part of the communities they serve, helping them understand how mathematics knowledge exists outside of Eurocentric ways of knowing (D'Ambrosio, 1985; Powell & Frankenstein, 1997), how mathematical thinking is situated within local contexts (Lave, 1988), and how to merge the classroom and community spaces to form a third space that honors all practices, knowledges, and beliefs (Gutiérrez et al., 1999). However, reaching this level of awareness is particularly difficult as it essentially asks teachers to become

ethnographic researchers (Oughton, 2010). This approach also has a tendency to prioritize teachers' cultural capital, since the teacher is often involved in translating the community knowledge for the classroom (Oughton, 2010; Turner & Drake, 2016).

Digital Storytelling

Another approach to connecting out-of-school mathematics to in-school mathematics involves the ancient art of storytelling. When students in urban emergent communities tell narratives about their out-of-school mathematical experiences, they position themselves and their communities as mathematical. They tap into the power of authorship to counter stigmas that discourage them from engaging in mathematics (Aguirre et al., 2013; Love, 2014; Özpinar et al., 2017). In a world where video and image-sharing platforms, such as Instagram and TikTok allow for routine sharing of personal stories (Rideout, 2017; The Associated Press-NORC Center for Public Affairs Research, 2017), a strong case exists for utilizing these emerging digital literacies. Therefore, this study's aim involved developing and exploring how Digital Mathematics Storytelling, a mechanism in which students use videos, photographs, and audio to craft and share mathematically-rich narratives from their families and communities, might help connect out-of-school mathematics to in-school mathematics in a non-school-based setting.

Digital storytelling involves using images, voice, and music to tell a story in the form of a short one to five-minute videos (Lambert, 2013). Storytelling is the primary mechanism for sharing important knowledge between generations in nearly all cultures–the very act of storytelling can define a community, a history, and a shared knowledge base (Prusak et al., 2012). Furthermore, children from marginalized communities often tell counter-stories that push against deficit-focused stereotypes, using these stories to explore and strengthen their identities and connect more deeply to their communities (Delgado, 1989; Duncan, 2006; Matias & Grosland, 2016).

The transformative moment in a digital storytelling cycle happens within the listening-focused small group space called the *storycircle*, when storytellers share their stories-in-progress to each other (Lambert, 2013). This storycircle forges a collaborative learning space where participants see the value of their cultural and community identity (de Jager et al., 2017). It is within the sharing of and retelling of stories that mathematics identities are formed as children begin to see themselves as part of their mathematics narrative (Aguirre et al., 2013; Chao, 2014; Langer-Osuna, 2015; Sfard & Prusak, 2005). Often, structured story prompts or visual organizers can help children manage the complexity in their stories (Ohler, 2006), so that children do not simply document what is happening, but craft a narrative that involves conflict, growth, and change in order to strengthen their ties to the community. Simply put, Digital Mathematics Storytelling is not just documenting what one sees, but involves crafting a narrative that centers one's humanity, growth, conflict, and soul.

Figure 1 shows our initial framework of a digital mathematics storytelling experience, which features *two* storycircles, the first involving self-reflection and the second involving sharing drafts for feedback from peers and adults. In this example, a 4th-grade child initially wants to tell a story about how she uses mathematics in the kitchen, a classic connection to home mathematics. In her first storycircle, as she thinks about how to tell her story and realizes that she does not see much measuring and adherence to recipes at home, but rather sees her mother and aunt cooking through approximation and tasting. In her second storycircle, she shares her emerging narrative with peers and uses their feedback to assemble video and audio clips to create a finished video to share at a culminating community screening. This research paper troubles our initial Digital Mathematics Storytelling framework by exploring the research question: *During*

the COVID-19 pandemic, when engaging in classroom-based research became too burdensome for teachers in urban emergent communities, what happens when enacting and building a Digital Mathematics Storytelling workshop for youth, particularly in connection to the construct of mathematics identity?

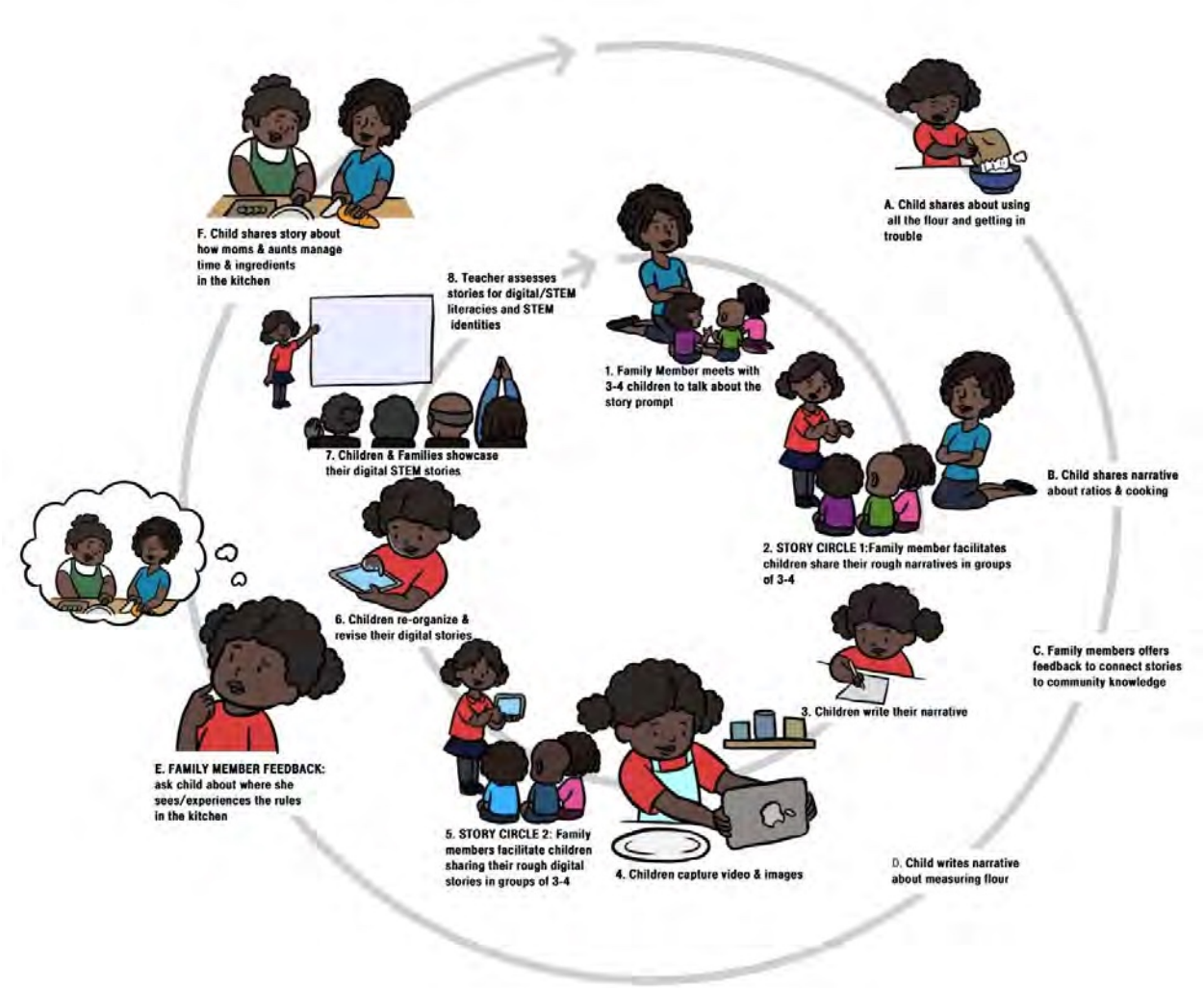

Figure 1. The Initial Storycircle Framework, which shows how a child's mathematics story evolves through two storycircles of reflection, sharing, and revision.

Research Design and Methodology

The research team enacted two week-long digital mathematics storytelling camps involving 18 students, aged 12-17, in grades 7-11. The students came from a variety of school districts and ethnic backgrounds and were recruited heavily from the researchers' own networks. The camps were hosted at a university-owned community innovation and outreach center in the Midwestern region of the United States of America. Because the camp was hosted in a facility operated by this university, all participants had to show proof of COVID-19 vaccination, which potentially influenced the pool of recruited participants.

Participatory and (Re)design Research

Researching technology that values participants' voices invites a Participatory Design Research methodology, which builds upon design-based research, but positions all participants as integral to designing the research goals and aims (Bang & Vossoughi, 2016). One of the main critiques, however, of design-based research (Cobb et al., 2003; The Design-Based Research Collective, 2003) is that, while very suitable for technology-driven educational research, the researchers still hold the authority to make research decisions (Engeström, 2011). Therefore, we attempted to enact a modified (Re)design Research method, to allow participants to not just engage in the enactment, but also help us with the very design of the Digital Mathematics Storytelling research framework itself.

By utilizing feedback from students who participate in the Digital Mathematics Storytelling camp, we used this developmental study to focus on developing protocols of how to implement Digital Mathematics Storytelling for middle and high-school aged students in urban emergent communities. Additionally, we explored the ways that Digital Mathematics Storytelling impacted and allowed insight into students' evolving mathematics and storytelling identities.

Research Measures

Pre and Post-Interviews. Over the course of the first two days of the Digital Mathematics Storytelling camp, a member of the research team met with each student to talk about the student's identities around mathematics and digital storytelling in a 5-to-10-minute interview. Then, on the last day of the camp, each student engaged in a similar 5-to-10-minute post-intervention interview with a research team member. These interviews also asked students about what they would like to change about the camp, which allowed us as facilitators to alter our daily structures to respond to what the students felt could better help them become Digital Mathematics Storytellers..

Analysis of Digital Mathematics Stories. The final Digital Mathematics Stories that the students submitted as their "final project", as well as the digital artifacts (videos, images, photographs, text comments) that the students used in their process to create their stories, were also analyzed. In this paper, we focus less on the content of these stories and more on what they unveil about the ways the camp and the protocols of Digital Mathematics Storytelling engaged the students.

Reflective Analysis. Over the course of the two camps, the students engaged in the developing Digital Mathematics Story curriculum. At the beginning of the first camp, this curriculum consisted of four loose modules, each involving a combination of whole-group, small-group, and individual activities. The modules were designed to take about three hours to enact, which was the length of each day of the camp. This initial Digital Mathematics Story curriculum was created and maintained by the research team and based heavily on the existing Digital Storytelling modules created over the past 30 years by StoryCenter (Lambert, 2013). Every afternoon, after the students had left the camp, the research team met for an hour to discuss how the day went and how to alter the next day's plans, with the only caveat being that the camp should culminate in the students creating individual 3–5-minute Digital Mathematics Story videos to present on the last day of the camp. These conversations were recorded and served as an artifact of how we engaged in continual tweaking and augmentation of the daily activities to best engage the students.

Analysis

The three measures, as detailed in Table 1, show: (1) The Pre and Post-Interviews, (2) analysis of the Digital Mathematics Stories, and (3) the recordings and notes of the daily

reflections to document how we changed the curriculum. First, in terms of exploring ways to enacting a Digital Mathematics Storytelling protocol, we used a Participatory (Re)design Research Framework (Bang & Vossoughi, 2016; de Jager et al., 2017; Lambert, 2013). Second, to attend to student's mathematics identities as connected to other narrative and other social identities (Aguirre et al., 2013; Langer-Osuna & Nasir, 2016; Sfard & Prusak, 2005).

Table 1: Alignment of the research objectives, data collection, and analysis methods

Research Objective	Data	Analysis
Enactment of a Digital Mathematics Storytelling Experience	Pre/Post Interviews Students' Stories Reflective Conversations	Participatory (Re)design (Bang & Vossoughi, 2016; The Design-Based Research Collective, 2003)
Mathematics & Storytelling Identitites	Pre/Post Interviews Students' Stories	Identity as Narrative (Sfard & Prusak, 2005)

Results

Evolution of the Digital Mathematics Storytelling Enactment

The initial digital mathematics storytelling modules consisted of a warmup game to start the day, two initial activities to help get students comfortable with making and editing videos, and four daily modules focusing on students making videos that explored their identities as a (1) storyteller, (2) digital storyteller, (3) mathematician, and (4) digital mathematics storyteller. Additionally, each morning started off with a community building game. Each of these modules focused on exploring activities around those identities such as learning to tell a story in three acts or how a close-up shot conveys a different tone than a wide-angle shot.

In the early feedback from the students and our own reflective conversations, we noticed that (1) students gravitated towards group tasks and wanted to engage in almost all activities in small groups as opposed to individually and (2) students who signed up to attend this camp thought that this would primarily be a mathematics camp and thereby were hoping to have more opportunities to engage in mathematics. Both early observations led to modifications to our protocol.

Community Activities

This summer camp occurred in 2021. Every single student in our camp had spent the prior year in a remote or virtual learning environment and had missed opportunities to work with other peers in a physical setting. So, we decided to augment all the modules so that they did not emphasize individual videos and contributions, and to use the majority of our camp time to focus on community and group activities and games. This was a move that seemed appreciated, as almost every one of the post-interviews mentioned that the best part of the camp was the games that students played to get to know each other and build camaraderie. In hindsight, we even realized that the end goal of having each student create their own individual digital mathematics story took away from this emphasis on community as it situated digital storytelling as an individual endeavor. In the post-interviews, all but three of the students mentioned that they had much more fun working on the group video projects as opposed to making their own individual videos. And when students were asked to create individual video stories, two students never

finished their videos, but were willing contributors to the group video stories. Figure 2 shows an example of the ways the students engaged in creating videos together in small groups.

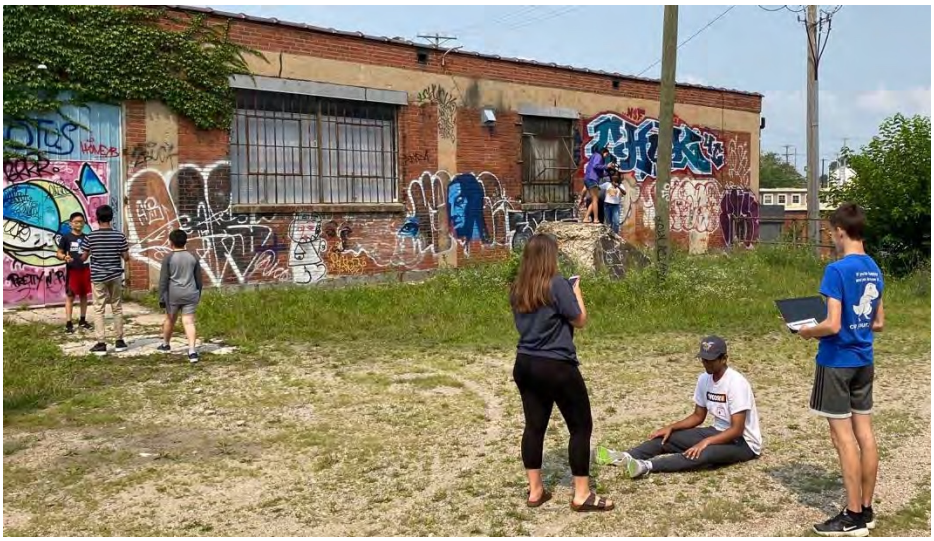

Figure 2: One finding was that students engaged much more with group video storytelling, as shown here, as opposed to making individual videos.

Mathematics Identity

Because so many of the students wanted to engage in mathematics, the research team decided to stop focusing so heavily on telling stories and actually engage the students in an augmented mathematics circle, opening up space for students to join groups to solve open-ended, challenging mathematics tasks. Figure 3 shows a group of students analyzing and discussing each other's strategy to an open-ended mathematics task. In the majority of the post-interviews, students mentioned how much fun it was to engage in this open ended, inquiry-based mathematics discussion, particularly because it was so different than the mathematics they were used to doing at school.

Figure 3: Students were surprised that this was more a video making camp and not a mathematics camp, so we gave them an opportunity to engage in group mathematics problem solving

Storytelling Identity

Additionally, students expressed to us that they found engaging in visual storytelling and learning about storytelling to be quite new and challenging. The majority of students who attended the camp shared that they had experience making videos in the past, but that these were videos for class projects or talking head videos. In our emphasis on understanding the various aspects of video filmmaking, such as exploring the differences in wide, medium, close-up, and extreme close-up shots or how to diagram a story into an exposition, rising action, climax, falling action, and conclusion, we realized that a generational divide existed between what we, as educational researchers thought storytelling was as compared to our students. We crafted our modules to explore storytelling from unpacking popular commercial films from *Pixar* or *Marvel Studios*. But what we found was that, while these pop-culture references were recognized by the students, our students' funds of knowledge around videomaking and storytelling revolved more around a new style of visual communication: *the YouTube video*. Again and again, our students wanted to make videos where they spoke directly to the camera, use graphics and editing features that drew visual emphasis onto particular objects or close-ups, and contemplate how to engage the viewer *after* their video was viewed.

Discussion

Overall, our digital mathematics storytelling camps opened a space for us to learn directly from our participants about how to enact and support the process of digital mathematics storytelling, as connected to emerging mathematics and storytelling identities. As with all (re)design research, what we sought was not a solution to a problem, but to better understand a process, the process of connecting storytelling to mathematics using digital video technology. First, we found that our students in urban emergent communities craved opportunities to engage with each other, both as mathematicians and storytellers. We interpret this to mean that as a field, the mathematics experiences our students encounter are too heavily based in individual accomplishment and competition. Second, we learned that our own interpretation of digital storytelling needs to be updated for the modern world, in which our own students' savviness with the language of *TikTok* and *YouTube* enabled them to revise what digital storytelling is and looks like. And finally, we all struggled in connecting storytelling to mathematics. A week-long camp is not enough time to do away with the years of focusing on mathematics as solving short, single-answer problems and seeing and understanding the ways narrative structures can be used to explore mathematical thinking. Our work is ambitious. But through this experience, we found a glimmer of hope that a digital mathematics storytelling experience can start re-orientating a student as to what mathematics is, how it connects to personal experiences, and how it is the product of one's own narrative.

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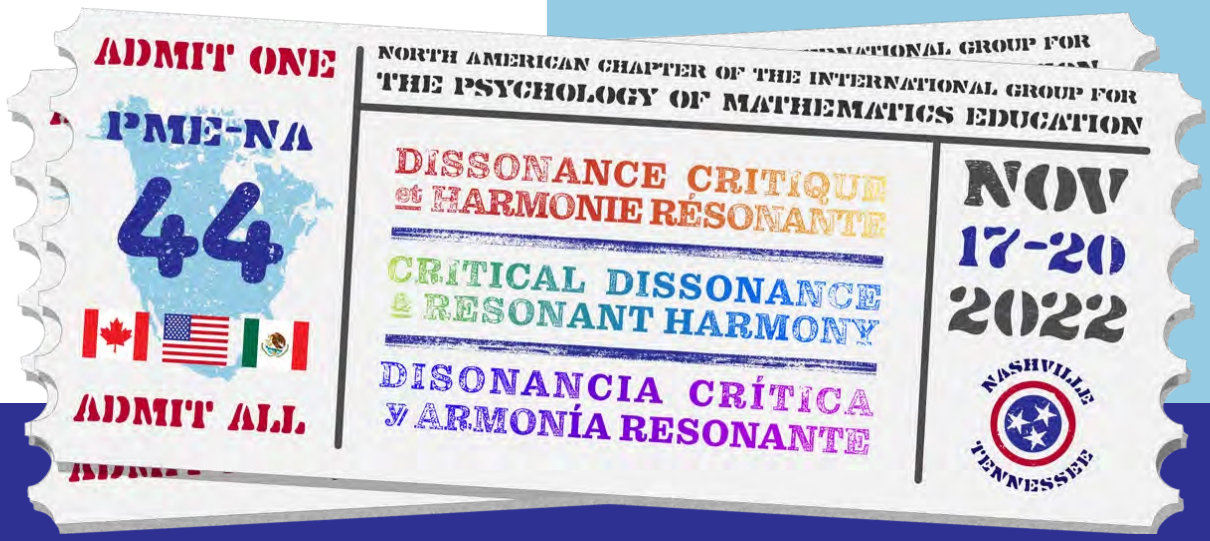
2022

PROCEEDINGS OF THE 44TH ANNUAL MEETING OF THE NORTH AMERICAN CHAPTER OF THE INTERNATIONAL GROUP FOR THE PSYCHOLOGY OF MATHEMATICS EDUCATION

CRITICAL DISSONANCE AND RESONANT HARMONY



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Land Acknowledgement:

The PME-NA 44 Conference is held on unceded Indigenous land including the traditional homelands of the Cherokee, Shawnee, and Yuchi. The connections of Indigenous Peoples to this land continues to the present day. As we begin our conference it is important to acknowledge our place, both geographically and historically, paying tribute to the land and our ancestors—and honoring both. We note that just speaking the word Tennessee is a tribute to a first nations' word for "where the river bends." The genocide, forced displacement, and cultural erasure of indigenous peoples resulting from the colonization of this land is particularly felt here, where the Trail of Tears cut through Middle Tennessee. In the midst of this history, Native American Indians tell their story today—including the joy of return. Founded in 1980, the Native American Indian Association of Tennessee is working to improve the quality of life for Indigenous People in this state. This includes raising funds to one day build the Circle of Life Indian Cultural Center, which will showcase a research library, exhibit halls, emergency relief support, job training, and education. These efforts help to close the circle of hatred and prejudice so that all Tennesseans can come together in freedom and pride.

An important goal of land acknowledgments is to increase support of local Indigenous communities. You can support the work of the Native American Indian Association of Tennessee by donating at naiatn.org. You can also learn more about the history of Tennessee's Indigenous communities by visiting the First Peoples exhibit at the Tennessee State Museum, which is about 3 miles from the conference site. More information is at tnmuseum.org.

This statement was created in conversation with local Indigenous leaders and informed by the Native Governance Center's Guide to Indigenous Land Acknowledgment.