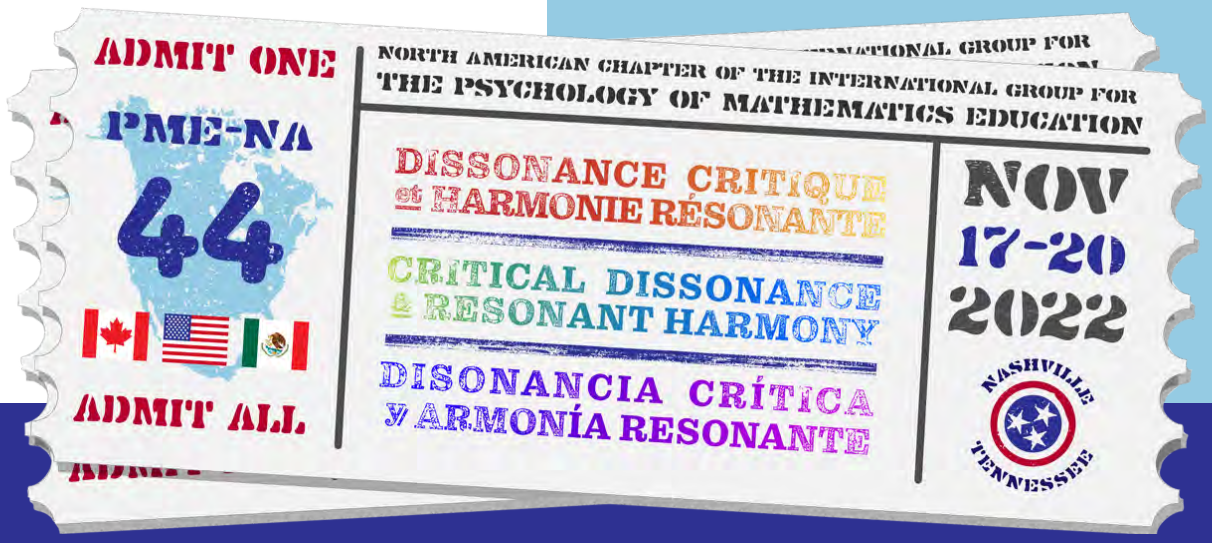
NOVEMBER 17-20, 2022

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

CRITICAL DISSONANCE AND RESONANT HARMONY

NASHVILLE, TN



CONFERENCE ORGANIZERS:

Alyson E. Lischka
Elizabeth B. Dyer
Ryan Seth Jones
Jennifer N. Lovett
Jeremy Strayer

MIDDLE TENNESSEE STATE UNIVERSITY

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Welcome Message

Welcome to PME-NA 44, the Forty-Fourth Annual Conference of the North American Chapter of the International Group for the Psychology of Mathematics Education. The local organizing committee welcomes you to Nashville, Tennessee – Music City – either in-person or virtually through our conference hub. It is our hope that this will be an engaging and thought-provoking opportunity for colleagues to consider **Critical Dissonances and Resonant Harmonies** that together continue to enrich the field of mathematics education research.

We appreciate your attendance and participation – your willingness to share and discuss your research is vital to a successful conference. We also thank the many individual who have supported the planning for this event:

- The PME-NA Steering Committee, with special thanks to Karl Kosko for your leadership in navigating pandemic planning,
- Past conference chairs, Sandy Spitzer, Dana Olanoff, Kim Johnson, and Sam Otten for your guidance and wisdom sharing throughout the planning process,
- Aaron Brakoniecki, PME-NA Webmaster, for your work in maintaining the conference website,
- Elizabeth Suazo-Flores and Genevieve Barabe for translation for conference advertising and website,
- Jose Martinez Hinestroza, for your support and encouragement of Spanish-language participants
- The Strand Leaders, without whom the review process would not have been as thorough or efficient,
- The Brief Report Moderators, who ensure that the delivery of the brief report sessions runs smoothly,
- Carly Sullivan, conference planner, who helped us navigate decisions with our venue,
- MTSU campus administrative assistants Catherine Burnette, Martha Damron, Carmen Bucka, Casey Penston, and Sherry Schaefer who helped us navigate this process in countless ways,
- MTSU Mathematics and Science Education Doctoral students who are our ready and able assistants throughout the conference.

We hope you enjoy Nashville and are encouraged to consider new dissonances and harmonies in your work!

Conference Information

Conference Hotel

Loews Vanderbilt Hotel
2100 West End Avenue
Nashville, TN 37203
(615) 321-1943

Contact Information

If you have any issues or questions, please visit us at the registration desk located in the Symphony Ballroom Foyer (just outside Symphony Ballroom) on the lobby level. You can also send an email to pmenaloc@gmail.com.

Meeting Rooms Wifi Information

To use the wireless internet in the conference meeting rooms:

1. Connect to the network named "**PMENA44**"

2. When prompted for the access code/password, enter **PMENA44**

Online Conference Hub and Website

Visit the Cvent Conference Website to view the conference program, join sessions remotely, and participate in the virtual poster session at https://tinyurl.com/NashPMENA.

The Cvent Website will be the main point of contact for virtual attendees and a useful tool for those attending in person. You will be prompted to log in with your name and email address; be sure to use the same email address as your conference registration.

Please Follow us on Twitter! • Twitter: @PMENA44 • Hashtag: #PMENA44

A blue box in the program designates papers that meaningfully incorporated and/or addressed the PME-NA 44 conference theme, Critical Dissonance and Resonant Harmony. One or two papers were selected per strand by the local organizing committee based on nominations from strand leaders. All of these papers are scheduled in Blackbird Studio A on the Mezzanine Level.

Conference Mobile App and Website Information

Both virtual and in-person attendees can use the CVent Website and App (https://tinyurl.com/NashPMENA) to plan their schedule, view posters, and more! In-person attendees may also be interested in accessing the conference Mobile App to have those options on their phone or tablet. **Please note that you cannot join virtual sessions from the Cvent mobile app, only from the Cvent website.**

Get the App

1. Go the App Store on iOS devices and the Play Store on Android.

2. Search for **Cvent Events**. Once you've found the app, tap either Get or Install.

3. After installing, a new icon will appear on the home screen.

Find the Event

1. Once downloaded, open the Cvent app and enter **PME-NA 44** in the search bar.

2. Tap the download icon to load the conference information and then open the event.

3. You will need to log-in to the app to view the schedule. In order to log-in, a verification code will be sent to the email/phone number you used when registering for the conference. If you have any issues receiving the verification code, please stop by the conference registration desk.

* You will have to get a new verification code if you are inactive in the app for more than 24 hours.

* You can search by speaker on the Attendee Hub Website but not on the App.

Use the App

1. Set your own personalized schedule (will sync automatically with your schedule on the conference hub website) by using the Schedule tab.

2. Access the event schedule, all session descriptions, and proceedings papers for each session by using the Sessions button. Just like in the conference website, you will need to "Add" the session to your schedule to access its proceedings paper. You can always "Remove" it later.

3. View all the speakers and see their associated sessions, check out the virtual versions of the posters, and find more information like floorplans, wifi login, and more using the More tab.

For questions on how to download the app or use any of the features, please come see us at the Conference Registration desk located in the Ballroom Lobby!

Health Safety and Inclusivity Information

We care about each and every member of our community, and as we gather, we extend special consideration for those among us who experience an elevated level of risk to their safety in gathering.

In an effort to facilitate safe spaces for attendees of PME-NA44, please be advised that we will be implementing the following:

- **Masks are strongly recommended in all indoor settings**. Please bring masks with you. A limited number of masks will be available at the conference.
- Color-coded name badge stickers and room signs will be used to communicate masking needs, attendees are expected to respect and honor the communicated needs of our community.
    - **Red:** Please mask when in the same indoor space
    - **Yellow:** Please mask when in close contact
    - **Green:** No needs or preferences related to masking
- Conference-provided meals may be taken to-go.
- The discussion board on the CVent Website will provide a voluntary way for attendees to communicate information regarding exposure or testing status with others.

In addition to caring for our health, we are providing a variety of accommodations and options so that all community members have access to conference events and feel welcomed:

- You will be able to change your display name as you wish within the CVent website and app.
- If your in-person name tag does not display your name appropriately, please ask for a reprint at the registration desk.
- There are gendered and all gender restrooms available throughout the conference space. See the venue maps in Cvent or in this program for locations.
- There is a lactation space available in the Quonset Hut room on the Mezzanine Level. A sink is available in the all gender restroom just past the elevator on the same floor.
- The Castle on the Mezzanine level is available as a quiet space at all times except during working group sessions.
- Automatically generated closed captions (from Zoom) are available for all PME-NA sessions. In addition to closed captions, automatically generated translation to Spanish (from Wordly) is available for all keynote sessions. Both will be accessed from the CVent website during the conference.
- All conference rooms will have reserved seating close to speakers and/or screens for all sessions. If you have need for accommodations regarding proximity (e.g., limited mobility, hearing impairment, vision impairment, etc.), we encourage you to use these designated seats.

More details can be found on the conference website. or in the appendix at the end of this program.

Schedule Overview

Thursday, November 17

4:00 - 7:00	Registration/Check-In	Ballroom Foyer
6:00 - 7:30	Plenary	Ballroom
7:30 - 9:00	Welcome Reception	Ballroom Foyer & Ballroom

Friday, November 18

7:00 - 6:00	Registration Open	Ballroom Foyer
7:00 - 8:00	Breakfast	Ballroom (I/II)
8:00 - 8:40	Paper Session	Breakout Rooms
9:00 - 10:30	Working Groups	Breakout Rooms
10:50 - 11:30	Paper Session	Breakout Rooms
11:30 - 12:15	Lunch	Ballroom
12:15 - 1:25	Plenary	Ballroom
1:40 - 2:20	Paper Session	Breakout Rooms
2:40 - 3:20	Paper Session	Breakout Rooms
3:20 - 3:50	Afternoon Break	Starstruck Gallery and other locations
3:50 - 4:30	Paper Session	Breakout Rooms
4:45 - 6:00	Poster Session 1	Ballroom (I/II)
	Dinner on Your Own	
6:30 - 8:30	Graduate Student Reception	Jasper's Restaurant and Game Room 1918 West End Ave

Schedule Overview

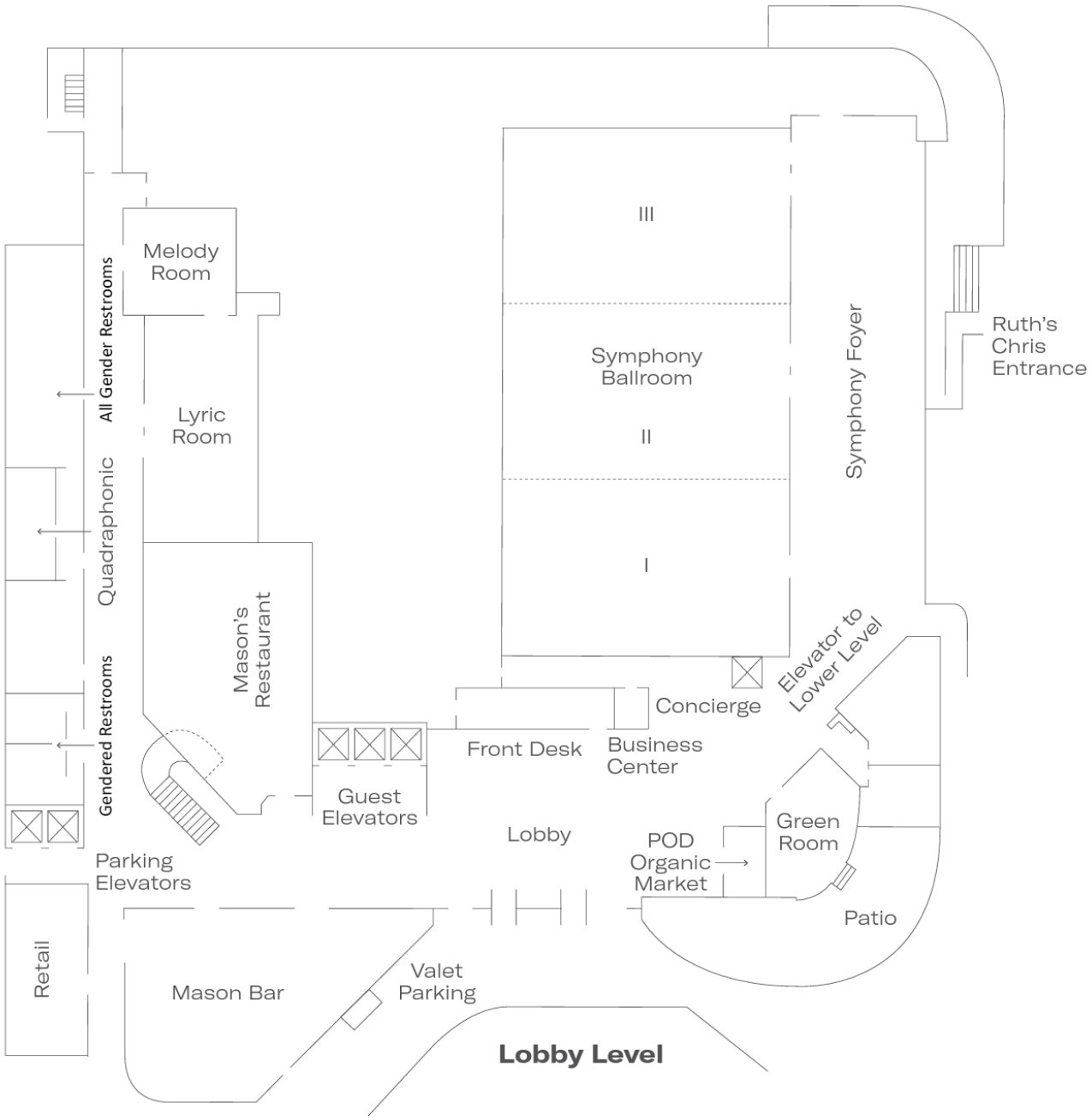
Saturday, November 19

7:00 - 8:00	Breakfast	Ballroom (I/II)
8:00 - 8:40	Paper Session	Breakout Rooms
8:55 - 9:35	Paper Session	Breakout Rooms
9:55 - 11:10	Plenary	Ballroom
11:10 - 12:20	Business Meeting/Lunch	Ballroom
12:25 - 1:05	Paper Session	Breakout Rooms
1:20 - 2:50	Working Groups	Breakout Rooms
2:50 - 3:20	Afternoon Break	Breakout Rooms
3:20 - 4:00	Paper Session	Starstruck Gallery and other locations
4:15 - 4:55	Paper Session	Breakout Rooms
5:00 - 6:15	Poster Session	Ballroom (I/II)
5:30 - 7:00	Reception and Entertainment	Ballroom and Foyer
	Dinner on your own	

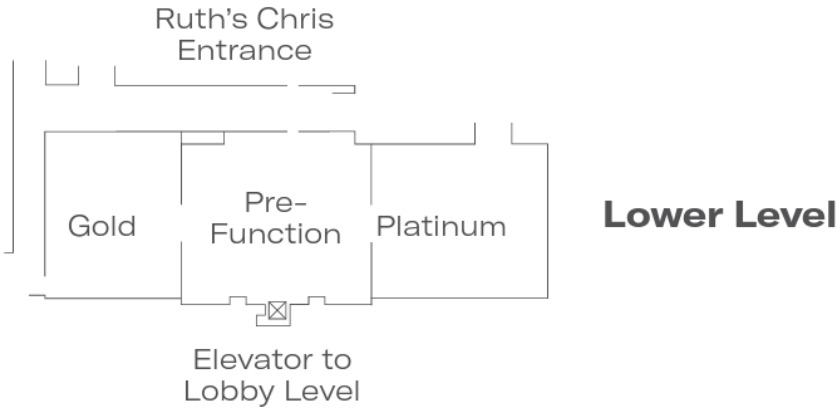
Sunday, November 20

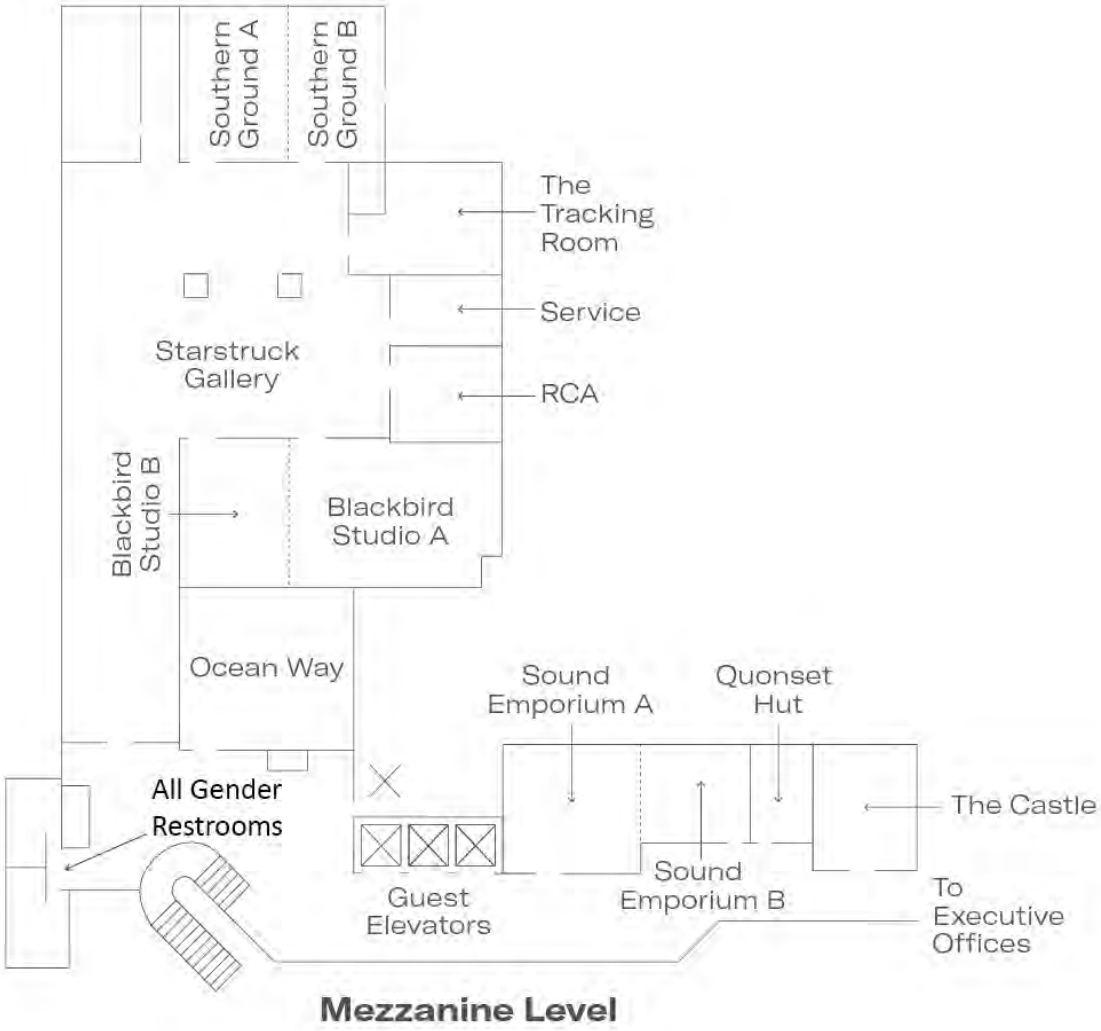
7:45 - 8:30	Steering Committee Meeting	
7:30 - 8:30	Breakfast	Ballroom (I/II)
8:30 - 9:10	Paper Session	Breakout Rooms
9:30 - 10:10	Paper Session	Breakout Rooms
10:30 - 12:00	Working Groups	Breakout Rooms

Conference Venue Floor Plans



Conference Venue Floor Plans





Local Organizing Committee and Volunteers

Local Organizing Committee

Alyson E. Lischka, *Middle Tennessee State University*
Elizabeth Dyer, *University of Tennessee-Knoxville*
Ryan "Seth" Jones, *Middle Tennessee State University*
Jennifer Lovett, *Middle Tennessee State University*
Jeremy Strayer, *Middle Tennessee State University*

pmenaLOC@gmail.com

Strand Leaders

The Local Organizing Committee is extremely appreciative of the following people for serving as Strand Leaders. They managed the reviewing process for their strand and made recommendations to the Local Organizing Committee. The conference would not have been possible without their efforts.

Nina Bailey
Pavneet Kaur Bharaj
Stephanie Casey
Charity Cayton
María de los Angeles Domínguez Cuenca
Lara Dick
Nick Fortune
Maria S. Gargonza
Natasha Gerstenschlager
Maureen Grady
Will Hall
Kristin Harbour
Jose Martinez Hinestroza
Doris Jeannotte
Signe Kastberg
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LouAnn Lovin
Sararose Lynch
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Ricardo Martinez
Allison McCulloch
Susanna Moitoris Miller
Cody Patterson
Priya Prasad
Rani Satyam
Patrick Sullivan
Alexis Stevens
Barb Swartz
Janet Walkoe
Lucy Watson
Doug Whitaker
Ashley Whitehead
Derek Williams
Chris Willingham

Volunteers

MTSU Mathematics and Science Education Doctoral Program Students

Kingsley Adamoah
Rosina Andrews
Christopher Bonnesen
Samantha Fletcher
Monica Frideczky
Amanda Lake Heath
Jordan Kirby
Lori Klukowski
Sarvani Mallapragada
Rachel Perri
Nathan Potratz
Sara Salisbury
Fonya Scott
Jennifer Seat
Jennifer Webster
Joshua Wilson
Demet Yalman Ozen

Translators

Elizabeth Suazo-Flores
Genevieve Barabe

Sponsors

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Department of Mathematical Sciences

Center for Educational Media

Tennessee STEM Education Center

College of Education

MIDDLE TENNESSEE STATE UNIVERSITY

Mathematics and Science Education Doctor of Philosophy Program

Brief Report Session Moderators

Rohini Ajay
Sebnem Atabas
Joseph Antonides
Seyedehkhadijeh Azimi
Lori Burch
Stephanie Casey
Michelle Cirillo
Zandra de Araujo
David Fifty
Kim Johnson
Nick Kim
Patrick Kirkland
Keith Leatham
Chen Lin
Kristy Litster
Alesia Moldavan
Florence Obielodan
Brian Odiwuor
Dana Olanoff
Asli Ozgun-Koca
Robyn Pinilla
Kelsey Quaisley
Elizabeth Roan
Francisco Sepúlveda
Daniel Siebert
Laura Van Zoest
Bill Walker
Jonathan Watkins
Alex White
Ashley Whitehead
Xiangquan (James) Yao
Stacey Zimmerman
Jeremy Zelkowski
Karen Zwanch

Plenary Sessions: Speakers and Abstracts

Thursday, November 17

Re-Membering Place: Mathematical Actions for Innovative, Resilient, and Culturally Rich Communities

How might mathematics educators recognize discourses as resonating harmonies in their practices as researchers? We will share the ways our individual research journeys came to contribute to collective work of re-thinking / re-membering the role of mathematics education in relating to each other, mathematics, communities, and place - ways of relating that are more sustainable, inter-connected, and kincentric. This re-membering is seen as contributing to critical dissonance and the potential for resonating harmony(ies) or algo-rhythms among / between mathematics education, communities, and place.

Dr. Florence Glanfield, Vice-Provost (Indigenous Programming & Research), Professor, Department of Secondary Education, University of Alberta

Dr. Cynthia Nicol, Professor of Mathematics Education, David F. Robitaille Professorship in Mathematics and Science Education, University of British Columbia, Vancouver Canada

Dr. Jennifer Thom, Associate Professor, Mathematics Education & Curriculum Studies, University of Victoria



Friday, November 18

Examining Learning Trajectories: Strengths, Challenges, and Opportunities

Learning trajectories research has occupied a prominent role in the field of mathematics education, as well as at PME-NA, with plenary papers discussing the history of learning trajectories and the CCSS-M (Confrey, 2012), the theoretical and methodological differences between learning trajectories and learning progressions (Battista, 2010), and the use of learning trajectories to develop curricula and cognitive models of students' reasoning (Sarama, 2018). In this panel, we propose a new set of lenses for examining the promise and pitfalls of learning trajectories, both as research tools and as tools for teacher professional development. Building on the conference theme of critical dissonance and resonant harmony, we will consider how learning trajectories can be used to create more socially just contexts for learning and teaching, to improve learning conditions for all mathematics students, and to center students' and teachers' voices. We will share vignettes to support discussion about what learning trajectories can offer for researchers, teacher educators, and practitioners, as well as for considering the opportunities and challenges of leveraging learning trajectories as tools for inclusion and equity.

Dr. Amy Ellis, Professor, Department of Mathematics, Science, and Social Studies Education, Mary Francis Early College of Education, University of Georgia

Dr. Maria Blanton, Senior Scientist, TERC

Dr. Marrielle Myers, Associate Professor of Elementary Mathematics Education, College of Education, Kennesaw State University

Dr. Jennifer Suh, Professor, Elementary Education PK-6, Mathematics Education Leadership, George Mason University




Saturday, November 19

Deconstructing Dissonance and Resonance across Historically Marginalized Learners' Mathematics Experiences to Advance Intersectional Justice

This plenary presents findings from my research that depict historically marginalized learners' experiences of dissonance between their intersectional identities and oppressive contexts of mathematics education. My framework of STEM Education as a White, Cisheteropatriarchal Space is used to show how such dissonance reflects interplay between ideological, institutional, and relational forces in mathematics education that shape intersectional oppression and agency. I also account for disruptions of white supremacy and cisheteropatriarchy across mathematical contexts that contributed to resonant harmony in learners' intersectionality of experiences. With such harmony limited and partially resonant with learners' identities, I ask what robust forms of resonance in mathematics education can look like and if they can be achieved. I conclude with research implications for the advancement of intersectional justice in mathematics education.

Dr. Luis Leyva, Assistant Professor of Mathematics Education at Vanderbilt University – Peabody College of Education & Human Development

Sessions: Detailed Schedule and Descriptions

Thursday, November 17, 2022

4:00 to 7:00pm
001. Conference Check-In Registration
Lobby Level Symphony Ballroom Foyer

6:00 to 7:30pm
002. Opening Plenary: Re-Membering Place: Mathematical Actions For Innovative, Resilient, And Culturally Rich Communities
Lobby Level Symphony Ballroom
Cynthia Nicol, University of British Columbia; Florence Glanfield, University of Alberta; Jennifer S. Thom, University of Victoria
How might mathematics educators recognize discourses as resonating harmonies in their practices as researchers? We will share the ways our individual research journeys came to contribute to collective work of re-thinking / re-membering the role of mathematics education in relating to each other, mathematics, communities, and place - ways of relating that are more sustainable, inter-connected, and kincentric. This re-membering is seen as contributing to critical dissonance and the potential for resonating harmony(ies) or algo-rhythms among / between mathematics education, communities, and place.

7:30 to 9:00pm
003. Welcome Reception
Lobby Level Symphony Ballroom Foyer

Friday, November 18, 2022

7:00 to 7:50am
004. Graduate Student Meeting to Discuss Doctoral Programs in Mathematics Education
Lobby Level Green Room
Brady A Tyburski, Michigan State University, James Drimalla, University of Georgia, Aida Alibek, University of Georgia
There have now been three NSF-funded national conferences on doctoral programs in mathematics education in the United States. The goal of these conferences has been to understand the nature of doctoral programs in the United States and to determine the best practices and principles for these programs. Yet, the intended audience for these conferences has been primarily faculty members. In the interest of including more graduate student voices in this conversation, we (a group of doctoral students) have organized this session in collaboration with one of the organizers of the most recent national conference. Our goal is to bring together graduate students to discuss their experiences in doctoral programs in both break-out groups and whole-group discussion. We will conclude by planning how we should continue this conversation going forward, including consideration of a national conference on doctoral programs that features doctoral student perspectives and goals.

7:00am to 4:00pm
005. Friday Conference Check-In/Registration
Floor Lobby Level Symphony Ballroom Foyer

7:00 to 8:00am
006. Friday Breakfast
Floor Lobby Level Symphony Ballroom I & II

Friday, November 18, 2022 – Morning Program

	8:00 - 8:40am	9:00 – 10:30am Working Groups/Colloquia	10:50 – 11:30am
Mezzanine Level Blackbird Studio A	007. Investigating Mathematics Department Leaders' Experiences and Understandings of Equity	020. Conceptions and Consequences of What We Call Argumentation, Justification, and Proof: Interrogating our Frameworks	036. Bridging Frequentist and Classical Probability Through Design
Mezzanine Level Blackbird Studio B	008. Mathematical Making in Teacher Preparation: Research at the Intersections of Knowledge, Identity, Pedagogy, and Design	021. Adaptations To Lesson Study to Support Equitable Teaching Practices	037. Brief Report - Mathematics Teacher Leadership and Professional Development
Lower Level Gold	009. Brief Report - Developing Knowledge of Teachers and Students	022. Working Through Dissonance: Addressing Tensions that Arise When Studying Mathematics Teacher Preparation Using an Equity Lens	038. Professional Identity Development of Mathematics Teaching Assistants
Lobby Level Green Room	010. NSF Session: Programs and Opportunities for Mathematics Education Research at the National Science Foundation	023. Mathematics Curriculum Recommendations for Elementary Teacher Preparation Working Group: Phase II	039. Journal Session: Welcome to the Margins of Mathematics Education: A New Journal for Critique, Theory, and Philosophy in Our Field
Lobby Level Lyric	011. Towards an Elaboration of Concreteness Fading: Reflections on a Constructivist Teaching Experiment	024. Research Colloquia: Playful Mathematics and Learning	040. Brief Report - Mathematics Teachers' Understanding of Power in Mathematics Learning
Lobby Level Melody	012. Brief Report - Abstract Algebra Instruction	025. Research Colloquia: Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium	041. Manipulatives, affordance and the learning of fraction: The twelfth task/Matériel de manipulation, affordance et apprentissage des fractions: La tâche douzième
Mezzanine Level Ocean Way	013. Brief Report - Students' Algebraic Reasoning and Relationships	026. Latine Studies In Mathematics Education: Working Group Exploring The Borderlands Of Latine Learners	042. Brief Report - Educators' Perspectives on Student Identity in Mathematics Learning
Lower Level Platinum	014. What do the emerging themes in high school teachers' journals tell us about their thinking?	027. Aesthetic and Affective Dimensions of Mathematics Learning	043. Brief Report - Influencing Elementary Pre-Service Teachers' Beliefs
Mezzanine Level RCA	015. Brief Report - The Role of Language and Dialog in Mathematics Learning Processes	028. Complex Connections: Reimagining Units Construction and Coordination with Algebraic and Covariational Reasoning	044. What Factors Contribute to Student Success in Precalculus Flipped Classrooms
Mezzanine Level Sound Emporium A	016. Mathematics Teacher Educators' Reflections on their own practice of equity and social justice with teacher candidates	029. Myths of Objectivity in Mathematics Education / Mitos en torno a la Objetividad en la Educación Matemática	045. Brief Report - Teachers' Thinking about Function and Proportional Reasoning
Mezzanine Level Sound Emporium B		030. Conceptualizing Ethics, Authenticity, and Efficacy of Simulations in Teacher Education	046. Interacción con representaciones dinámicas para argumentar sobre la validez de una construcción geométrica/Interaction with dynamic representations to argue about the validity of a geometry construction
Mezzanine Level Southern Ground A	017. "Mirror logic": A preservice mathematics teacher's thinking about radian in the context of light reflection	031. Taking up Mathematics Education Research Spaces as Resistance: Toward Disability Justice	047. Study of the Consistency in New York State First Year Math Exams
Mezzanine Level Southern Ground B	018. Collective Curricular Noticing Within a Mathematics Professional Learning Community	032. Gender and Sexuality Working Group: Applying Theory to Data	048. Examining The Nature of Pedagogical Content Knowledge (PCK) With A Validation Argument For The PCK-Fractions Measure
Lobby Level Symphony Ballroom III	019. Brief Report - Student Engagement with Elementary Number Concepts	033. Coming Out On The Other Side of "The Equity Group": From Choque to Harmony	
Mezzanine Level The Castle		034. Philosophical Underpinnings of Mathematics Teacher Educators' Work / Bases Filosóficas del Trabajo de los Educadores de Matemáticas	
Mezzanine Level Tracking Room	216. Conceptual reorganization, from count-up-to to break-apart-make-ten: A case of a 6th grader struggling in mathematics (description found in Sunday schedule below)	035. Teaching and Learning with Data Investigation	049. Understanding Preservice Teachers' Noticing of Online Teaching

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

007. Investigating Mathematics Department Leaders' Experiences and Understandings of Equity
Professional Development/ In-Service Teacher Education
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

In the wake of national movements calling for attention to equity, colleges, departments, and instructors are now faced with various responsibilities to implement practices and structures to support diversity, equity, and inclusion (DEI). This project aims to design a professional development program for mathematics graduate teaching assistants (MGTAs) by helping them learn evidence-based teaching practices to support diverse groups of learners in engaging mathematics activities. Part of these efforts included investigating department leaders' understanding of equity. This paper focuses on interviews with department leaders at a large, public, research university. Our analysis shows that despite the implementation of university structures focused on improving equity, department leaders had very different understandings of equitable teaching, and reported differences in how equity factors into their roles.

Participants: *David Fifty, Oregon State University; Mary Beisiegel, Oregon State University; Stacey C.Zimmerman, Western Carolina University*

008. Mathematical Making in Teacher Preparation: Research at the Intersections of Knowledge, Identity, Pedagogy, and Design
Pre-Service Teacher Education
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

In this proposal, we share research that explores the potential benefits of a novel Making experience within mathematics teacher preparation that we hypothesized would inform the pedagogical and curricular thinking of prospective teachers of elementary mathematics (PMTs). That experience had PMTs exploring at the intersection of content, pedagogy, and design to digitally design, 3D print, and share an original manipulative with a child to promote their mathematical thinking. We share several vignettes of our research that aim to discern some of the potential benefits the experience might offer PMTs. These take a variety of theoretical and methodological approaches at the intersections of teacher knowledge, identity, pedagogy, and design. Implications of our findings for teacher preparation and professional learning are provided throughout the paper and in its conclusion.

Participants: *Denish Ogweno Akuom, Montclair State University; Steven Greenstein, Montclair State University; Eileen Fernandez, Montclair State University*

009. Brief Report - Developing Knowledge of Teachers and Students
Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Participants:

Developing empathy through epistemic activities: Teachers' experiences living and learning in base 7 *Marc Husband, St Francis Xavier University; Evan Throop-Robinson, St Francis Xavier University; Lisa Lunney Borden, St. Francis Xavier University*

This research report describes new insights into how teachers develop empathy for learners and build capacity for more responsive teaching. To develop empathy, we introduce an epistemic activity for teachers involving an unfamiliar base system that promotes the construction, communication, and critique of knowledge. Teacher responses from two professional learning groups provided data for analysis. A phenomenographic approach was used to analyze survey data and report teachers' experiences. This study suggests that teachers developed empathy—putting themselves into a students' sense-making experience and seeing the value in their work. Additionally, specific interactions that arose from the investigation influenced teachers' future teaching practices. Results show that teachers recognize and appreciate students' feelings and desire further sense-making opportunities for their future practice.

Responsive Research and professional learning: Coming to know adults and children in a new partnership *Lynsey Gibbons, University of Delaware; Annie Wilhelm, Southern Methodist University; Latrice Marriano, University of Delaware; Robyn K Pinilla, Southern Methodist University*

The analysis reported here examined the initial relationship-building activities a research team engaged in with educators and children at a local elementary school, as the they began to develop a partnership. In our initial interactions and activities with educators, we had three goals: 1) to develop relational trust, 2) to get to know the institutional settings in which teachers worked, and 3) to design responsive professional learning alongside teachers and leaders. In this brief report, we examine the following question: How do you come to know the adults and children in a school in order to design professional learning? We discuss our findings in relation to understanding school leaders' vision for teaching and teacher learning; teacher support structures and accountability; and teachers' experience, dispositions, and practices. Implications for improving learning conditions for each and every learner are discussed.

010. NSF Session: Programs and Opportunities for Mathematics Education Research at the National Science Foundation
Special Event
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

In this session, NSF Program Officers from the Division of Research on Learning and from the Division of Undergraduate Education will discuss programs and opportunities that are relevant to the mathematics education research community. We will begin with an overview of the various programs, including Improving Undergraduate STEM Education (IUSE), Building Capacity in STEM Education Research (BCSER), STEM Education Postdoctoral Research Fellowship (STEM Ed PRF), EHR Core Research (ECR), Discovery Research PreK-12 (DRK-12), Robert Noyce Teacher Scholarship Program (Noyce), among others. We will also present details about the different programs, the proposal submission process, the proposal review process, and we will also discuss features that contribute to strong proposals. We will then answer questions about these programs, breaking into smaller groups, if necessary, to accommodate different participants' interests and areas of focus.

Presenters:

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

Jennifer Ellis, National Science Foundation
Margret Hjalmarson, National Science Foundation
Eric Knuth, National Science Foundation
Elise Lockwood, National Science Foundation

011. Towards an Elaboration of Concreteness Fading: Reflections on a Constructivist Teaching Experiment
Student Learning and Related Factors
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Over half a century has passed since Bruner suggested his three-stage enactive-iconic-symbolic model of instruction. In more recent research, predominantly in educational psychology, Bruner's model has been reformulated into the theory of instruction known as concreteness fading (CF). In a recent constructivist teaching experiment investigating two undergraduate students' combinatorial reasoning, we utilized an instructional approach that maintains the enactive-iconic-symbolic stages of CF, but through a gradual and much elaborated process. We found that our theory of levels of abstraction explicated the "fading" effect that is central to CF. In this theoretical report, we discuss how CF can be elaborated by our instructional approach and theoretical perspective.

Participants: *Joseph Antonides, Virginia Tech; Michael Battista, Ohio State University*

012. Brief Report - Abstract Algebra Instruction
Pre-Calculus, Calculus, and Higher Math
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Relationships Between Dimensions Of Authenticity During An Inquiry-Oriented Abstract Algebra Activity *Holly Zolt, Texas State University; Anthony Tucci, Texas State University; Kathleen Melhuish, Texas State University*

One of the goals of advanced undergraduate mathematics courses is to engage students in activity that is authentic to the mathematics discipline. However, engaging students in such activity often involves managing tensions between authenticity-to-students and authenticity-to-the-discipline. In this paper, we use the Authentic Mathematical Proof Activity (AMPA) Framework to further explore potential relationships and tensions between different dimensions of authenticity. We analyzed classroom data from an inquiry-oriented abstract algebra course where instruction focused on unpacking the fundamental homomorphism theorem. Our results focus on the complexity dimension of authenticity and how this dimension relates to other dimensions of authenticity within instruction. We identify ways that instructor decisions shape authenticity even within the context of a carefully developed task.

Which should come first: isomorphism or homomorphism? *Alison Mirin, Arizona State University; Rachel Rupnow, Northern Illinois University*

Isomorphism and homomorphism are central concepts in abstract algebra, but their interrelatedness provokes questions about which should be taught first. This study investigates instructors' pedagogical preferences and rationales for their ordering of the concepts and compares them to textbooks that they use. We found that for a third of participants, there was a lack of alignment between preferences and textbooks. Additionally, the metaphors used in support of a homomorphism-first approach centered on the idea of formal definition, while those used in support of an isomorphism-first approach focused on sameness.

013. Brief Report - Students' Algebraic Reasoning and Relationships
Early Algebra, Algebraic Thinking, and Function
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Quantitative Reasoning, Deductive Reasoning, and Operating with Algebraic Symbols: A Novel Framework *Teo Paoletti, University of Delaware; Charles Hohensee, University of Delaware; Allison L. Gantt, University of Delaware*

Quantitative reasoning, deductive reasoning, and operating with algebraic symbols have each individually been well-researched by the mathematics education community. However, in the context of algebra problems and relationships, these three types of reasoning do not just occur independently. Rather, students can engage in these types of reasoning in different combinations, which has not yet been well conceptualized by mathematics education research. In this theoretical report, we present a novel framework that describes six different combinations of how students use quantitative reasoning, deductive reasoning, and/or operating with algebraic symbols. We describe and illustrate each combination using examples from extant literature.

Early Algebra Moments: Opportunities to Foster Students' Algebraic Thinking / Momentos de Algebra Elemental: Oportunidades para Formentar del Razonamiento Algebraico *Ingrid Ristroph, The University of Texas at Austin; Eric Knuth, University of Texas at Austin; Despina Stylianou, The City College of New York; Hangil Kim, University of Texas at Austin; Boram Lee, University of Texas at Austin; Bethany Miller, The University of Texas at Austin*

We explore early algebra moments, that is, the opportunities that arise during the course of classroom instruction that a teacher could potentially capitalize upon to address important early algebra ideas or practices. We categorize early algebra moments as anticipated (based on the intended lesson) or spontaneous (not anticipated and arise "in the moment"). In this paper, we report on the analysis of sixteen video-taped observations of Grade 5 teachers' implementation of the same early algebra lesson and illustrate the results with contrasting exemplars of the two types of moments. In addition, we also highlight an episode of a spontaneous moment that capitalizes on collective argumentation. Finally, we discuss implications for future research, professional development, and student learning associated with the early algebra moments.

014. What do the emerging themes in high school teachers' journals tell us about their thinking?
Professional Development/ In-Service Teacher Education
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

We examine in-service high school teachers' journals to explore the emerging themes in a mathematics content course for their

professional development. We use a sociocultural perspective and characterize journals as signifying teachers' communication and written discourses about their thinking and experiences in the course. We use applied thematic analysis to analyze the emerging themes. Our results demonstrate the complexity of teacher thinking and suggest that teachers do not necessarily separate their thinking about themselves or mathematics from their thinking about their students; similarly, they can take different roles as teachers and learners in a given context. Our results indicate exercising caution about potentially operating with an oversimplified picture of teacher thinking via compartmentalized pieces, especially if such frameworks are used to measure teacher thinking, knowledge, and development.

Participants: *Beste Gucler, University of Massachusetts Dartmouth; Jane Ji, University of Louisiana Monroe*

015. Brief Report - The Role of Language and Dialog in Mathematics Learning Processes
Technology and Learning Environment Design
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Participants:

A Bakhtinian Lens on the use of Dialogic Instructional Videos *Mike Foster, San Diego State University/University of California, San Diego*

Assessing the efficacy of dialogic videos has primarily made use of quantitative measures of learning outcomes. While there is a need to push this analysis towards mechanisms of learning, I first take a step back. Applying a new lens to the existing literature that I believe can help advance our understandings of students use of dialogic instructional videos.

Conferencing to Support Mathematical Argument with Multilingual Students *Salvador Huitzilopochtli, Univ. of CA-Santa Cruz; Judit Nora Moschkovich, University of California-Santa Cruz*

This classroom design study sought to support multilingual, middle-school students learning mathematical argument with writing practices (leveraging audience, revising, and conferencing). The study was set in a rural, Northern California, dual-immersion school with over 96% Latinx students and over 80% low-income. We used a proof schemes (Harel & Sowder, 1998) framework to examine revisions that students made during mathematical conferences. Findings show that some students used conferencing as an opportunity to revise (or generate arguments) while other students used conferencing as an opportunity to revise procedures or their use of formal terms. Findings support the notion that language should not serve as a gatekeeper that prevents multilingual students from accessing rigorous mathematics.

016. Mathematics Teacher Educators' Reflections on their own practice of equity and social justice with teacher candidates
Equity and Justice
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

In this paper, we present findings from a collaborative self-study in which we used dimensions of the Rehumanizing Mathematics (RM) framework (Gutiérrez, 2018), to situate and integrate our work as mathematics teacher educators (MTEs) across mathematics content and methods courses. We specifically utilize storytelling as a way to describe how our respective work with teacher candidates aligns with particular dimensions in the RM framework. Our findings indicate that our collaborative self-reflections have positively influenced our individual practices. We have recognized through our collaborations that we have much to learn from one another to both inform and strengthen our practice as MTEs in ways that put forth a collective commitment to rehumanizing mathematics education for our students and the children they will ultimately teach

Participants: *Nirmala Naresh, University of North Texas; Colleen McLean Eddy, University of North Texas; Karisma Morton, University of North Texas*

017. "Mirror logic": A preservice mathematics teacher's thinking about radian in the context of light reflection
Curriculum, Assessment, and Related Topics
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Integrated Science, Technology, Engineering, and Mathematics (iSTEM) education approaches allow learners to utilize multiple disciplinary perspectives. However, the discipline of mathematics remains underrepresented in iSTEM education approaches. To explore the nature of mathematical thinking with an iSTEM learning approach, I investigate the thinking of Alex (pseudonym), a preservice mathematics teacher (PMT) who engaged in a task-based digital activity that involves the concept of radian angle measure in the context of light reflection. Findings suggest that Alex's ways of thinking involved mathematics terminology, concepts, and processes, including mathematically appropriating the principle of light reflection. iSTEM education approaches that emphasize mathematics can contribute to conceptualizations of mathematics in addition to other disciplines through mathematics.

Participants: *Hanan*Alyam*i, Purdue University; Lynn Bryan, Purdue University*

018. Collective Curricular Noticing Within a Mathematics Professional Learning Community
Curriculum, Assessment, and Related Topics
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

This paper explores how a professional learning community (PLC) redesigns high school mathematics lessons towards a shared commitment. We describe the nature of a PLC's collective curricular vision to illuminate how teachers can come to new understandings as a group in order to shift the ways students experience mathematics. Using the curricular noticing framework (attending, interpreting, and responding), we analyzed the meetings of a PLC with six teachers as they individually presented lessons to be redesigned with a focus on the group's shared commitment. Findings indicate three ways ideas were introduced that led to expansive responses, which suggests this analytic approach could identify ways in which a PLC can work towards new curricular decisions.

Participants: *Erin Barno, Boston University; Leslie Dietiker, Boston University*

019. Brief Report - Student Engagement with Elementary Number Concepts
Mathematical Processes and Practices
Brief Research Report Session
8:00 to 8:40 am

Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

Participants:

Using Structure to Find the Distance on an Empty Number Line *Laura Bofferding, Purdue University; Mahtob Aqazade, Rice University*

Looking for and making use of structure along with using the mathematical tools (i.e., number line) are important mathematical practices. In this paper, we explore 32 first-grade and 36 third-grade students' noticing and making use of the structure of two identical number lines when determining the distance of a bunny's jumps. The number lines represented a distance from 11 to 27, and students could choose to jump to 20 (nearest multiple of ten), 21 (adding ten), or 15 (nearest multiple of five). Choosing 21 (distance of 10) was the most frequent choice, and overall, 71% of third graders' and 17% of first graders' attempts showed a correct distance. However, less than one-third of students made connections between their two number lines and noticed their structure. This study informs the importance of number combination knowledge and highlighting structure in order to leverage efficient addition strategies.

Mathematics Education Design Principles to Build an Evidence Base for Fraction Intervention *Jessica H. Hunt, North Carolina State University; Kristi Martin, Sam Houston State University*

We report the results of the second of two pilot studies (see Author) from an intervention designed and developed based on a validated trajectory of students' unit fraction, partitive fraction (i.e., non-unit fractions less than one), and iterative fraction (i.e., non-unit fractions greater than one) concepts. The research questions for this study are: (a) To what extent does a supplemental fraction intervention implemented in a school intervention setting and based on trajectories of students' fraction learning demonstrate evidence of increased student outcomes, defined as conceptual advance evidenced by units coordination? And (b) Is there a statistically significant increase in score on a standardized measure of fractional concepts and operations after participating in a supplemental fraction intervention implemented in a school intervention setting?

Friday, November 18, 2022 9:00 – 10:30 – Working Groups and Colloquia

Abstracts for all working groups and colloquia can be found at the end of the program.

036. Bridging Frequentist and Classical Probability Through Design

Statistics, Probability, and Data Science
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

The frequentist and classical models of probability provide students with different lenses through which they can view probability. Prior research showed that students may bridge these two lenses through instructional designs that begin with a clear connection between the two, such as coin tossing. Considering that this connection is not always clear in our life experiences, we aimed to examine how an instructional design that begins with a scientific scenario that does not naturally connect to theoretical probability, such as the weather, may support students' bridging of these two models. In this paper, we present data from a design experiment in a sixth-grade classroom to discuss how students' shifts of reasoning as they engaged with such a design supported their construction of bridges between the two probability models.

Participants: *Amanda Provost, Montclair State University; Su San Lim, Montclair State University; Toni York, Montclair State University; Nicole Panorkou, Montclair State University*

037. Brief Report - Mathematics Teacher Leadership and Professional Development

Policy, Instructional Leadership, Teacher Educators
Brief Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Participants:

Master Teaching Fellows' Perceptions of Teacher Leadership *Mahtob Aqazade, Rice University; Adem Ekmekci, Rice University; Anne Papakonstantinou, Rice University*

Teacher leadership is essential to meet the needs of students, teachers, and schools in an effective way. To provide a better support system in high-need schools, our Robert Noyce Master Teaching Fellowship program further developed and supported fourteen secondary mathematics teacher leaders. In this paper, we described two of the master teaching fellows' (MTF) reflections on and perceptions of teaching mathematics in high-need schools and teacher leadership throughout this program. To do so, we applied a deductive approach in thematic data analysis and relied on conceptual framework of teacher leadership and domains of teacher leader model standards. The emerged themes reflected the ways in which these two MTFs attempted to (a) promote student success, (b) address concerns around diversity and equity, and (c) facilitate uncertain challenges during COVID-19 pandemic.

Elementary Teachers' Shift From Arithmetic To Functional Thinking Through Professional Development *Alysia Goyer, University of Nevada, Reno; Tejvir Kaur Grewall, University of Nevada, Reno; Sierra Gil, University of Nevada, Reno; Teruni Lamberg, University of Nevada, Reno*

Elementary In-service teachers participated in professional development related to algebraic thinking. A pre and posttest was administered. The analysis of how teachers conceptualized and solved a problem involved functional thinking shifted from the pre and posttest. Initially teachers solved the problem using additive thinking involving arithmetic. After professional development, teachers shifted to using functional thinking to solve the same problem. Implications for teacher knowledge and professional development are described.

038. Professional Identity Development of Mathematics Teaching Assistants

Professional Development/ In-Service Teacher Education
Research Report Session

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold

This study examined how the social interactions that mathematics teaching assistants (TAs) have within their institution influenced their professional identity development as early-career undergraduate instructors. We drew on a sociocultural perspective of professional identity development in higher education to examine TAs' interactions with students, faculty, and other TAs. We qualitatively analyzed five mathematics TAs' responses to semi-structured interviews and found that some dimensions of their identities were more frequently situated within specific relationships, while others were evident in multiple relationships. Overall, the social interactions were sites for professional identity development. Identity is a complex construct, and a better understanding of how professional identity is developed can inform higher education institutions on ways to support positive identity development of future mathematics instructors.

Participants: *Royce Olarte, University of California Santa Barbara; Micah Swartz, Texas State University; Sarah A. Roberts, University of California, Santa Barbara*

039. Journal Session: Welcome to the Margins of Mathematics Education: A New Journal for Critique, Theory, and Philosophy in Our Field

Special Event
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

The Journal for Theoretical & Marginal Mathematics Education (JTM-ME) publishes papers of interest to the mathematics education field that focus on critical, philosophical, psychoanalytic, experimental, theoretical, or post-qualitative research. Cross-disciplinary approaches to theory and methods are also encouraged. JTM-ME positions itself within and against mathematics education: it was conceptualized as an outlet to make space for forms of research—and their constituent researchers—directly and tacitly excluded from spaces of mathematics education, and as a space to directly challenge hegemonies, norms, and un-critiqued discourses in mathematics education, i.e., it simultaneously creates new space within mathematics education and challenges traditional spaces of mathematics education. This conference session includes a discussion by two of the editors of JTM-ME that will include motivation, structure, review process, and unique differences that set JTM-ME apart in the growing sea of academic journals. Website: jtm.cppi.me

Presenters:

Alexander S. Moore, Virginia Polytechnic Institute and State University
David Matthew Bowers, University of Tennessee, Knoxville

040. Brief Report - Mathematics Teachers' Understanding of Power in Mathematics Learning

Equity and Justice
Brief Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Participants:

"I Was Playing into White Supremacy": Preservice Teachers' Narratives Positioning Whiteness, Mathematics, and Themselves *Alexa W.C. Lee-Hassan, University of Illinois at Chicago*

This report explores preservice teachers' nascent political conocimiento for teaching mathematics by analyzing narrations of their experiences in a math content course as part of a racially diverse group of students. The report describes variations in the ways in which the preservice teachers position themselves with respect to Whiteness, mathematics, and the dynamics of class participation.

Analytical Processes for Measuring Equitable Noticing in Mathematics / Procesos Analiticos para Medir la Mirada Profesional y Equidad en Matematicas *Cindy Jong, University of Kentucky; Jonathan Norris Thomas, University of Kentucky; Walker Mask, University of Kentucky; Molly Fisher, University of Kentucky; Edna O'Brien Schack, Morehead State University*

In this paper, we provide two analytical methods for measuring the intersecting constructs of equity and professional noticing, as defined by Jacobs et al. (2010). One is a scoring rubric utilizing Gutiérrez's (2009) four dimensions of equity to include access, achievement, identity, and power, along the dominant and critical axes. The second is a flowchart to examine asset, deficit, or neutral language in professional noticing responses about students' mathematical thinking. We discuss the affordances and limitations of both methods, along with challenges for measuring equitable noticing in meaningful ways. Preliminary findings have shown a positive increase in the dominant axis where responses elaborate upon the dimensions of access and achievement.

041. Manipulatives, affordance and the learning of fraction: The twelfth task/Matériel de manipulation, affordance et apprentissage des fractions: La tâche douzième

Mathematical Processes and Practices
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

This study investigates the use of manipulatives by elementary students working on a fraction task. Extending previous work on the role played by the manipulatives in students' activity, we aim at describing how the choices made for the task design disrupt students' activity, creating opportunities to learn. The theoretical underpinnings allow envisioning the students' activity through the concept of routine and the manipulatives through the concept of affordance. The analysis of the students' mathematical activity allows us to better understand how manipulatives can serve as breaching elements, leading students to modify their mathematical activity, and thus, creating opportunities to learn.

Participants: *Doris Jeannotte, UQAM; Claudia Corriveau, Université Laval*

042. Brief Report - Educators' Perspectives on Student Identity in Mathematics Learning

Equity and Justice
Brief Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Principal's Storylines about Languages in Mathematics Class *Annica Andersson, University of Southeastern Norway; Beth Herbel-Eisenmann, Michigan State University; Hilja Lisa Huru, UiT The Arctic University of Norway; David Wagner, University of New Brunswick*

Drawing on in-depth interviews, this paper focuses on nine principals' storylines about Indigenous and (rather) newly migrated students, mathematics and languages in Norway. We share two of the storylines we found in our analysis: mother tongue teachers are important resources; and Students don't (yet) have the basic language skills to build their mathematical language. Our discussion

connects these findings to some earlier work and discusses the implications for math education.

Using Anti-Bias Picture Books to Elicit Social Justice Mathematics Lessons in Early Childhood Teacher Education *Bailey Anne Kaufman-Ridout, Fordham University; Alesia Mickle Moldavan, Georgia Southern University*

This study examines early childhood preservice teachers' experiences using anti-bias picture books to design mathematics lessons addressing issues of social justice during a children's literature course. With reference to the Teaching Mathematics for Social Justice framework (Gutstein, 2006) and the Learning for Justice (2016) social justice standards, preservice teachers designed lessons to address issues of identity, diversity, justice, and action. Findings indicate that the preservice teachers were more likely to target social justice pedagogical goals focused on identity and diversity over justice and action. Additionally, the preservice teachers experienced increased confidence when working with such lessons. Recommendations are made that preservice teachers in early childhood education have explicit opportunities to engage in such tasks to develop their mathematical consciousness and professional practice.

043. Brief Report - Influencing Elementary Pre-Service Teachers' Beliefs

Pre-Service Teacher Education
Brief Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Dissonance Created Through Open Mathematical Tasks: Preservice Teachers' Beliefs Illuminated *Amy Brass, Pennsylvania State University; Emily Mainzer, Penn State University*

It is well-documented that elementary preservice teachers (PSTs) enter teacher education programs with beliefs about mathematics education largely formed from their own schooling experiences. These beliefs are often narrow and strongly influence how PSTs will eventually teach mathematics to their elementary students. In an effort to create dissonance regarding these beliefs, we presented PSTs with four tasks of varying levels of openness as part of their elementary math methods course. After participating in discussions surrounding these tasks, PSTs completed an open-ended questionnaire that asked them about the experience. Preliminary findings suggest the open tasks challenged PSTs' beliefs about mathematics as a subject, mathematics learning, and mathematics teaching.

Using Mindfulness to Support the Well-Being of Preservice K-8 Teachers During a Pandemic *Rachael Mae Welder, University of Nevada, Reno; Megan Burton, Auburn University; Heidi Eisenreich, Georgia Southern University*

In this presentation, we will report initial findings from the implementation of a Mindfulness-Based Intervention (MBI) during the COVID-19 pandemic in an effort to mitigate the effects of stress and anxiety on preservice K-8 teachers (PTs) as learners of mathematics for teaching. Three teacher educators, at three U.S. institutions, implemented the MBI in their mathematics content and methods courses for PTs, as a way to connect with and holistically support students during a semester of pandemic-induced online instruction. Initial analysis of survey data (n=136) shows that PTs reported mindfulness helping them to become self-aware and learn strategies for regulating their behaviors. PTs saw value in applying mindfulness outside of the classroom and with their future students. By introducing coping strategies, we were able to show PTs the importance of caring for their mental and emotional well-being and the well-being of their future students.

044. What Factors Contribute to Student Success in Precalculus Flipped Classrooms

Pre-Calculus, Calculus, and Higher Math
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Learners' motivation and attitude to work are essential the successful implementation of the constructivist learning-centric approach. Yet, very few studies have examined the connections between students' motivation and achievement goals in flipped instruction. To address the current gap, this study investigated the relationship between students' motivation beliefs, flipped method, and achievement in Precalculus using pre- and post-course surveys collected from 32 undergraduates. Both motivation beliefs and flipped instruction influenced academic achievement positively in the course and moderated by students' efforts.

Participants: *Florence F Obielodan, University at Buffalo, The State University of New York; Ji-Won Son, The State University of New York at Buffalo*

045. Brief Report - Teachers' Thinking about Function and Proportional Reasoning

Mathematical Knowledge for Teaching
Brief Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Participants:

Examining Changes in Preservice Secondary Mathematics Teachers' Definitions of Function (from Pretest to Post-Intervention) *Radhika Pathak Kharel, Illinois State University; Matthew Winsor, Illinois State University*

This study examined preservice secondary mathematics teachers' (PSTs') definitions of a function and how those definitions changed as a result of a teaching intervention. Fourteen PSTs in a senior-level content capstone course participated in the study. PSTs' definition of a function before and after the intervention were analyzed using the comparison method. The findings showed that the PSTs struggled to revise their rote-learned definitions of a function to incorporate both definition univalence and arbitrariness in their descriptions of functions. In addition, the findings indicated that PSTs were able to identify whether or not the given relations or graphs represented a function.

One Teacher's Knowledge of Proportions in Practice *Chandra Orrill, UMass Dartmouth; Rachael Eriksen Brown, Penn State Abington; Rohini Thapa, UMass Dartmouth; Emmanuel Nti-Asante, University of Massachusetts, Dartmouth*

This exploratory study offers a unique qualitative approach to exploring a teacher's knowledge of proportional reasoning and how that knowledge appears in the classroom. Using two theoretical frameworks, Knowledge in Pieces and the Knowledge Quartet, the study analyzes one middle grades teacher's proportional reasoning knowledge in two content interviews as well as

in classroom data. Results suggest the teacher has both procedural and conceptual knowledge. Interestingly, the teacher tended to rely on procedural approaches with a preference for efficiency.

046. Interacción con representaciones dinámicas para argumentar sobre la validez de una construcción geométrica/Interaction with dynamic representations to argue about the validity of a geometry construction

Technology and Learning Environment Design
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

From mathematics education, a great variety of studies have focused on analyzing the presence of digital technology from different points of view. Those who work with proof and argumentation have resisted presenting results with a technological component, due to the idea of formality associated with those terms, which has increased the existing tension between the theoretical and empirical nature of mathematics. Taking into consideration that with the presence of environments such as DGS the student can access to dynamic representations, we seek to understand the impact of the interaction with these representations on the arguments proposed by the students. For this, we carried out an exploratory and descriptive study whose results show that the interaction with dynamic representations provides students with validation tools different from those on paper/ Desde la matemática educativa, gran variedad de estudios se ha enfocado en analizar la presencia de la tecnología digital desde diferentes puntos de vista. Quienes abordan la prueba y la argumentación se han resistido a que se presenten resultados con un componente tecnológico, debido a la idea de formalidad asociada estos términos, lo que ha aumentado la tensión existente entre la naturaleza teórica y empírica de la matemática. Teniendo en cuenta que con la presencia de entornos como DGS el estudiante puede acceder a representaciones dinámicas, nosotros buscando entender el impacto de la interacción con estas representaciones en los argumentos que proponen los estudiantes. Para esto realizamos un estudio de tipo exploratorio y descriptivo cuyos resultados muestran que la interacción con representaciones dinámicas brinda a los estudiantes herramientas de validación diferentes a las del papel.

Participants: *María Alejandra Calderón González, Cinvestav; Luis Moreno-Armella, Cinvestav-IPN*

047. Study of the Consistency in New York State First Year Math Exams

Curriculum, Assessment, and Related Topics
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

As standards documents have been introduced over the past 20 years, many states have evolved in standards and related high stakes exams. For many teachers across the U.S., the rollout of standards and exams has not been an experience that builds trust in state education leaders. In this study, we consider three major changes in the first-year high school math exams in New York State since 2002, looking at consistency in item types, topics addressed, and student performance. Shifts in all were noted, but the changes in topics, especially when not obvious by the names given to standards, are suggested as the mostly likely to misinform or misguide teachers. We consider how state educational leaders are working to build trust for the next iteration of standards. While this study is particular to one state, the methods and findings should be of interest to those who study testing in high schools.

Participants: *Stephanie Leah Schaefer, Southern New Hampshire University/American College of Education; Deborah Moore-Russo, University of Oklahoma*

048. Examining The Nature of Pedagogical Content Knowledge (PCK) With A Validation Argument For The PCK-Fractions Measure

Mathematical Knowledge for Teaching
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

This study presents an extension of the validity argument for the PCK-Fractions measure. PCK-Fractions is designed to assess the effectiveness of professional experiences in facilitating teachers' pedagogical content knowledge (PCK) for children's fraction reasoning in grades 3-5. We examined data across 101 participants from two Midwest universities including non-education majors, education majors, and education majors with grade 3 to 5 math field experiences. Results provide additional validity evidence for the PCK-Fractions. Namely, evidence indicates differences in scores between groups of participants—preservice teachers grade 3 to 5 field experience had higher scores than those without, and all preservice teachers had higher scores than non-education majors.

Participants: *Maryam Zolfaghari, Kent State University; Karl Wesley Kosko, Kent State University; Christine Kathryn Austin, Kent State University*

049. Understanding Preservice Teachers' Noticing of Online Teaching

Teaching Practice and Classroom Activity
Research Report Session
10:50 to 11:30 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

The rapid move to online teaching brought about by the global pandemic highlighted the need for the educational research community to develop new conceptual tools for characterizing these environments. In this paper, we propose a conceptual framework Instructional Technology Triangle (ITT) which extends the instructional triangle of teachers, students, and content to include technology as a mediating mechanism. We use the ITT framework to analyze noticing patterns in the written reflection of a prospective secondary teacher, Nancy, who taught four online lessons over the course of one semester. The fluctuations in Nancy's noticing patterns, in particular, with respect to technology, shed light on her trajectory of learning to teach online and the role of reflective noticing in this process. We discuss implications for the theory and practice of teacher preparation and professional development.

Participants: *Jinqing Liu, University of New Hampshire; Orly Buchbinder, University of New Hampshire; Merav Weingarden, University of New-Hampshire*

11:30am to 12:15pm
050. Friday Lunch
Floor Lobby Level Symphony Ballroom

12:15 to 1:25pm
051. Examining Learning Trajectories: Strengths, Challenges, and Opportunities
Floor Lobby Level Symphony Ballroom
Amy Ellis, University of Georgia; Maria Blanton, TERC; Marrielle Myers, Kennesaw State University; Jennifer M. Suh, George Mason University
Learning trajectories research has occupied a prominent role in the field of mathematics education, as well as at PME-NA, with plenary papers discussing the history of learning trajectories and the CCSS-M (Confrey, 2012), the theoretical and methodological differences between learning trajectories and learning progressions (Battista, 2010), and the use of learning trajectories to develop curricula and cognitive models of students' reasoning (Sarama, 2018). In this panel, we propose a new set of lenses for examining the promise and pitfalls of learning trajectories, both as research tools and as tools for teacher professional development. Building on the conference theme of critical dissonance and resonant harmony, we will consider how learning trajectories can be used to create more socially just contexts for learning and teaching, to improve learning conditions for all mathematics students, and to center students' and teachers' voices. We will share vignettes to support discussion about what learning trajectories can offer for researchers, teacher educators, and practitioners, as well as for considering the opportunities and challenges of leveraging learning trajectories as tools for inclusion and equity.

Friday, November 18, 2022 – Afternoon Program

	1:40 – 2:20pm	2:40 – 3:20pm	3:50 – 4:30pm
Mezzanine Level Blackbird Studio A	052. Brief Report - Students' Geometry Reasoning in Technology-Enhanced Learning Environments	067. The Prime Number Theorem as a Mapping between Two Mathematical Worlds	083. Building Towards Harmony Between Identity and Mathematics Synthesizing Figured Worlds and Rightful Presence
Mezzanine Level Blackbird Studio B	053. Tensions About Equity: Instructors' Nepantla attending to Identity and Power in Mathematics	068. Brief Report - Geometry Curriculum and Assessment	084. The self as noticer: Supporting preservice teachers' developing awareness
Lower Level Gold	054. Brief Report - Curriculum Implementation and Adaptation	069. Middle School Students' Mature Number Sense is Uniquely Associated with Grade-Level Mathematics Achievement	085. Using Video to Identify What Is Not Known In Students' Mathematical Thinking
Lobby Level Green Room	055. Journal Session: Publishing in Educational Studies in Mathematics	070. Development of a Mathematics Discipline-Specific Language Scale	086. Embodying Covariation Through Collaborative Instrumentation
Lobby Level Lyric	056. Conceptualizing Mathematics Teacher Educator Knowledge: Comparing and Contrasting Existing Frameworks	071. Brief Report - Elementary Teachers' Conceptions of Students	087. Justifications Students Use When Writing an Equation During a Modeling Task
Lobby Level Melody	057. Relationships between teacher questioning and student generalizing	072. Brief Report - Computational Thinking in Mathematics Learning	088. Brief Report - Students' Algebraic Reasoning and Argumentation
Mezzanine Level Ocean Way	058. Faculty and Student Perceptions of Instructional Servingness in Gateway Mathematics Courses at a Hispanic-Serving Institution	073. Brief Report - Gender and Mathematics Identity	089. Brief Report - Novice Teachers' Perspectives on Equity
Lower Level Platinum	059. Brief Report - Teacher and Student Thinking about Fractions	074. Brief Report - Elementary Teachers' Enactment of Number Talks	090. Self-Efficacy, Instructional Beliefs and the Use of Mathematical Practice Standards
Mezzanine Level RCA	060. Undergraduate Perspectives On The Nature of Mathematics Through Exploration of Unsolved Conjectures	075. Promoting variational thinking with the aid of digital technology/Promoviendo el pensamiento variacional con apoyo de la tecnología digital	091. Aesthetic Dimensions of Student Mathematical Creativity
Mezzanine Level Sound Emporium A	061. Supporting the Development of Positive Mathematics Teaching Identities in Preservice Teacher Education	076. The Role of a Boundary Object in a Study of Middle Grades Mathematics Instruction	092. "I watched as he put things on the paper": A feminist view of mathematical discourse
Mezzanine Level Sound Emporium B	062. Brief Report - Teachers' Use of Statistical Simulations	077. Undergraduate Students' Conceptions About Complex Numbers: A Trajectory of Their Mental Structures/Concepciones sobre los Números Complejos de Alumnos de Pregrado: Una Trayectoria de sus Estructuras Mentales	093. Personal Inferences as Warrants of Undergraduate Students' Arguments in Calculus Contexts
Mezzanine Level Southern Ground A	063. Promoting proportional reasoning with the support of digital technology / Promoviendo el razonamiento proporcional con apoyo de la tecnología digital	078. Brief Report - Supporting Pre-Service Teachers' Enactment of Discussion-based Mathematics Learning	094. Relevance as Perceived by High School Students in Decontextualized Mathematics Lessons
Mezzanine Level Southern Ground B	064. Brief Report - Pre-Service Teachers' Views about Mathematics Lessons	079. Mathematics Education Researchers' Practices in Interdisciplinary Collaborations: Embracing Ways of Knowing/Las Practicas en Grupos Interdisciplinarios de los Investigadores de Educacion Matematicas: Abrazando las Formas de Saber	095. Brief Report - Supporting Student Reasoning in Mathematics-Specific Technology Platforms
Lobby Level Symphony Ballroom III	065. Teachers Motivations for and Enactments of Ambitious Mathematics Instruction: The Case of Rough Draft Math	080. Playful Math: Modeling Students' Engagement in Play-Based Algebra Activities	096. Developing Asset-based Instruction through Learning Trajectory-based Curricular Design
Mezzanine Level The Castle			
Mezzanine Level Tracking Room	066. Supporting Discussion Practice in Mathematics Methods: Applications of Whole-Class Scaffolding	081. How Proportional Reasoning is Presented in U.S. and Korean Textbooks	097. Different Ways of Learning Number Density: A Hypothetical Trajectory with High School Students/Diferentes Formas de Aprender la Densidad Numérica: Una Trayectoria Hipotética con Estudiantes de Bachillerato

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

052. Brief Report - Students' Geometry Reasoning in Technology-Enhanced Learning Environments
Geometry and Measurement
Brief Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A
Participants:

Área Y Perímetro: Diseño de Tareas Auténticas Asistidas por un Software en 3D *Romario Montaño Ramos, Benemeritas Universidad Autónoma de Puebla; Honorina Ruiz-Estrada, Tutora; Josip Slisko, Benemérita Universidad Autónoma de Puebla*

En este documento se presentan los aspectos centrales para el diseño de tareas auténticas y algunos resultados obtenidos durante su implementación, las cuales fueron aplicadas a un grupo de seis estudiantes pertenecientes al Consejo Nacional de Fomento Educativo (CONAFE) del estado de Puebla. En el análisis se tuvieron en cuenta los conocimientos previos de los estudiantes y su interacción con cada una de las tareas. Los resultados obtenidos muestran que los estudiantes presentan concepciones erróneas con respecto a las relaciones existentes entre los conceptos de área y perímetro y se evidencia el uso de conocimientos extraescolares cuando se trabajan con tareas auténticas asistidas por un software de realidad virtual.

Developing a Framework for Characterizing Student-Created Diagrams in DGEs *Xiangquan Yao, Pennsylvania State University*

Dynamic geometry environment offers a wide range of tools for its users to create and interact with geometry diagrams. This paper proposes a framework to characterize the geometry diagrams learners create in DGEs. The framework considers a learner's approach to creating a geometry diagram (i.e., perceptual-based, measurement-based, construction-based, and transformation-based), the driving force that guides the learner's specific actions in a DGE (i.e., tool-driven, and property-driven), and constraints in the resulting diagram (i.e., drawing, underconstrained, overconstrained, and appropriately constrained). Examples of student work on one geometry construction problem are used to illustrate the use of the framework.

053. Tensions About Equity: Instructors' Nepantla attending to Identity and Power in Mathematics
Professional Development/ In-Service Teacher Education
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

In this paper, we discuss the case studies of two professional development (PD) participants: Nhung Tran and Stella Miller. This data comes from an NSF-funded grant studying mathematical persistence of inquiry and equity (MPIE) at a two-year college. We analyze participant conceptualizations of equity using Gutiérrez' (2009) equity framework. By considering the dominant axis (Access and Achievement) and the critical axis (Identity and Power), we identify places of dissonance, or Nepantla, that emerge for each participant. We discuss how these tensions give us valuable information as we consider future iterations of PD on the MPIE project.

Participants: *Brinley Poulsen Stringer, San Diego State University; Gabriela Hernandez, San Diego State University; Charles Wilkes, University of Michigan; Mary E Pilgrim, San Diego State University*

054. Brief Report - Curriculum Implementation and Adaptation
Curriculum, Assessment, and Related Topics
Brief Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold
Participants:

How Do Teachers and Districts Implement Statewide Co-designed Instructional Frameworks? *Michelle Stephan, UNC Charlotte; Catherine S. Schwartz, East Carolina University; Katherine J Mawhinney, Appalachian State University*

We report the findings from our efforts to co-design statewide instructional frameworks to support elementary and middle school mathematics teachers' and leaders' implementation of state standards in ways that align with visions of high quality mathematics instruction. In this paper, we explore whether districts as well as individual teachers took up the instructional frameworks, their reasons for doing so, and the ways they used them to support instruction. Our findings indicate that the instructional frameworks were widely adopted across the state, supported teachers' pacing and sequencing efforts, and provided opportunities for professional learning. However, school/district leaders and classroom teachers had different views on why their district decided to take the frameworks up, indicating a communications divide that needs to be addressed in future co-design efforts.

Investigating Elementary Mathematics Teachers' Adaptation of Activities Found on Virtual Resource Pools CE POOLS *Lara Dick, Bucknell University; Amanda Ganett Sawyer, James Madison University*

Over the past decade, teachers have increasingly turned online to supplement their mathematics curriculum and some research regarding where and how teachers search has been completed. However, there are many open questions regarding this rising phenomenon, one of which is learning more about what teachers do after finding a mathematics activity online. We report on a subset of a survey of elementary school teachers across the United States about their use of elementary mathematics activities found via virtual resource pools; for this manuscript, we share results on two questions related to teachers' adaptation of elementary mathematics activities they obtained.

055. Journal Session: Publishing in Educational Studies in Mathematics
Special Event
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Publishing mathematics education research since 1968, Educational Studies in Mathematics is read by scholars across the globe. The journal's articles represent a range of perspectives on mathematics teaching and learning, from a wide range of countries. ESM is open to papers addressing methodological, pedagogical/didactical, political and socio-cultural aspects of teaching and learning of mathematics, and open to all research approaches. This session will outline the publication and review processes in order to encourage and support submissions to the journal, and to invite and guide prospective reviewers. Participants will be invited to ask questions with co-editor-in-chief, David Wagner. Anticipated questions include: What are the common concerns identified by reviewers from different regions and scholarly traditions? What are common concerns raised for papers

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

from particular regions? How are reviewers chosen? What is a typical timeline for the peer review process? What are the style and length expectations for submissions?

Presenter: ***David Wagner***, University of New Brunswick

056. Conceptualizing Mathematics Teacher Educator Knowledge: Comparing and Contrasting Existing Frameworks

Mathematical Knowledge for Teaching
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Over the past two decades, the landscape of research on mathematics teacher educators (MTE) has grown considerably. One particular area of interest has focused on the knowledge needed by MTEs for their work with preservice K-8 teachers (PTs). In an effort to understand this varied landscape, we conducted an extensive review of research on frameworks of MTE knowledge. This report explores the theoretical underpinnings of MTE knowledge and highlights similarities and differences among theoretical frameworks. By mapping the terrain of research on MTEs' knowledge, our goal is to identify aspects of MTE knowledge to inform the types of research that may be needed for its further development.

Participants: *Rachael Mae Welder, University of Nevada, Reno; Alison Castro Superfine, University of Illinois at Chicago; Priya Vinata Prasad, The University of Texas at San Antonio; Dana Olanoff, Widener University*

057. Relationships between teacher questioning and student generalizing

Teaching Practice and Classroom Activity
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

This study shares two frameworks for analyzing teacher actions that support students in generalizing and examines how those frameworks align with a framework for teacher questioning. One classroom teaching episode focused on the mathematical activity of generalizing a visual pattern is shared to illustrate effective questioning for promoting generalizing.

Participants: *Allyson Hallman-Thrasher, Ohio University; Jennifer Thompson, Ohio University; Kayla Heacock, Ohio University; Lizhen Chen, Ohio University*

058. Faculty and Student Perceptions of Instructional Servingness in Gateway Mathematics Courses at a Hispanic-Serving Institution

Equity and Justice
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Research exploring how Latin* STEM students at Hispanic-Serving Institutions (HSIs) are served has largely focused on features of organizational structures (e.g., support programs), but minimally examined instructional practices and classroom experiences. This is an important gap to fill, especially in gateway mathematics courses (e.g., calculus, statistics), where faculty relationships and quality of instruction impact Latin* students' persistence and identities in STEM. To advance this area of research, this report presents findings from an analysis of how HSI mathematics faculty and student perspectives on instruction in introductory statistics converged and diverged in terms of serving Latin* populations. We present two illustrative cases of dissonant and resonant perspectives on instruction with an expansive framing of mathematical ability as a form of servingness. Our report concludes with research and practice implications.

Participants: *Luis Antonio Leyva, Vanderbilt University - Peabody College of Education & Human Development; Nicollette Mitchell, Vanderbilt University - Peabody College of Education & Human Development; R. Taylor McNeill, Vanderbilt University - Peabody College of Education & Human Development; Martha Byrne, Sonoma State University; Ben Ford, Sonoma State University; Lorely Chávez, Vanderbilt University - Peabody College of Education & Human Development; Enrique Abreu-Ramos, Vanderbilt University - Peabody College of Education & Human Development*

059. Brief Report - Teacher and Student Thinking about Fractions

Mathematical Knowledge for Teaching
Brief Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Elementary School Teachers' Understanding of Unit Fractions *Arthur B. Powell, Rutgers University; Muteb M. Alqahtani, State University of New York at Cortland; Özlem DOĞAN TEMUR, Suny Cortland; daniela tirnovan, Rutgers*

Teachers' mathematical knowledge is critical for their teaching of mathematics. We investigated whether elementary teachers believe that a unit fraction, 1/n, results only from a whole equipartitioned into n parts. We adapted Ciosek and Samborska's (2016) Frame Task, presenting a frame consisting of three unequal segmented squared rings, with one squared ring shaded. In semi-structured interviews, 19 teachers engaged the task and reasoned whether the shaded portion equals 1/3 of the frame. Our findings indicate about three-quarters of the participants believe that either (1) to have one-third of a quantity, a section needs to be one of three parts, or (2) a section cannot be 1/3 of an object if the object is partitioned into three unequal sections. Finally, we hypothesize how an iterative perspective of unit fractions may mitigate against the false beliefs that Ciosek and Samborska (2016) and our study document.

Relationship Between Discourse and Students' Evaluation of Strategies to Subtract Fractions with Mixed Numbers *Kristy Litster, Valdosta State University; Beth L. MacDonald, Utah State University*

This mixed methods study explored the relationship between two types of small-group mathematics discourse (Reflective and Exploratory) and the quantity and type of strategies discussed. The study focused on 97 fifth-grade students, organized into 34 small (17 Reflective, 17 Exploratory) and the strategies they used to solve two problems (4½ - 3¾; 4-3¾). Results indicated that both discourse types can encourage student evaluation of multiple computational strategies. However, several factors seemed to increase or decrease the strategies discussed. In exploratory discourse, the student in the group writing the answer may limit discussion by solving the problem themselves. In reflective discourse, when students all agreed on the same answer they were less likely to discuss any strategies. For both discourse types, dissonance in answers or strategies often prompted the discussion of multiple strategies to determine accuracy.

060. Undergraduate Perspectives On The Nature of Mathematics Through Exploration of Unsolved Conjectures
Mathematical Processes and Practices
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

We report on a research study conducted within a transition-to-proof course for mathematics majors at a large public university. Within the course, students explored famously unproven conjectures and reflected on how their perspectives of mathematics changed through this exploration (if at all). In this report we share students' takeaways from the project. For instance, some students experienced mathematics as a creative subject for the first time, as they tried their own methods to solve the conjectures; other students reflected on developing a greater understanding of the behind the scenes work of mathematicians that goes into mathematical creation. We also report on the subjective emotional experiences of the students, which ranged from frustration from being unable to find patterns to enjoyable exploration.

Participants: *Jeffrey Pair, California State University Long Beach; Gabe Calva, California State University Long Beach*

061. Supporting the Development of Positive Mathematics Teaching Identities in Preservice Teacher Education
Pre-Service Teacher Education
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Research suggests that preservice teachers enter teacher education with predominantly negative dispositions towards mathematics. We present a case study of an approach to supporting the development of positive mathematics teaching identities among students in a middle-years math methods course. Our findings suggest that engaging in narrative reflection in tandem with collaborative problem solving in a mathematical discourse community over time helped students to transform their relationships with mathematics and forge positive mathematics identities. Providing opportunities for students to share and work through their vulnerabilities was critical to this process. Our findings illustrate a promising approach for teacher educators to support the development of positive mathematics teaching identities in preservice teacher education.

Participants: *Lara Condon, University of Pennsylvania; Janine Remillard, University of Pennsylvania*

062. Brief Report - Teachers' Use of Statistical Simulations
Statistics, Probability, and Data Science
Brief Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

Participants:

In-Service High School Statistical Teachers' Reasoning on Significance Tests with Simulation *Francisco Sepulveda, CINVESTAV, IPN, México; Ernesto Alonso Sánchez, Departamento de Matemática Educativa, Cinvestav-IPN; Guadalupe Carrasco Licea, Colegio de Ciencias y Humanidades, Plantel Sur. UNAM*

Our research questions are the next two: How in-service teachers use simulation to solve p-value problems? How do teachers reason when solving p-value problems with simulation? The answers to two p-value problems by 19 in-service teachers who worked in teams on an on-line update course are analyzed. The course was conceived as a design experiment. Teachers were able to learn to use the Fathom software, but some resistance to the informal approach is observed in teachers' need to make more calculations than necessary to solve the problems. Misconceptions about significance level, and the documented verificationist conception of statistical tests were also observed.

Learners' Uses of Designed Computer Simulations in Probabilistic and Stochastic Settings *Karoline Smucker, Eastern Oregon University*

Simulations play a key role in statistics and probability education, and are important tools for students and teachers. This report presents preliminary findings from design research investigating the impact of computer simulations on learners' approaches to tasks involving probabilistic modeling, sampling, and stochastic reasoning. Five preservice secondary mathematics teachers engaged with a series of seven tasks, with a goal of understanding their use of the computer simulations in the course of problem solving. The designed simulation environments were created using the Common Online Data Analysis Platform (CODAP). Analysis of one participant's approaches suggests that the simulation was used in several distinct ways; in particular it was used to confirm, to test, and to investigate/refine.

063. Promoting proportional reasoning with the support of digital technology / Promoviendo el razonamiento proporcional con apoyo de la tecnología digital
Number Concepts and Proportional Reasoning
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

In this paper, we present an advance of doctoral research in which we explore alternative ways of teaching that promote proportional reasoning in Mexican students between 14 and 15 years old, with the support of digital technology. We have designed a sequence of activities that pretends to signify the concepts of ratio and proportion, in their diverse representations and from the perspective of linear functions. Elements of the Realistic Mathematics Education framework and Cuevas-Pluvinage Didactics were used to design the tasks. The proposed learning objectives and activities were organized using a hypothetical learning trajectory. The analysis and detailed evaluation of a student's responses allows us to identify: didactic advantages of the design, learning difficulties, and ideas that can favor vertical mathematization.

Participants: *Erasmo Islas-Ortiz, Cinvestav IPN, México; Carlos Armando Cuevas, Cinvestav IPN; José Orozco-Santiago, Facultad de Ciencias Físico Matemáticas - Universidad Autonóma de Coahuila*

064. Brief Report - Pre-Service Teachers' Views about Mathematics Lessons
Pre-Service Teacher Education
Brief Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Participants:

How Preservice Elementary Teachers View Lesson Coherence *Ji-Won Son, The State University of New York at Buffalo; Florence F Obielodan, University at Buffalo, The State University of New York; Samantha Wallace, University of Buffalo; Adam Heck, University at Buffalo-The State University of New York*

The purpose of this study is to investigate how preservice

elementary teachers view mathematics lesson coherence. It is often reported that how lessons are less coherent in U.S. mathematics classrooms compared to high-achieving countries. Stigler and Hiebert (2009) urged the importance of teacher' conception and their learning to achieve coherent lessons. In this study we examined 18 preservice teachers' views of lesson coherence. We developed theoretical framework by extensively reviewing previous studies. By crosschecking preservice teachers' responses across our survey questions using the framework, we illustrate what knowledge of lesson coherence the preservice teachers have and have not, and thus suggest how teacher educators help preservice teachers to develop and analyze lessons to be more coherent.

Subverting Dominant Scripts of Mathematics Teaching: Exploring Prospective Elementary Teachers' (Re)Imaginings of a Class Discussion *Sheila Orr, Michigan State University; Sandra Crespo, Michigan State University*

Recent calls to (re)humanize mathematics education require a clearer articulation of how this equity oriented pedagogy can be taught to and learned by teacher candidates. In this article we propose and theorize "flipped scripts" as a research and pedagogical construct that can help identify prospective teachers' (PTs) potential to (re)imagine mathematics classrooms as inclusive and equitable spaces for learning. We use examples of PTs' imagined representations of a mathematics class discussion to examine explicit and hidden messages they communicate about students as capable or struggling learners of mathematics. We conclude by offering implications and affordances of studying PTs' generated "flipped scripts"as indicators of their potential to take up and enact humanizing mathematics pedagogical approaches.

065. Teachers Motivations for and Enactments of Ambitious Mathematics Instruction: The Case of Rough Draft Math

Teaching Practice and Classroom Activity
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

The purpose of this study was to characterize variations in how teachers enacted an approach to ambitious mathematics teaching: "rough draft math." We also examined teachers' motivations for their enactments. Thirty-two teachers from five states in the U.S.A. were recruited to participate in interviews based on recommendations from leaders of book studies focusing on this teaching practice. All participants enacted "rough draft math" by intentionally building their classroom culture to welcome students' draft thinking to achieve the goal of promoting students' productive dispositions. However, additional variations in enactments drew attention to potential tensions between multiple goals of ambitious mathematics teaching (empowering students and learning through revising). Findings suggest insights for supporting teachers' learning to teach ambitiously; findings also contribute to building a knowledge base for teaching.

Participants: *Amanda Jansen, University of Delaware; Crystal Collier, University of Delaware*

066. Supporting Discussion Practice in Mathematics Methods: Applications of Whole-Class Scaffolding

Policy, Instructional Leadership, Teacher Educators
Research Report Session
1:40 to 2:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

Discussion practices are used in mathematics methods courses to support prospective teachers' pedagogical ideas. Underexamined but central to the development of discussions of pedagogy, are mathematics teacher educators' (MTEs') tacit and explicit theories of learning and teaching. We report findings from a self-study of three MTEs' discussion practice in methods courses. Data sources include transcripts of MTEs' dialogic analysis of their discussion practice and evidentiary maps based on instructional artifacts. We argue that whole-class scaffolding serves as a tacit theory informing MTE discussion practices. We support this argument using evidence that our discussion practice was driven by prospective teachers' move toward independence and by layering instructional activities.

Participants: *Signe Kastberg, Purdue University; Susan L. Hillman, Saginaw Valley State University; Alyson E. Lischka, Middle Tennessee State University*

067. The Prime Number Theorem as a Mapping between Two Mathematical Worlds

Number Concepts and Proportional Reasoning
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

Elementary school arithmetic emphasizes two principal operations: addition and multiplication. Children typically learn rules for computing with these operations, and most develop additive reasoning along the way. Fewer develop multiplicative reasoning, and fewer still understand how these operations emanate from their own mental activity. This paper draws upon literature on children's construction of number and applies it to the prime number theorem. It frames additive and multiplicative reasoning in terms of units coordination activity that we can learn from children. Understanding how children might map between their additive and multiplicative worlds provides insights into the prime number theorem.

Participants: *Anderson Norton, Virginia Tech; Kyle Flanagan, Virginia Tech*

068. Brief Report - Geometry Curriculum and Assessment

Curriculum, Assessment, and Related Topics
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Participants:

A Story of Triangle Congruency In A Chinese Textbook *Jane Jane Lo, Western Michigan University; Jinqing Liu, University of New Hampshire; lili zhou, Purdue university*

In this paper, we report findings from an analysis of the introduction and development of triangle congruency from a grade 8 mathematics textbook from China, using the Mathematics Curriculum as A Story framework developed by Dietiker (2015). Drawing from multiple conceptions of corresponding conceptions of congruency, the Chinese textbook provides students with varied opportunities to write proofs and to make connections to a real-life context. The findings of this study demonstrate the illuminating power of this curriculum framework to fill the gap of current textbook analysis research.

Geometric Rotations and Angles: How are they Connected? *Navy Dixon, Brigham Young University; Sariah Stevenson, Brigham*

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

Young University; Dawn Teuscher, Brigham Young University; Shannon Dingman, University of Arkansas

With the adoption of the Common Core State Standards for Mathematics 12 years ago, the topic of geometric transformations was shifted from high school to grade 8. In our research with middle grades teachers, they often discussed their difficulty in teaching geometric rotations. Therefore, we analyzed 444 middle grade students' responses, across four states, to eight rotation questions from the SMART assessment. The results corroborate teachers' challenges with teaching and student learning of rotations. Results indicate that students have a rigid understanding of angle measure that may be impacting their understanding of geometric rotations. Although angle measure is introduced in grade 4, we hypothesize that teachers need to provide additional opportunities for students to expand their rigid understanding of angle measure.

069. Middle School Students' Mature Number Sense is Uniquely Associated with Grade-Level Mathematics Achievement

Number Concepts and Proportional Reasoning
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Students with mature number sense make sense of numbers and operations, use reasoning to notice patterns, and flexibly select the most effective and efficient problem-solving strategies (McIntosh et al., 1997; Reys et al., 1999; Yang, 2005). Despite being highlighted in national standards and policy documents (CCSS, 2010; NCTM, 2000, 2014), students' mature number sense and its nomological network are not yet well specified. For example, how does students' mature number sense relate to their knowledge of fractions and their grade-level mathematics achievement? We analyzed 129 middle school students' scores on measures of mature number sense, fraction and decimal knowledge, and grade-level mathematics achievement. We found mature number sense to be measurably distinct from their fraction and decimal knowledge and uniquely associated with students' grade-level mathematics achievement.

Participants: *Patrick Kirkland, University of Norte Dame; Claire Guang, University of Notre Dame; Nicole McNeil, University of Notre Dame*

070. Development of a Mathematics Discipline-Specific Language Scale

Mathematical Knowledge for Teaching
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Existing studies have defined and assessed 1) disciplinary literacy, 2) mathematical literacy, and 3) general academic language. However, there is a need to define and assess mathematics discipline-specific language (MDL), particularly for elementary school teachers. Therefore, the purpose of this study was to develop a research instrument to assess the MDL of elementary school teachers. The final instrument developed through iterative analysis included 20 items on a 3-point Likert-like scale distributed between three distinct MDL categories: technical, symbolic, and visual. Instrument validity was confirmed using Confirmatory Factor Analysis with the set of 211 video recordings and corresponding lesson plans of mathematics lessons taught by pre-service elementary school teachers enrolled in a graduate special education program.

Participants: *Alanna Gibbons, Teachers College, Columbia University; Irina Lyublinskaya, Teachers College, Columbia University*

071. Brief Report - Elementary Teachers' Conceptions of Students

Professional Development/ In-Service Teacher Education
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Participants:

Elementary Teachers' Conceptions of Argumentation and Their Argument-Based Lesson Designs for Teaching both Mathematics and Programming *Hyejin Park, Drake University; Tugba Boz, University of Jyväskylä; ChanMin Kim, PennState University*

We explored how elementary teachers designed argumentation-based lessons in the context of robotics-integrated mathematics classrooms. We purposefully focused on two teachers who taught elementary mathematics with robotics during their professional development (PD) participation. Throughout the PD, teachers learned to use argumentation in teaching mathematics, science, and coding. We analyzed their lesson plans to understand how the teachers structured their lessons for argumentation in robotics-integrated mathematics classrooms. We also examined teacher interview data collected at the end of PD to capture their understanding of argumentation. Our data analysis showed that the ways that teachers designed argumentation-based mathematics lessons with robotics are largely aligned with their interpretations of argumentation. Future studies are needed to explore the support teachers need in planning integrated lessons focusing on argumentation.

How Teachers Interpret and Respond to Students' Common Misunderstandings: Pathways Towards Instructional Decisions *John Ezaki, University of Southern California; Michael Lawson, Kansas State University; Yasemin CopurGencturk CopurGencturk, University of Southern California*

Knowledge of student misunderstanding is a critical aspect of teacher knowledge, with implications for teacher practice and student achievement. However, there is no mechanism describing the progression from how teachers identify student misunderstandings to the types of strategies used when addressing misunderstandings. In this study, we analyze 342 cases of student misunderstandings, underlying rationales, and instructional strategies reported by 153 elementary mathematics teachers. Using fsQCA, we identified pathways showing the conditions that lead to teachers providing instructional responses that target the misunderstanding and/or build students' conceptual understanding. Overall, we found that if teachers provide mathematical rationales to explain why students struggle with a concept/procedure, then their instructional responses help students develop conceptual understanding.

072. Brief Report - Computational Thinking in Mathematics Learning

Teaching Practice and Classroom Activity
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Culturally Relevant Computing Tasks: Evidence of Synergies between Students' Mathematical and Computational Thinking *Fernando Alegre, Louisiana State University; Zuhal Yilmaz, Louisiana State University; Juana Moreno, Louisiana State University; Rose Kendrick, Louisiana State University*

In this study, we explore the synergies between students' mathematical and computational thinking as they engage in an open-ended computing "Quilts" project related to their historical and cultural heritage. The activity aims to create a culturally relevant learning environment in which students have opportunities to code personalized quilts that demonstrate their culture and values. An open-coding process was used to analyze 352 team projects. The results of the study suggested that the computational medium gave students flexibility to devise multiple design plans using the power of mathematics and opportunities to test their chosen approaches. Some of the plans included defining functions, using geometric transformations and estimating coordinates. The code provided insights into the students familiarity with mathematical concepts, level of abstraction and precision in their calculations. Each team created unique quilts that demonstrate multiple values such as respect, unity and personal life experiences such as music, nature, and homeland.

Thinking Outside the Box: Preparing Elementary Teachers Integrate Computational Thinking and Mathematics *Terrie Galanti, University of North Florida*

There is growing research attention on the natural overlap between computational thinking and mathematics in K-12 education with respect to structure, abstraction, and modeling in problem solving. This brief research report describes how elementary teachers in an online graduate-level computational thinking course make sense of a volume optimization problem using block-based programming. When provided with Scratch code that structures the dynamic relationship between changing height and changing volume, teachers construct a variety of representations of their use of code to reason deeply about mathematics. Implications for preparing teachers to leverage the affordances of abstraction and automation in teaching mathematics are discussed.

073. Brief Report - Gender and Mathematics Identity

Equity and Justice
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Exploring Women of Color's Varied Expressions of Math Identity *Ciera Street, Colorado State University; Jess Ellis Hagman, Colorado State University*

One area in the growing call to create more equitable and just mathematics classrooms is supporting and strengthening students' mathematical identity. Limited scholarship in this area considers an intersectional lens when exploring undergraduate mathematical identity (Leyva, 2021; McGee 2016). Informed by Data Feminism, this research uses a transformative, mixed methods approach to consider how women of color in introductory undergraduate mathematics group based on attributes of mathematical identity. I first analyzed quantitative data using cluster analysis followed by the discussion of qualitative data through free response survey questions and future follow-up interviews to better conceptualize the experiences of each cluster. Key ideas emerging from this work include the role of peers and friendship, instructor care, class structure, and mathematical affect in women of color's mathematical identity.

The competing expectations of motherhood and mathematics: Internalized gendered and racialized narratives within *Sam Prough, University of Delaware*

This paper draws attention to the tensions between the expectations of mathematics and motherhood to highlight how mothers positively engage with their children in mathematics, even when that activity is not recognized or granted legitimacy. Using narrative inquiry, I highlight the stories of five participants that show the gendered and racialized expectations of motherhood and mathematics as the participants interact meaningfully with their children in the subject. The findings demonstrate the pervasive nature of gendered binaries and privileged whiteness in the expectations of women and mothers in both motherhood and mathematics. The constraining expectations of what it means to mother and be involved in mathematics shows the need to shift perspectives of what counts as mothering, as parenting, and what counts as mathematics.

074. Brief Report - Elementary Teachers' Enactment of Number Talks

Pre-Service Teacher Education
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Analysis of Pre-service Teachers' Virtual Number Talks Practice: Implications for the Preparation of Facilitating Mathematics Discussions *Audrey Meador, West Texas A&M University; Nicole Fletcher, Fairfield University*

Efforts within mathematics teacher education have recognized and attended to the importance of developing pre-service teachers' skills for effectively leading mathematical discussions. Number Talks have been utilized in teacher preparation programs to create opportunities to practice discussion facilitation moves. A virtual Number Talk field experience was enacted to provide pre-service teachers the experience of facilitating Number Talks while navigating technology. Two purposefully selected pre-service teacher's experiences conducting virtual Number Talks were analyzed using a formative assessment that decomposed the discussion practice. As a mode of using research to inform teacher educator practice, results of the analysis provide implications for assisting pre-service teachers in orchestrating productive mathematics discussions using technology in order to move from critical dissonance to resonant harmony in praxis.

Number Talks: Preliminary Relationships Between Teachers' Use of Questions and Students' Agency *Beth L. MacDonald, Utah State University; Hilary Tanck, Utah State University*

Number Talks are widely used across the U.S., as they uniquely place student reasoning at the center of mathematics instruction while allowing for few resources

and time throughout enactment. The purpose of this brief paper is to describe how relations between teachers' use of questions and students' engagement in a Number Talk associate with students' number sense. Findings suggest students' "student-to-student dialogue" was significantly associated with teachers' "generating discussion" questions and students' number sense development.

075. Promoting variational thinking with the aid of digital technology/Promoviendo el pensamiento variacional con apoyo de la tecnología digital

Technology and Learning Environment Design
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

"In this article we present the development of an investigation on the promotion of variational thinking in 14-15 year old students in Mexico, the study consists of the design and application of a sequence of didactic activities that simulate a real situation virtually. The activities are organized through a hypothetical learning trajectory supported by digital technology and elements of Cuevas-Pluvinage didactics. The activities were evaluated according to the levels of covariation proposed by Carlson and colleagues, categorizing students' achievements and difficulties for each level of understanding. The results show that the activities favor students' progress by moving from the context situation to the different representations, establishing the relationship between the variables and identifying their functional dependence. En este artículo presentamos el desarrollo de una investigación sobre la promoción del pensamiento variacional en estudiantes de 14-15 años en México, el estudio consiste en el diseño y la aplicación de una secuencia de actividades didácticas que simulan de forma virtual una situación real. Las actividades se organizan mediante una trayectoria hipotética de aprendizaje con apoyo de la tecnología digital y elementos de la didáctica Cuevas-Pluvinage. Las actividades se evaluaron de acuerdo con los niveles de covariación propuestos por Carlson y colegas, categorizando los logros y las dificultades de los estudiantes para cada nivel de comprensión. Los resultados muestran que las actividades favorecen el progreso de los estudiantes al transitar de la situación de contexto hacia las diversas representaciones logrando establecer la relación entre las variables e identificar su dependencia funcional."

Participants: *Helen Mariel Pérez Martínez, Cinvestav-IPN; Carlos Armando Cuevas, Cinvestav IPN; Erasmo Islas-Ortiz, Cinvestav IPN, México; José Orozco-Santiago, Facultad de Ciencias Físico Matemáticas - Universidad Autonóma de Coahuila*

076. The Role of a Boundary Object in a Study of Middle Grades Mathematics Instruction

Teaching Practice and Classroom Activity
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

This report is about how a group of U.S. teachers (N =98) and researchers used a boundary object in a collective study of grades 6-8 mathematics instruction. The focus is the teachers' engagement with a framework for effective instructional practices. Using qualitative content analysis of teachers' responses to use of the framework, we assessed its implementability and usefulness while supporting shared understandings of effective mathematics instruction. We found the framework supported shared understanding and implementation across varied contexts and was viewed as useful for meeting teachers' instructional and professional goals. Constraints were related to ambiguity around understanding and use of instructional practices related to student struggle. These findings demonstrate how a brief researcher-designed framework can serve as a bridge between teachers and researchers, meeting the professional goals of both.

Participants: *Angela R Crawford, Boise State University; Michele Carney, Boise State University; Joe Champion, Boise State University; Megan Schmidt, Boise State University*

077. Undergraduate Students' Conceptions About Complex Numbers: A Trajectory of Their Mental Structures/Concepciones sobre los Números Complejos de Alumnos de Pregrado: Una Trayectoria de sus Estructuras Mentales

Student Learning and Related Factors
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

This paper describes the conceptions about complex numbers that a group of university students has, which were built from the application of an activity sequence centered on these numbers. This sequence is based on the APOS theory, some aspects of semiotic representation theory, and the use of digital technology. Particularly, both the general results of a pretest and a posttest are shown and compared. Additionally, the example of a student is analyzed to show evidence of how the mental structures and mechanisms that define the students' conceptions are built through the implementation of the sequence. The results show how the activity sequence allowed students to coordinate algebraic and geometric processes on complex numbers to improve their conceptions.

Participants: *Diana Carolina García-Caro, Universidad de Guadalajara; Carlos Valenzuela, Universidad de Guadalajara; Maria Teresa Sanz, Cepartamento Didáctica de la Matemática. Universidad de Valencia; María García González, Universidad Autónoma de Guerrero*

078. Brief Report - Supporting Pre-Service Teachers' Enactment of Discussion-based Mathematics Learning

Pre-Service Teacher Education
Brief Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Participants:

Mathematical Argumentation: Alignmetn of Task Goals with Preservice Teachers' Enactments in a Simulated Classroom
Calli Shekell, ETS; Jamie Mikeska, ETS; Heather Howell, Educational Testing Service; Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Pavneet Kaur Bharaj, Indiana University Bloomington; Jennifer Dix, Towson University

Mathematical argumentation is a practice in which K-12 students should be engaging but supporting preservice teachers (PSTs) in learning to facilitate argumentation among students is challenging. The tasks used to support PSTs' learning in this area should be as carefully selected as the tasks that classroom teachers choose for their students. In this study, we examine a task that was designed for PSTs to practice facilitating an argumentation-focused mathematics discussion in a simulated classroom environment. Findings showed that while this task provided opportunities for PSTs to practice engaging the students in mathematical argumentation, actual engagement in argumentation was not inevitable. This suggests that careful consideration of

alignment between a specific discursive practice and the design features of a task could yield better learning opportunities for PSTs when using online simulations.

Unpacking the Five Practices Using an Online Professional Development *Amanda Reinsburrow, Drexel University; Jason Silverman, Drexel University; Valerie Klein, Drexel University; Wesley Shumar, Drexel University; Anthony Matranga, California State University San Marcos*

Understanding and utilizing the Five Practices for Orchestrating Productive Mathematics Discussions (Smith et al., 2009; Stein et al., 2008) has grown importance as teachers continue to be challenged to engage their students in student-centered, discourse-based instruction. We argue that by engaging in rehearsals of the five practices and decomposing practice, the teachers are not only able to advance their understandings of each of the five practices, but also gain knowledge of its value in their classroom practice and its role in the supporting student development. Preliminary results from analysis of our online professional development suggest that participants learned more about utilizing the five practices within their classrooms and are able to share the role they believe it has in their classroom practice.

079. Mathematics Education Researchers' Practices in Interdisciplinary Collaborations: Embracing Ways of Knowing/Las Practicas en Grupos Interdisciplinarios de los Investigadores de Educacion Matematicas: Abrazando las Formas de Saber

Policy, Instructional Leadership, Teacher Educators
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Mathematics education researchers (MERs) engage in interdisciplinary collaborations that contribute to the mathematics education discipline. MERs' learned forms of work and discourse, i.e., practices, are particular to their mathematics education discipline and might not align with practices needed to conduct interdisciplinary work. We interviewed four MERs who were leaders of interdisciplinary groups to learn about practices they reported using while collaborating with their groups. Using qualitative content analysis, we describe five practices commonly reported by the four MERs. We argue that these five practices are central ways of knowing and doing for MERs when working in interdisciplinary groups. Our study contributes to the mathematics education discipline by unpacking practices MERs use to engage in interdisciplinary groups that are influenced by interpersonal relationships.

Participants: *Elizabeth Suazo-Flores, Purdue University; William Walker, Purdue University; Hanan Alyami, Purdue University; Signe Kastberg, Purdue University; Mahtob Aqazade, Rice University*

080. Playful Math: Modeling Students' Engagement in Play-Based Algebra Activities

Mathematical Processes and Practices
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

Interest-driven activities, such as mathematical play, can support student agency, motivation, and engagement, and can foster dispositions that reflect authentic disciplinary engagement. However, the bulk of research on mathematical play investigates the mathematics that emerges in young children's natural play or in informal spaces such as video games. We introduce the term "playful math" to highlight the potential of playifying classroom-based activities, and we explore the nature of students' activity when engaged in playful math tasks in a teaching experiment. Our findings show that playful math tasks increased students' agency, authority, investment, and goal selection, as well as encouraged the development of creative, challenging ideas. We present a case of two students' playful engagement in the form of an Explore-Strategize Cycle and discuss implications of playful math for student engagement.

Participants: *Amy Ellis, University of Georgia; Dru Horne, University of Georgia; Anna Bloodworth, University of Georgia; Annelise W Nielsen, University of Idaho; Robert Ely, University of Idaho*

081. How Proportional Reasoning is Presented in U.S. and Korean Textbooks

Curriculum, Assessment, and Related Topics
Research Report Session
2:40 to 3:20 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

The purpose of this study is to examine how proportional reasoning is introduced and developed in two widely used U.S. and Korean mathematics textbooks for grades 6-7. Seven research-based frameworks that identify student learning opportunities for understanding of proportional reasoning were used to analyze the textbooks. The results showed that American textbooks include more problems that require explanations and make use of more effective contextual and number structure of problems than Korean textbooks. In contrast, Korean textbooks make a shift from providing highly contextualized problems to presenting abstract and purely computational problems, which aligns with the process of concreteness fading. In addition, Korean textbooks contain more unique types of topics and representations.

Participants: *Ji-Won Son, The State University of New York at Buffalo; SeungJung Jo, University of Western Idaho; Samantha Wallace, University of Buffalo; Florence F Obielodan, University at Buffalo, The State University of New York*

Friday, November 18, 2022 Afternoon Snack Break 3:20 – 3:50

Join us for an afternoon snack break in the Starstruck Gallery or Ballroom Foyer

083. Building Towards Harmony Between Identity and Mathematics Synthesizing Figured Worlds and Rightful Presence

Equity and Justice
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

As identity becomes more discussed within education, it becomes crucial to understand identity in relation to power and social justice. In this paper, we discuss the identity frameworks of figured worlds and rightful presence to operationalize the critical consideration of identity within mathematics learning environments. We argue that by themselves, figured worlds and rightful presence have shortcomings that make it difficult to attend to power, and contextualize change, respectively. When considered in tandem, however, these two frameworks complement one another and build a stronger attention to identity that mobilizes student agency in the classroom. We call on educators and researchers to combine and utilize these frameworks to address the dissonance of identity that often occurs for marginalized students, thus building towards a greater harmony of identity and mathematics.

Participants: *Brinley Poulsen Stringer, San Diego State University; Mariah Gabriella Moschetti, San Diego State University; Gabriela Hernandez, San Diego State University*

084. The self as noticer: Supporting preservice teachers' developing awareness

Pre-Service Teacher Education
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Gaining insight into how one's noticing shapes decision making can enable a teacher to reflect on how they frame, interpret, and respond to classroom activity and disrupt the influence of dominant ideologies. Working in the context of teacher education, we conjectured that systematically analyzing and reflecting on their own noticing can enable preservice teachers (PSTs) in mathematics to develop more equitable practices. Using data from summative assignments in a course on advancing equitable teaching, we investigate how PSTs use lenses of equitable teaching to make sense of their noticing and develop conceptions of equity. Analysis reveals that PSTs engaged in meaningful reflection and adopted terms from the course but avoided discussing the sociopolitical dimensions of instruction. These findings have implications for course design and facilitation in the context of developing PSTs' noticing for equity.

Participants: *Ethan Rubin, University of California Irvine; Elizabeth van Es, University of California Irvine*

085. Using Video to Identify What Is Not Known In Students' Mathematical Thinking

Professional Development/ In-Service Teacher Education
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Continually engaging with students' mathematical thinking is both rewarding and challenging in teaching practice. This paper describes and analyzes two video-based professional learning (PL) activities designed to help teachers go beyond their initial perceptions of what students understand and to identify what else they might learn about students' thinking. The findings suggest the potential of the activities to evoke different types of curiosity about student-thinking and the conditions that may support such questioning.

Participants: *Madhuvanti Anantharajan, Stanford University; Michael Jarry-Shore, Stanford University*

086. Embodying Covariation Through Collaborative Instrumentation

Technology and Learning Environment Design
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Covariational reasoning and the creation and interpretation of graphs of covariational situations are important skills in mathematics and science. Unfortunately, research shows that students often struggle to make meaningful connections between graphs and the covariational situations they represent. Educational activities designed to help students overcome this struggle tend to use either student-generated or automatically-generated graphs, and have students either act out covariational situations or more passively observe them. In this paper, we present the design of a tool and task that enabled two students to simultaneously embody both the creation of a graph and the covariational actions that the graph represents. Through a process of collaborative instrumentation, the students made meaningful connections between their motions and the embodied traces they created as they reasoned about the covarying quantities of height and time.

Participants: *Toni York, Montclair State University; Steven Greenstein, Montclair State University; Denish Ogweno Akuom, Montclair State University*

087. Justifications Students Use When Writing an Equation During a Modeling Task

Mathematical Processes and Practices
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Literature typically describes mathematization, the process of transforming a real-world situation into a mathematical model, in terms of desirable actions and behaviors students exhibit. We attended to STEM undergraduate students' quantitative reasoning as they derived equations. Analysis of the meanings they held for arithmetic operations (+,-,·,÷) provided insight into how participants expressed real-world relationships among entities with arithmetic relationships among values. We extend the findings from K-12 literature (e.g., using multiplication to instantiate a rate) to STEM undergraduates and found evidence of new ways of justifying the usage of arithmetic operations (e.g., using multiplication to instantiate an amount).

Participants: *Elizabeth Roan, Texas State University; Jennifer A Czocher, Texas State University*

088. Brief Report - Students' Algebraic Reasoning and Argumentation

Early Algebra, Algebraic Thinking, and Function
Brief Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Progressions in Grades K-1 Students' Understanding of Parity Arguments *Ingrid Ristroph, The University of Texas at Austin; Maria Blanton, TERC; Angela Murphy Gardiner, TERC; Ana Stephens, University of Wisconsin-Madison; Rena Stroud, Merrimack*

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

College; Eric Knuth, University of Texas at Austin

Understanding how young learners come to construct viable mathematical arguments about general claims is a critical objective in early algebra research. The study reported here characterizes empirically developed progressions in Grades K–1 students' thinking about arguments concerning sums of evens and odds. Data are drawn from classroom lessons of an early algebra instructional sequence and interviews conducted at four timepoints during the implementation of the sequence. Overall, students transitioned from unfamiliarity with the concepts of even or odd prior to instruction in Kindergarten to making valid parity arguments at the conclusion of instruction in Grade 1. Results of this study align with other research that shows young learners can develop viable arguments to justify mathematical generalizations.

Students Reasoning in Dynamic Situations: Spatial Proximity Reasoning *Halil Ibrahim Tasova, California State University San Bernardino*

In this paper, I introduce a mode of reasoning, which I call spatial proximity reasoning, that entails coordinating the (co)variation of an object's degree of proximity (i.e., closeness or nearness) to other objects (i.e., reference objects) in a dynamic real-world situation. I compare and contrast spatial proximity reasoning with quantitative (co)variational reasoning. I also present the implications of spatial proximity reasoning on students' graphing activities in one- and two-dimensional spaces.

089. Brief Report - Novice Teachers' Perspectives on Equity

Pre-Service Teacher Education
Brief Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Designing and Refining a Tool to Support Mentor and Novice Co-Learning Equity-Oriented Teaching *Ruth Heaton, Teachers Development Group; Kara Jones Jackson, University of Washington; Mary Carlson, Montana State University; Imani Goffney, University of Maryland-College Park; Melinda Knapp, Oregon State University-Cascades; Torrey Kulow, Portland State University; Taylor E Stafford, University of Washington*

Mentor teachers (MTs) help teacher candidates (TCs) learn by supporting them before and after lessons and positioning themselves as observers of TCs' practice. This design research study reimagines the MT-TC relationship to be one of co-learning and tests a provisional theory and design of a Collaborative Learning Structure (CLS) tool to support MT-TC co-learning equity-oriented teaching around teaching's enduring uncertainties. We studied a debriefing episode from a 6th grade teacher's coaching cycle. She and the coach tried out a portion of our initial CLS. Our analysis demonstrates that rather than planning to confer in moments that feel 'curious or uncertain,' it may be more beneficial to ask teachers to confer in 'decision-making moments' while teaching thereby testing a revised theory of co-learning equity-oriented teaching learning that centers marginalized students' sense making in the improvised work of teaching.

Preservice and Beginning Teachers' Perspectives on Equity *Rebecca McGraw, University of Arizona; Anthony Fernandes, University of North Carolina - Charlotte; Becca Jarnutowski, University of Arizona; Jennifer Wolfe, University of Arizona*

This report is part of a larger, longitudinal study focusing on the development of equity-related knowledge, beliefs, and practice across 68 individuals and five teacher preparation programs. In this brief report, we seek to unpack the ways five preservice and beginning mathematics teachers think about equity, especially as it relates to their current and future teacher practice. Analysis of interview data from these participants suggest as many as twelve different aspects of equity reflected in their thinking, as well as multiple actions teachers could take to promote equity including raising expectations, rejecting deficit views, and using complex instruction.

090. Self-Efficacy, Instructional Beliefs and the Use of Mathematical Practice Standards

Teaching Practice and Classroom Activity
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Teachers' beliefs, knowledge, and decisions can affect the way teachers teach, and, consequently, what students learn. Self-efficacy beliefs of various types may also interact with beliefs about the most appropriate and effective teaching and the selection of instructional practices to implement. We examined the relationships among teachers' mathematics self-efficacy, mathematics teaching self-efficacy, instructional beliefs, and effective mathematical teaching practices for teachers who had been identified as effective teachers. We found that although both scored similarly on the beliefs surveys, there were noticeable differences in their use of the Standards of Mathematical Practice (NGACBP & CCSSO, 2010).

Participantd: *Amy E Roehrig, Illinois State University; Tami S. Martin, Illinois State University*

091. Aesthetic Dimensions of Student Mathematical Creativity

Teaching Practice and Classroom Activity
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

There is a popular myth that mathematical creativity is a trait possessed by a small group of people. This is perpetuated by the lack of understanding of what influences mathematical creativity, especially in the classroom. In particular, professional mathematicians often name aesthetic experiences as a critical aspect of their mathematical creativity. Therefore, this study examines aesthetic dimensions of episodes of student creativity from the high school classroom. Several types of aesthetic experiences arose across the episodes. Students were motivated to take creative action by experiences of mystery or discomfort. Furthermore, in some instances, taking a creative action was accompanied and propelled by a sense of craziness or satisfaction.

Participant: *Meghan Riling, Vanderbilt University*

092. "I watched as he put things on the paper": A feminist view of mathematical discourse

Equity and Justice
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

In this study we present results of a discourse analysis of the interactions between two partners, Uma and Sean, through a feminist lens. During roughly five hours of small group work in a

teaching experiment, how each partner used language to position each other's thinking as mathematically significant and establish a collaborative environment varied dramatically. Specifically, Uma shouldered the burden of continuously working to maintain collaboration, oftentimes at the expense of having her thinking positioned as mathematically significant. On the other hand, Sean regularly offered little opportunity for Uma to engage openly with his thinking, which ultimately constrained Uma's opportunities to learn.

Participants: *Allison S Theobold, California Polytechnic University, San Luis Obispo; Derek Williams, Montana State University*

093. Personal Inferences as Warrants of Undergraduate Students' Arguments in Calculus Contexts

Pre-Calculus, Calculus, and Higher Math
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

The purpose of this paper is to highlight issues related to students' personal inferences that arise when students verbally explain their justification for calculus statements. We conducted clinical interviews with three undergraduate students who had taken first-semester calculus but had not yet been exposed to formal proof writing activities through undergraduate mathematics courses. We analyzed these students' verbal justification of four statements, each of which described a different relationship between two quantified variables in calculus contexts. In this paper, we document students' personal inferences that were evoked in their justifications and discuss how they are similar to or different from the logical inferences that have been accepted and practiced by the mathematics community for mathematical arguments.

Participants: *Kyeong Hah Roh, Arizona State University; Erika David Parr, Rhodes College; Derek Eckman, Arizona State University; Morgan Early Sellers, Colorado Mesa University*

094. Relevance as Perceived by High School Students in Decontextualized Mathematics Lessons

Student Learning and Related Factors
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

When mathematics educators work towards making mathematics more relevant, they often think about including more real-world applications into mathematics lessons. But what happens when a lesson is devoid of real-world contexts? In what ways can students find it relevant? This study explores how high school students perceived relevance when they were asked to describe their experience during decontextualized mathematics lessons. Students highlighted how they found certain characteristics of the lessons to be useful in their learning and how they perceived relevance through different feelings experienced in the lessons. This, in turn, broadens our perspective of what relevance means to students.

Participants: *Aamina Adil, Boston University; Kihoon Lee, Boston University; Leslie Dietiker, Boston University*

095. Brief Report - Supporting Student Reasoning in Mathematics-Specific Technology Platforms

Technology and Learning Environment Design
Brief Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Participants:

Preservice Teachers' Task Choice in Technology-Rich Environments *Michael S Meagher, Brooklyn College - CUNY; Michael Todd Edwards, Miami University of Ohio; Asli Özgün-Koca, Wayne State University*

A group of 27 preservice teachers (PSMTs) from two different institutions ranked and provided a rationale for their rankings of three versions of a task presented on three different technology platforms (CODAP, Geogebra, spreadsheet). The PSMTs then worked through the tasks in detail, reranked the tasks and provided a rationale for why they either changed or maintained their ranking. More than half the PSMTs changed their ranking and almost half changed their first choice of task. Rationales for change showed increased attention to the mathematical content of the task and the possibilities for "math action technologies" Dick and Hollebrands (2011) available in each platform.

Relationship Between Covariational Reasoning and Use Schemes in an Approach Task/Relación Entre el Razonamiento Covariacional y los Esquemas de Uso en una Tarea de Aproximación *Mihály André Martínez-Miraval, Pontificia Universidad Católica del Perú; Martha Leticia García-Rodríguez, Instituto Politécnico Nacional*

The study aims to analyze the change in the mental actions of a student associated with the use schemes that he mobilizes when solving an approximation task to the area of a region with GeoGebra. Theoretical elements related to the covariational reasoning approach and the instrumental approach were considered. The student, after generating, mobilizing and refining his use schemes, made visible behaviors that are associated with mental actions, such as drawing a polygon to approximate an area and recognizing that, the more points on the graph, the distance between them is smaller and a better approximation is obtained. That is, observable behaviors can be associated with levels of reasoning or with changes in associated mental actions, which indicate a transition from one level of reasoning to another.

096. Developing Asset-based Instruction through Learning Trajectory-based Curricular Design

Curriculum, Assessment, and Related Topics
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This research report describes a Learning Trajectory-based Curricular Design project that engaged teachers and coaches in the design and implementation process. As the project team, we focused on deepening teacher designers' understanding of the learning trajectory (LT) while situating student learning along a continuum to advance student thinking. Analysis of the design and implementation cycle demonstrated that teacher designers used their professional judgment and knowledge of LTs to assess the quality and appropriateness of curricular resources as they made instructional decisions to meet the needs of diverse learners. School-based coaches used these teaching resources as a type of professional development for identifying g student strengths and "packaged" the resources for teachers who were overwhelmed from teaching during the pandemic. We discuss the importance of applying LT research for asset-based instruction.

Participants: *Jennifer M. Suh, George Mason University; Theresa Wills, George Mason University; Sara Kirschner, George Mason University; Alayna Wearly, George Mason University; Maureen E. Vora, George Mason University; Kate Roscioli, George Mason University*

097. Different Ways of Learning Number Density: A

Hypothetical Trajectory with High School Students/Diferentes Formas de Aprender la Densidad Numérica: Una Trayectoria Hipotética con Estudiantes de Bachillerato

Number Concepts and Proportional Reasoning
Research Report Session
3:50 to 4:30 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

We present a study where we designed a Hypothetical Learning Trajectory (HLT) for promoting the learning of the property of numerical density in high-school students. The tasks of the HLT used various school mathematics topics that can provide opportunities for thinking about that property and were framed in several contexts and semiotic representation registers. We present the sequence of the HLT, as well as some results of its implementation with four high-school students. We analyze the participants' data in terms of their thinking regarding discreteness and density. We observed that at the end of the HLT tasks, the participants recognized more easily an infinite quantity of intermediate rational or real numbers in an interval, although they didn't fully comprehend that only natural numbers have successors./ Se presenta un estudio donde se diseñó una Trayectoria Hipotética de Aprendizaje (THA) para promover el aprendizaje de la propiedad de densidad numérica en estudiantes de bachillerato. Las actividades de la THA se inspiraron en varios temas de la matemática escolar que se pueden aprovechar para hablar de esta propiedad y se enmarcan en diversos contextos y registros semióticos. Mostramos la secuencia de la THA y algunos resultados de una implementación de esta con cuatro estudiantes de bachillerato. Se analiza el pensamiento de los participantes en términos de sus pensamientos sobre lo discreto y lo denso. Se observa que al final de la THA se acercan a reconocer una infinidad de números racionales o reales intermedios en un intervalo, aunque no logran comprender del todo que solamente los números naturales tienen sucesores.

Participants: *Mayra Zulay Suárez, Centro de Investigación y de Estudios Avanzados del IPN; Ana Isabel Sacristán, Cinvestav-IPN*

Friday, November 18, 2022

4:45 – 6:00

Poster Session 1

Symphony Ballroom I and II

Cash Bar will be available in the Symphony Ballroom Foyer.

Friday, November 18, 2022

6:30 – 8:30

Graduate Student Reception

Jasper's

1918 West End Ave., Nashville, TN

Saturday, November 19, 2022 – Morning Program

7:00 to 8:00am
100. Saturday Breakfast
Floor Lobby Level Symphony Ballroom I & II

	8:00 - 8:40am	8:55 – 9:35am
Mezzanine Level Blackbird Studio A	101. Use of Signifiers in Mathematical Discourse in Korean and English	116. Brief Report - Technology and Mathematics Identity
Mezzanine Level Blackbird Studio B	102. Maestros, Estudiantes, Lenguaje y Matemáticas: Prácticas pedagógicas para una formación con visión global/Teachers, Students, Language, and Mathematics: Pedagogical practices for pre-service teachers with a global vision	117. Brief Report - Disrupting Discourses in Mathematics Education
Lower Level Gold	103. Brief Report - Worked Examples and Tutoring in Online Mathematics Learning	118. Brief Report - Students' Spatial Reasoning
Lobby Level Green Room	104. NSF Session: The Faculty Early Career Development Program (CAREER) at the National Science Foundation	119. Journal Session: Disturbing The Field Through Your Scholarship
Lobby Level Lyric	105. Brief Report - Mathematics Teaching for Relevance and Justice	120. Middle School Students' Types of Mathematical Personifications
Lobby Level Melody	106. Brief Report - Self Efficacy and Mathematical Authority	121. "It's a different mindset here": Facilitation challenges in a practice-based professional development
Mezzanine Level Ocean Way	107. Using Public Records to Support the Productive Use of Student Mathematical Thinking	122. Formatively Assessing Novices' Capabilities with Modeling Content
Lower Level Platinum	108. Climate Change by the Numbers: How Numerical Estimation Can Support Science Learning	123. Brief Report - Student Agency and Mathematical Problem-Solving in Classrooms
Mezzanine Level RCA	109. K-2 Student's Composing of Lego Structures	124. Conversations about Learning Trajectories
Mezzanine Level Sound Emporium A	110. Brief Report - Pre-service Teachers' Attitudes towards Mathematics	125. Brief Report - Elementary Students' Spatial Mathematical Thinking
Mezzanine Level Sound Emporium B	111. Identifying Persistent Unconventional Understandings of Algebra: A Case Study Of An Adult With Dyscalculia	126. Brief Report - Productive Struggle in Mathematics Teaching
Mezzanine Level Southern Ground A	112. Tipos de razonamiento matemático que caracterizan los argumentos de un profesor en la generalización de patrones	127. Equitable Teaching Practices: Developing Emergent Bilinguals' Positive Mathematical Identities
Mezzanine Level Southern Ground B	113. Discourses of Justice: Connecting Visions and Practices to Identify Areas for Future Research and Teaching	128. Brief Report - Students' Mathematical Reasoning and Practices
Lobby Level Symphony Ballroom III	114. Leveraging Equity and Civic Empathy through Community-based Mathematical Modeling	129. Examining Elementary and Middle School Mathematics Instruction: Are We Promoting Equity and Access?
Mezzanine Level The Castle		
Mezzanine Level Tracking Room	115. Exploring the Relationship Between Qualitative Lesson Scores and Quantitative Qualities of Individual Codes	130. How the Teacher and Students Impact the Unfolding of Mathematical Ideas Across a Lesson

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

101. Use of Signifiers in Mathematical Discourse in Korean and English
Pre-Calculus, Calculus, and Higher Math
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A
We consider how the existence of different signifiers for mathematical objects in different languages manifests in discourse about those objects. Based on the observation that there is a common signifier "derivative" in English used for both the derivative at a point and the derivative function and two phonetically and semantically different signifiers for those objects in Korean, we explore the differences between one Korean teacher's discourse and one American teacher's discourse about the derivative. Our analysis uncovered differences in metarules regarding the use of signifiers, as well as differences in possible connections to colloquial discourse. Additionally, we found that, after both objects are defined, the American teacher's discourse shifts in a way that precludes the simultaneous use of the common signifier for both objects whereas, in the Korean teacher's discourse, there was no similar shift.
Participants: *Jungeun Park, University of Delaware; Douglas Rizzolo, University of Delaware*

102. Maestros, Estudiantes, Lenguaje y Matemáticas: Prácticas pedagógicas para una formación con visión global/Teachers, Students, Language, and Mathematics: Pedagogical practices for pre-service teachers with a global vision
Pre-Service Teacher Education
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B
"We describe the second phase of an ongoing investigation that asks about the way in which pre-service teachers assume their pedagogical practices in a global context where language and mathematics are combined. Such a focus supports the goal of preparing teachers who can respond to current educational challenges. One of these challenges is the use of English as a global language. We present an experience from collaborative work between students and professors of two courses teaching methods and didactic of mathematics, one in the United States and the other in Colombia. This included the design of activities for the teaching of mathematics using children's books as a reference. Among the results we noted that the activities were influenced more by the use of language than by the mathematical content to be taught. Describimos la segunda fase de una investigación en curso que se pregunta sobre la manera en que los maestros en formación asumen sus prácticas pedagógicas en un contexto global donde el lenguaje y las matemáticas se conjugan. Tal intención obedece al propósito de formar maestros que respondan a los retos educativos actuales. Uno de estos retos es el uso del inglés como lengua global. Se presenta una experiencia de trabajo conjunto entre estudiantes y docentes de dos cursos de enseñanza de métodos y didáctica de las matemáticas, uno en Estados Unidos y otro en Colombia. Esto implicó el diseño de actividades para la enseñanza de las matemáticas usando como referencia un cuento infantil. Dentro de los resultados se identifica que las actividades fueron influenciadas mas por el uso del lenguaje que por el contenido matemático que se quería enseñar."
Participant: *Gladys Krause, William and Mary; Adriana Ines Avila Zarate, Universidad Autónoma de Bucaramanga; Elgar Gualdron Pinto, Universidad de Pamplona*

103. Brief Report - Worked Examples and Tutoring in Online Mathematics Learning
Pre-Calculus, Calculus, and Higher Math
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold
Participants:

Student Choices: Online Versus In-Person Tutoring Options *Nicole Infante, University of Nebraska at Omaha; Lori Ogden, West Virginia University; Keith Gallagher, University of Nebraska Omaha; Renee LaRue, West Virginia University; Deborah Moore-Russo, University of Oklahoma; Christine Tinsley, University of Oklahoma; Ashley Berger, University of Oklahoma*
Access to free, high-quality, institutionally provided tutoring services can be critical to the success of university students. When the pandemic forced university tutoring operations to close or move online, many chose to move operations online. The Fall 2021 semester saw the return of in-person tutoring at many institutions, however, online options remained in place to serve students who may not be able to participate in-person. This created more equitable access to a critical student support. We collected data on which format students chose at two research-focused institutions. At one institution, visits were split at 47% online and 53% in-person. In contrast, visits at the other institution were split at 5% online, and 95% in-person. We will discuss the courses with the highest usage in each format and explore why students may be choosing one format over the other.

Algebra Students' Impressions of Equation-Solving Worked Examples in an Online Environment *Avery Harrison Closser, Purdue University; Hannah Smith, Worcester Polytechnic Institute; Jenny Yun-Chen Chan, Worcester Polytechnic Institute*
Worked examples are an effective form of instructional support. As online tools are increasingly used for instruction, designers should optimize how worked examples are presented to support students. We present a small exploratory study on 105 algebra students who rated and evaluated formats of worked examples on equation-solving as part of a larger experiment. We found that students' ratings of the worked examples aligned with their learning outcomes. Further, across conditions, explanations of students' ratings revealed themes of worked example speed, equation-solving process, and content review. These findings provide considerations for researchers and teachers creating worked examples for online algebra learning environments.

104. NSF Session: The Faculty Early Career Development Program (CAREER) at the National Science Foundation
Special Event
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room
This session focuses on the CAREER program at the National Science Foundation in the Education and Human Resources Directorate. The CAREER program is designed to support early-career scholars' projects that provide a foundation for careers in research and education in institutions of higher education and non-profit, non-academic organizations. In this session, NSF Program Officers from the Division of Research on Learning and from the Division of Undergraduate Education will discuss various aspects of the CAREER program. We will outline specific aspects of the program, including eligibility requirements and required proposal

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

components. We will also discuss features that can contribute to strong CAREER proposals. We will then answer questions about the program, breaking into smaller groups, if necessary, to accommodate different participants' interests and areas of focus.

Presenters:

Margret Hjalmarson, National Science Foundation
Eric Knuth, National Science Foundation
Elise Lockwood, National Science Foundation

105. Brief Report - Mathematics Teaching for Relevance and Justice

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Participants:

Acknowledgment and Action: Teachers' First Act Towards Avenues for Social Justice Work *Candace Joswick, The University of Texas at Arlington; Robin Keturah Anderson, North Carolina State University; Melissa Troudt, University of Wisconsin - Eau Claire; Lisa Skultety, University of Central Arkansas*

As mathematics teacher educators working to better understand how to train teachers to enact justice-oriented practices, we situate our work in the guiding question: "How does your work have an impact on society more broadly, beyond individual mathematics classrooms and school districts?" Results from our development and implementation of a semester-long course for teachers shows that teachers can be supported to find reasonable avenues for action to take up in their classrooms, though they begin without a sense of empowerment or understanding of resources to do so. Our teacher participants are eager to leverage their unique knowledge and role in their contexts to advocate for the changes they envision—changes that create more socially just contexts for learning and teaching mathematics.

Connecting Mathematics to the Real World: One Group of elementary mathematics Teachers' Experience *Simon Byeonguk Han, Portland State University; Eva Thanheiser, Portland State University; Amanda Sugimoto, Portland State University; Molly L Robinson, Portland State University; Courtney Koestler, Ohio University; Mathew David Felton-Koestler, Ohio University; Howard E. Bartels, Ohio University; Jennifer Thompson, Ohio University; Danny Penner, Portland State University; Laura Wolfe, Ohio University*

In this study, we examined one group of elementary mathematics teachers' experience in connecting mathematics to the real world. We interviewed five elementary teachers at the beginning of a professional development collaboration designed to connect mathematics to the real world based on connecting to students' funds of knowledge. We asked their perspectives of connecting mathematics to the real world and what they knew about their students. We built Connecting Mathematics to the Real World framework based on the literature and categorized teachers' responses. We found that while all teachers had implemented word problems as a way to connect mathematics to the real world, none had contexts relevant to their students' lives. However, most of the teachers were interested in developing lessons that are more relevant to their students' lives.

106. Brief Report - Self Efficacy and Mathematical Authority

Student Learning and Related Factors
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Self-Efficacy During the Collegiate Transition and the Importance of Task Alignment: A Case Study *Jordan R Gill, Lansing Community College*

This case study examined how a period of transition could affect a student's mathematics self-efficacy (MSE) and their ability to productively struggle on challenging mathematics problems. This study focused on a single student named Candice who was making the transition from high school to college. Candice initially reported high levels of MSE to start the semester but experienced difficulty adjusting to her first college mathematics class, which was taught in an active learning style. Interviews with Candice revealed that her initially reported high MSE was associated with her ability to successfully complete her high school mathematics courses. The structure of her active learning style classroom presented new challenges that did not align with this MSE. This potentially resulted in a lowered state of MSE and a lack of engagement with productive struggle both inside and outside the classroom.

A Prospective Teacher's Shifting Views On How Mathematical Authority Operates In The Classroom *Michael Hamilton, University of Georgia*

This case study investigated how one prospective teacher's views of how mathematical authority operates in the classroom were influenced by her student teaching practicum by comparing mathematical authority diagrams produced prior to and after student teaching. While there were many similarities across the diagrams, many differences were directly related to the participant's student teaching experience(s). Additionally, the diagram produced after student teaching was more detailed, included more relationships between sources of mathematical authority, and indicated shifts in the teacher's views of students as mathematical authorities. Potential practical implications, particularly for mathematics teacher educators, will be discussed.

107. Using Public Records to Support the Productive Use of Student Mathematical Thinking

Teaching Practice and Classroom Activity
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

In this session, we share the results of an exploration into how secondary mathematics teachers' use of public records appeared to support or inhibit their efforts to conduct a sense-making discussion around a high leverage instance of student thinking. We report two broad ways teachers used public records - manipulating and referencing - to support establishing and maintaining students' thinking as objects during sense-making discussions.

Participants: *Ben Freeburn, Western Michigan University; Keith R. Leatham, Brigham Young University; Sini Graff, Brigham Young University; Nitchada Kamlue, Western Michigan University; Shari L Stockero, Michigan Technological University; Blake E Peterson, Brigham Young University; Laura R. Van Zoest, Western Michigan University*

108. Climate Change by the Numbers: How Numerical Estimation Can Support Science Learning

Technology and Learning Environment Design
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Prompting people to estimate climate change numbers before showing them the true value can shift learners' attitudes and conceptions. Yet, interventions created for such a learning experience are not easily accessible to the general public. The purpose of this preregistered study was to address this research gap by developing and testing an openly accessible online intervention that presents participants with novel numbers about climate change after they estimate those numbers. An experimental online study design was used to investigate the impact of the intervention on undergraduate students' climate change understanding and plausibility perceptions. Findings revealed that posttest climate change knowledge was higher among those randomly assigned to use the app compared with those assigned to a control condition, and that supplementing this experience with numeracy instruction was linked with more robust gains.

Participant: *Ian Thacker, University of Texas at San Antonio*

109. K-2 Student's Composing of Lego Structures

Geometry and Measurement
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Block building activities help develop students' spatial reasoning, but few studies focus on the development of block building skills beyond preschool. We worked with four kindergarten, four first grade, and four second grade students to learn more about their Lego block building. We compared students' accuracy, building strategies, and spatial language as they used manuals versus pictures of final Lego structures (presented in color versus grayscale) to build two Lego structures. On the first structure, students using color manuals or pictures had an easier time choosing correct bricks but had difficulty correctly placing them; students using grayscale manuals or pictures had difficulty picking the correct bricks but placed them more accurately. By the second design, students did better with the manuals, regardless of color. Students need more support to use specific spatial language and building with depth versus height.

Participants: *Sezai Kocabas, Purdue University; Yi Zhu, Purdue University; Yiheng Liang, Purdue University; Laura Bofferding, Purdue University*

110. Brief Report - Pre-service Teachers' Attitudes towards Mathematics

Pre-Service Teacher Education
Brief Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Participants:

Aversión a las Matemáticas de Maestros de Primaria en Formación: Causas, Razones y Percepciones./Elementary Pre-Service Teacher Aversions Toward Mathematics: Perceptions, Reasons, and Origins. *Jair Aguilar, The University of Texas Rio Grande Valley; Ming-Tsan (Pierre) Lu, UTRGV; Yajaira Flores, UTRGV*

En este reporte se muestran los resultados preliminares acerca del porqué maestros de primaria en formación (MPF) señalan tener una aversión hacia las matemáticas, en donde participaron 270 MPF mientras tomaban un curso en métodos matemáticos. Para la implementación del estudio seguimos una metodología mixta paralela-convergente que nos permitiera entender mejor la aversión matemática de los MPF. Una de las principales razones por la que los MPF mencionan tener una actitud negativa hacia las matemáticas se debe a la falta de confianza que se tiene acerca de los conocimientos matemáticos. De igual manera, a las experiencias negativas durante sus años escolares. Un dato sorprendente es que cerca del 60% de los MPF reconocen saber que desde primaria o secundaria, ya tenían una aversión hacia las matemáticas. This report shows the preliminary results about why pre-service teachers (PSTs) indicated having an aversion towards mathematics. Participants were 270 PSTs taking a mathematics methods course. For the implementation of the study we followed a convergent parallel mixed-method approach that helped us to better understand the mathematical aversion of the PSTs. One of the main reasons why the PSTs mentioned having a negative attitude towards mathematics is due to a lack of confidence in their mathematical knowledge. Also, to the negative experiences during their school years. A surprising fact is that close to 60% of the PSTs recognize knowing they already had an aversion towards mathematics, since elementary or secondary.

Exploring the use of online modules for supporting mathematics for teaching *Jennifer Holm, Wilfrid Laurier University*

This research examines the use of online modules in supporting the development of mathematics for teaching in pre-service teachers. This paper focuses on a single participant in the research study to provide some overarching themes that were presented in the work. The presentation will explore different solutions provided by the participant, as well as examples from the online platform. Although the results were mixed on even improving mathematics content knowledge, the case provides evidence for considering how to improve an online platform in supporting future teachers.

111. Identifying Persistent Unconventional Understandings of Algebra: A Case Study Of An Adult With Dyscalculia

Student Learning and Related Factors
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

Research on dyscalculia has focused almost exclusively on elementary-aged students' deficits in speed and accuracy in arithmetic calculation. This case study expands our understanding of dyscalculia by documenting how one college student with dyscalculia understood algebra during a one-on-one design experiment. A detailed case study of 19 video recorded sessions revealed that she relied upon unconventional understandings of algebraic quantities and notation, which led to persistent difficulties. This exploratory case study provides new insights into the character of difficulties that arose and persisted for one student with dyscalculia in the context of algebra and suggests the utility of documenting the persistent understandings that students with dyscalculia rely upon, particularly in understudied mathematical domains, like algebra.

Participants: *Katherine Elizabeth Lewis, University of Washington; Gwendolyn Sweeney, University of Washington; Grace Thompson, University of Washington; Rebecca Adler, Vanderbilt; Kawla Alhamad, Imam Abdulrahman bin Faisal University, Saudi Arabia*

112. Tipos de razonamiento matemático que caracterizan los argumentos de un profesor en la generalización de patrones
Mathematical Knowledge for Teaching
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

El artículo describe tipos de razonamiento matemático que evidencia un profesor de matemáticas de secundaria, al resolver una tarea de generalización de patrones figurales, asociado a sucesiones cuadráticas. Se sustenta de una propuesta teórica-metodológica que combina las definiciones de Peirce con algunos elementos del modelo argumentativo de Toulmin, que permiten delimitar el razonamiento a partir de los argumentos del profesor. Los resultados evidencian que el razonamiento matemático del profesor en el contexto de la generalización de patrones cuadráticos se fundamenta en acciones cognitivas como la descomposición de la figura, conteos estratégicos, reconocimiento del comportamiento del patrón figural, formulación, verificación y validación de conjeturas.

Participants: *Karina Nuñez-Gutierrez, Universidad Autónoma de Guerrero; Guadalupe Cabañas-Sánchez, Universidad Autónoma de Guerrero*

113. Discourses of Justice: Connecting Visions and Practices to Identify Areas for Future Research and Teaching
Equity and Justice
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

This systematic review aims to identify the Discourses (Gee, 2000) invoked regarding justice in PK-12 mathematics education literature, linking visions and practice. The three Discourses of Justice presented in this manuscript draw upon different visions of justice, where the differences arise through the proposed locus of change – the individual (Empowerment), the institution (Transformation) and ideologies around purposes of education (Democracy). However, the Discourses also share similarities across the associated teaching practices for each. There are differences in usage of these Discourses across the literature, which present opportunities for innovations in future research and teaching towards a more just math education system.

Participant: *Megan Brunner, Oregon State University*

114. Leveraging Equity and Civic Empathy through Community-based Mathematical Modeling
Equity and Justice
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This theoretical paper describes how Community-based Mathematical Modeling can advance equity and cultivate civic empathy in elementary school settings. We provide a framework for community-based mathematical modeling instruction consisting of five goals: facilitating connections, fostering engagement, promoting rigor, cultivating civic empathy, and elevating justice. We illustrate how these goals work together to advance equity and cultivate civic empathy through classroom vignettes of community-based modeling lessons. Through this theoretical synthesis, implications for community-based mathematical modeling instruction will be discussed

Participants: *Julia Aguirre, University of Washington Tacoma; Jennifer M. Suh, George Mason University; Holly N. Tate, George Mason University; Erin Turner, University of Arizona; Mary Carlson, Montana State University; Elizabeth Fulton, Montana State University*

115. Exploring the Relationship Between Qualitative Lesson Scores and Quantitative Qualities of Individual Codes
Teaching Practice and Classroom Activity
Research Report Session
8:00 to 8:40 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

Describing and measuring instructional quality of mathematics lessons is a common goal amongst mathematics education researchers. Such work takes several forms such as classifying and coding instructional moves and student activity or providing high-level rubric-based scores in relation to categories. In this work, we share an innovative mixed methods approach to analyzing lesson data that includes both a time-based classification of instruction and an overall scoring component. Using the Math Habits framework, our project team analyzed a set of 97 fourth-eighth grade mathematics lessons including overall scores. From this qualitative analysis, we developed quantitative models to predict overall scores and better understand the ways that individual codes do or do not contribute to overall lesson score characterizations.

Participants: *Kathleen Melhuish, Texas State University; Alexander White, Texas State University; Sharon Strickland, Texas State University; Elizabeth Wrightsman, Texas State University*

116. Brief Report - Technology and Mathematics Identity
Technology and Learning Environment Design
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

Participants:

Leveraging Technology to Support Sociopolitical Dispositions
Nicholas Witt, Western Michigan University

In this theoretical paper, it is argued that a crucial component of a critical literacy (Rubel & McCloskey, 2021) learning progression focused on Gerrymandering was the role of mathematical action technology (Dick & Hollebrands). I contend that the technology provided access to the relevant mathematics content, which contributed to an understanding of how the mathematics connects to the context. Empirical support from the implementation of the technology-based critical literacy lesson with prospective elementary and secondary mathematics teachers illustrates the emergence of a learning progression model. Implications regarding teacher education, curriculum development and integrating technology-based mathematics lesson set within critical literacy contexts will be discussed

Eliciting Youth Digital Mathematics Stories: The Impact of a Digital Mathematics Storytelling Summer Camp Experience
Theodore Chao, The Ohio State University; Melissa Adams Corral, California State University-Stanislaus; Ayse Ozturk, The Ohio State University, Newark; Ho-Chieh Lin, The Ohio State University; Angga Hidayat, the Ohio State University

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 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.

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

117. Brief Report - Disrupting Discourses in Mathematics Education

Equity and Justice
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Participants:

Redesigning Mathematics for the Margins: Empathy as a Disruptor of Deficit Thinking *Rachel Lambert, University of California Santa Barbara; Kara Louise Imm, Hunter College, The City University of New York (CUNY)*

A persistent problem in mathematics education has been deficit thinking by teachers about the mathematical potential of students with disabilities and students who have been marginalized in mathematics. This paper reports analysis of findings of a six-week virtual class in the summer of 2020 for 45 mathematics and special educators which integrated Universal Design for Learning (UDL) with design thinking, focusing on the teaching and learning of mathematics. Our approach grounds UDL in empathy, beginning design with developing understanding of student perspective through Empathy Interviews. In focus group conversations nine months late, participating classroom teachers reported that empathy and Empathy Interviews were the most important long-term takeaway of the course, and that empathy became a touchstone in their teaching practice. Empathy seemed to disrupt deficit thinking for these teachers.

Whiteness in Fearmongering Towards Mathematics Education Reform *Eric Cordero-Siy, University of Wisconsin-Madison; Michael Lolkus, Purdue University; Frances K Harper, University of Tennessee, Knoxville*

In this paper, we analyze a widely shared article from a prominent conservative media outlet that positions current mathematics education reform as something to be feared. This work has implications in how mathematics education researchers can understand, approach, and respond to the current backlash towards reform and beyond.

118. Brief Report - Students' Spatial Reasoning

Geometry and Measurement
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Participants:

Intertwining Spatial and Logical Reasoning in Qwirkle *P. Janelle McFeetors, University of Alberta; Krista Francis, University of Calgary; Stefan Rothschuh, University of Calgary; Nimah Ahmed, University of Alberta; Munesah Rahman, University of Calgary; Domonic Lodge, University of Alberta*

We argue that playing board games provides crucial experiences for developing logical and spatial reasoning. Drawing on Dewey, growth in spatial and logical reasoning requires the accumulation of sufficient experiences in action. Our design-based research involving Grade 4-6 students playing Qwirkle weekly revealed their significant improvement using three key tile arrangements that contributed to strategic play. These strategies occurred as a result of enacting intertwining spatial and logical reasoning. Both are necessary for flourishing in mathematics.

Tangram Puzzles' Priming of Squares for Mathematics Educators *Laura Bofferding, Purdue University*

Although solving tangram puzzles is a popular activity for helping students move along the 2D shape composition learning trajectory, there is little evidence of what makes one tangram puzzle with no internal lines more difficult than another. In this study, 46 educators saw either a square in a traditional or non-traditional orientation and then were asked to identify (within 4 seconds) where the square puzzle piece would go in a series of 75 tangram puzzles. Results indicate that adults were more likely to identify the location of the square if it had more sides outlined, but the orientation of the square or number of places it would fit in the puzzle were not associated with their success. These results call for similar studies with children and suggest that educators need to be careful to look beyond their own impressions when choosing suitable puzzles for students.

119. Journal Session: Disturbing The Field Through Your Scholarship

Special Event
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Navigating the publishing process across mathematics education journals is challenging. Investigations in Mathematics Learning is an international peer-reviewed mathematics education journal that seeks to stimulate, generate, coordinate, and disseminate research efforts designed to understand and influence factors that affect mathematics learning. In this session, we will discuss the journal and its publishing process, and provide mentoring for potential authors. We will use cases of manuscripts that initially received a decision of 'Reject and Encourage Resubmit' and after revisions, received a decision of 'Accept' – all within 18 months. A goal for this session is to provide pathways for publishing success. This session is suited for scholars at all levels and interest areas.

Presenter: ***Jonathan David Bostic***, Bowling Green State University

120. Middle School Students' Types of Mathematical Personifications

Student Learning and Related Factors
Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Unpacking middle school students' mathematical relationships is important as a step towards improving mathematical relationships. In this study, 500 middle school students drew personifications of mathematics. We examined these personifications of mathematics for insight into their relationships with mathematics. Using constant comparative methods, we present various ways the middle school students personified mathematics. Negative relationships were personified with terrible beasts, abusers, authoritarians, and pests/nuisances. Positive relationships were personified with best friends and nature. Some personifications supported both positive and negative relationships or were neutral relationships. Reflecting on these personifications point to components of positive relationships with mathematics that we should support and confronts ways we may be perpetuating negative relationships with mathematics.

Participants: *Nicole Marie Wessman-Enzinger, George Fox University; Clara M Stilwell, George Fox University*

121. "It's a different mindset here": Facilitation challenges in a

practice-based professional development
Professional Development/ In-Service Teacher Education
Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

In this paper we examine how facilitators' prior experiences as mathematics teachers frame their work when facilitating a practice-based professional development (PD) for the first time. We focus on the experiences of a novice facilitator of StoryCircles, a professional learning process in which teachers collectively script and visualize a problem-based lesson, arguing about their rationale for different decisions connected to discussions of students' work. We situate the challenges the facilitator encountered by identifying the expectations that were not met while she was facilitating, and offer possible connections to the PD design. We close by suggesting a perspective to account for facilitation challenges.

Participants: *Gil Schwarts, University of Michigan; Irma Stevens, University of Michigan; Pat G Herbst, University of Michigan; Amanda Marie Brown, University of Michigan*

122. Formatively Assessing Novices' Capabilities with Modeling Content
Pre-Service Teacher Education
Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

This paper examines the possibilities of designing a formative assessment that gathers information about novice elementary teachers' skills with modeling content and makes sense of such information. A decomposition of the practice of modeling content was developed and used to design the assessment. Participants included ten first-year teachers who graduated from a range of different teacher education programs. The findings reveal that our formative assessment works to gather information about teachers' capabilities with modeling content and that the associated tools support making sense of the information gathered. This suggests that such tools could support formative assessment of the developing capabilities of novice teachers.

Participants: *Meghan Shaughnessy, Boston University; Nicole Garcia, University of Michigan - Ann Arbor*

123. Brief Report - Student Agency and Mathematical Problem-Solving in Classrooms
Student Learning and Related Factors
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Models Built By University Students When Solving An MEA Associated With The Step Function *Carlos Enrique Flores-Gasca, University of Guadalajara; Veronica Vargas-Alejo, University of Guadalajara*

This article presents the results of an investigation related to identifying how university-level students built, modified, and refined their models to make sense of a problem situation where the step function underlies. A Model Eliciting Activity [MEA] was developed. It was implemented in an online environment, through the use of the Zoom platform. The theoretical framework that was used for the design of the activity, the implementation and the analysis of the results was the Models and Modeling Perspective. The participants in this study were 12 college-level first-semester students. As a result, it was shown that the students were able to modify and extend their histogram models to step functions.

Secondary Students' Agency in Mathematics Classrooms *Mitchelle Mbete Wambua, University of Missouri-Columbia*

This study describes how secondary mathematics teachers think about students' agency and the forms of agency their students exercise in class. By employing a teacher questionnaire, we found that students exercise different types of agency depending on how their mathematics classroom authority is distributed.

124. Conversations about Learning Trajectories
Special Event
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Join the panelists from the Friday Plenary on Learning Trajectories in informal conversations about their talk.

Presenters:
Amy Ellis, University of Georgia
Maria Blanton, TERC
Marrielle Myers, Kennesaw State University
Jennifer M. Suh, George Mason University

125. Brief Report - Elementary Students' Spatial Mathematical Thinking
Student Learning and Related Factors
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Participants:

Irrelevant Details When Using LEGO® Bricks as Manipulatives *Alison Tellos, Concordia University; Helena P. Osana, Concordia University; Anne Lafay, Concordia University*

The primary aim of the present study was to examine whether the studs on LEGO® bricks act as irrelevant details when solving fraction division problems. We also investigated whether prior knowledge plays a role in the irrelevant details effect and in children's problem-solving strategies. Fifth- and sixth-grade students (N = 38) first completed a fractions test to assess their prior knowledge. A video-recorded lesson then was delivered to all students on how to solve fraction division problems with LEGO® bricks. Most of the participants were not distracted by the studs on the LEGO® bricks when solving fraction division problems on a transfer task. Prior knowledge was related to accuracy on learning and transfer performance, with low prior knowledge students generating less accurate solutions than to high prior knowledge students.

The Spatial Structure of Hundreds Charts *Vera Wagner, Concordia University; Helena P. Osana, Concordia University; Jairo Navarrete, Universidad de O'Higgins*

Hundreds charts are an essential tool for teachers in the mathematics classroom. The present study investigated the effects of spatial configuration in hundreds charts on children's place-value knowledge and their strategies for solving arithmetic word problems. Kindergarten and first-grade students were assigned to three instructional conditions in which they worked with a researcher to solve arithmetic problems. The charts in the conditions differed by spatial configuration. Results showed that the children improved their place-value knowledge and were more likely to use strategies based on place-value

concepts when the numbers in the chart increased from top to bottom than when the numbers increased from bottom to top.

126. Brief Report - Productive Struggle in Mathematics Teaching
Pre-Service Teacher Education
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B
Participants:

A Preliminary Look at Prospective Mathematics Teachers' Productive Struggle *Nitchada Kamlue, Western Michigan University; Laura R. Van Zoest, Western Michigan University*

This exploratory study aims to describe what productive struggle looks like when prospective mathematics teachers in a middle school mathematics methods course engage with a challenging mathematics task. We hypothesize that a productive struggle consists of different types of struggles—goal struggle, strategy struggle, and sub-strategy struggle—that can coexist simultaneously. We provide insight into the complexity of prospective teacher productive struggle and how it differs from that of middle school students. This information is useful for teacher educators who want to capitalize on the opportunity productive struggle offers for prospective teacher learning.

Dissonance, Harmony, and Cultural Conflict in Interdisciplinary Co-Teaching *Aubrey Neihaus, Wichita State University; Scott Kaschner, Butler University*

In this brief research report, we share our preliminary findings from a collaborative analytic autoethnography investigating our co-teaching across the disciplines of mathematics and mathematics education. Even successful interdisciplinary collaborations can give rise to conflict, and we used identity to investigate sources of conflict. This conflict may be attributed to contestation of identities stemming from disciplinary cultural differences. However, by identifying and managing the underlying causes–identity and disciplinary cultural differences–we are able to see what gives rise to conflicts and resolve them. We will discuss our plans for further research and implications for interdisciplinary collaboration.

127. Equitable Teaching Practices: Developing Emergent Bilinguals' Positive Mathematical Identities
Equity and Justice
Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

This research report focuses on Emergent bilinguals (EBs) who traditionally face unequal opportunities to learn mathematics, harming their identities. The purpose of this paper is to illustrate how a fifth-grade teacher cultivated the development of her EBs' mathematical identities by giving them opportunities to participate in cognitively demanding activities. Drawing on a conception of mathematical identity as something that changes in response to different situations, we illustrate how a fifth-grade teacher positively impacted her students' mathematical identities. The results reveal that when teachers use instructional strategies such as distributing mathematical authority, positioning students as mathematically capable, and incorporating students' languages as a resource for instruction, their EBs have multiple opportunities to build positive mathematical identities.

Participants: *Libni Castellón, University of Wyoming; Richard Kitchen, University of Wyoming; Karla Valesca Matute, University of Wyoming*

128. Brief Report - Students' Mathematical Reasoning and Practices
Student Learning and Related Factors
Brief Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B
Participants:

Problem Solving and Perseverance in Geometry: Revelations from Think Alouds with Middle Grades Students *Joshua P Mannix, Ball State University; Brianna Bentley, North Carolina State University; Erin E. Krupa, North Carolina State University*

Problem solving is a very important skill for students to learn (e.g., Bonilla-Rius, 2020; NGA, 2010), and part of developing problem solving skills is learning to persevere. One strategy for learning how to persevere is by providing students with materials that allow them the opportunity to engage with challenging problems (e.g., Kapur, 2010; Middleton et al., 2015). This study of the Volume unit of our materials analyzes students' strategies for problem solving and persevering. Findings from these think-aloud interviews indicate that different students will utilize one or more methods for solving challenging problems, such as asking clarifying questions, talking themselves through the problem, and attempting various mathematical approaches.

Number Sense about Real Numbers: a first study with students aged 15-16 *Virginia Garrido Adame, Cinvestav*

Number sense has been studied from different perspectives. Defining it has not been an easy task and most of the definitions that exist in the literature deal with natural, integer and rational numbers. In this research report, the advances of a study whose objective is to characterize the number sense about real numbers are disclosed. As a result of the literature review, 15 skills were proposed, these were considered as indicators of the use of good number sense about real numbers. The indicators were validated with the application of a questionnaire. With the same test it was possible to observe the difficulties that students face when using real numbers. It was also noted that number sense skills could be tested with or without the use of a calculator.

129. Examining Elementary and Middle School Mathematics Instruction: Are We Promoting Equity and Access?
Teaching Practice and Classroom Activity
Research Report Session
8:55 to 9:35 am
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This descriptive study attended to the extent to which we see evidence of the presence of four practices that promote equity and access in 141 grades 3-8 mathematics lessons in the United States. We found that lessons generally showed evidence of some incorporation of the practices but often not at the highest level. Teachers in this sample engaged in social coaching at a relatively high level, across elementary and middle school lessons. Teachers tended to do less with respect to supporting connection and engagement between student context and the math learning environment. We also found statistically significant differences between elementary and middle school lessons in positioning students as competent and supporting a nurturing environment by proactively building relationships and productive classroom

culture. We offer possible interpretations and a few brief implications of these findings.

Participants: *Annie Wilhelm, Southern Methodist University; Jonee Wilson, North Carolina State University; Elizabeth L. Adams, Southern Methodist University; Temple A. Walkowiak, North Carolina State University*

130. How the Teacher and Students Impact the Unfolding of Mathematical Ideas Across a Lesson

Curriculum, Assessment, and Related Topics

Research Report Session

8:55 to 9:35 am

Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

By highlighting the curriculum modifications that lead to maintaining, or enhancing, the mathematical quality of an algebra lesson introducing the substitution method for solving systems of equations from the BLINDED textbook (blinded, year), we present an analysis of how a teacher and her students impact how the mathematical ideas unfold across the lesson and how they are experienced. Using a narrative-based analytical approach to write the stories of the written and enacted lessons, we found key similarities and differences in the lessons. In comparing the mathematical plots, we found evidence of how the teacher and students alter the unfolding story with the incorporation of more jamming than seen in the text and more questions developed based on the students' needs and their responses.

Participants: *Amanda Huffman, Purdue University; Andrew S Richman, Boston University Wheelock College of Education & Human Development; Leslie Dietiker, Boston University*

9:55 to 11:10am

131. Deconstructing Dissonance and Resonance across Historically Marginalized Learners' Mathematics Experiences to Advance Intersectional Justice

Floor Lobby Level Symphony Ballroom

Luis Antonio Leyva, Vanderbilt University - Peabody College of Education & Human Development

This plenary presents findings from my research that depict historically marginalized learners' experiences of dissonance between their intersectional identities and oppressive contexts of mathematics education. My framework of STEM Education as a White, Cisheteropatriarchal Space is used to show how such dissonance reflects interplay between ideological, institutional, and relational forces in mathematics education that shape intersectional oppression and agency. I also account for disruptions of white supremacy and cisheteropatriarchy across mathematical contexts that contributed to resonant harmony in learners' intersectionality of experiences. With such harmony limited and partially resonant with learners' identities, I ask what robust forms of resonance in mathematics education can look like and if they can be achieved. I conclude with research implications for the advancement of intersectional justice in mathematics education.

11:10am to 12:20pm

132. PME-NA Business Meeting and Lunch

Floor Lobby Level Symphony Ballroom

Saturday, November 19, 2022 – Afternoon Program

	12:25 – 1:05pm	3:20 – 4:00pm	4:15 – 4:55pm
Mezzanine Level Blackbird Studio A	133. Brief Report - Social Justice and Teacher Identity in Mathematics Teacher Education	164. Navigating the White Space of Mathematics: Lessons Learned from Mathematics Teacher Educators of Color	179. Obscuring Racial Inequities through Gender-Focused Discourse: An Intersectional Analysis of Participation in a Calculus Class
Mezzanine Level Blackbird Studio B	134. Brief Report - Graduate Teaching Assistants In Undergraduate Mathematics	165. Brief Report - Using Desmos to Support Mathematics Learning	180. Brief Report - Exploring Implementation of Activities for Secondary Pre-Service Teachers
Lower Level Gold	135. Students' Intuitive Meanings for Infinite Series Convergence and Corresponding Implications	166. Invented Strategies Changing Teachers' Pedagogical Content Knowledge	181. Brief Report - Programmatic Aspects of Pre-Service Teacher Education
Lobby Level Green Room	136. Journal Session: Reviewing For And Submitting To The Journal For Research In Mathematics Education	167. Brief Report - Online Professional Development	182. Offloading Cognitive Demands of Fractional Tasks on Working Memory Through Drawings
Lobby Level Lyric	137. How Transitions Between Related Artifacts Support Students' Covariational Reasoning	168. Exploring the Impact of Discussion-Leading Professional Development on Teachers' Practice	183. Brief Report - Measurement Validity in Mathematics Education
Lobby Level Melody	138. Investigating preservice teachers' mathematical knowledge for teaching: Focus on lesson planning and reflection	169. Iceberg of Culturally Relevant Mathematics and Science Pedagogy: A Pedagogical and Analytical Tool for Teacher Education	184. Brief Report - Examining Student Thinking
Mezzanine Level Ocean Way	139. "This One is That": A Semiotic Lens on Quantitative Reasoning	170. Brief Report - Curriculum Analysis	185. Brief Report - Elementary Pre-Service Teachers' Instructional Practices
Lower Level Platinum	140. Brief Report - Students' Mathematics Identity and Classroom Experiences	171. Professional learning at scale: Designing a boundary object	186. Brief Report - Mathematics Teacher Noticing of Student Small Groups
Mezzanine Level RCA	141. Mathematics teacher emotional knowledge	172. Explore teachers' collective learning through Chinese lesson study from a perspective of networking theories	187. Brief Report - Student Understandings of Parentheses
Mezzanine Level Sound Emporium A	142. Brief Report - Changes in Pre-Service Secondary Teachers' Understanding	173. Brief Report - Research Methods and Literature Synthesis	188. Elementary Mathematics Specialists: Preparation and Engagement in Teacher Leadership
Mezzanine Level Sound Emporium B	143. Potential of an MEA to Advance Business Students' Modeling Skills / Potencial de una MEA Para Impulsar Habilidades de Modelación de los Estudiantes en Negocios	174. Brief Report - Secondary Students Algebraic Thinking	189. Influence of Context on Teachers' Assessment Practices
Mezzanine Level Southern Ground A	144. College Students' Input on The Design of Worked Examples for Online Environments	175. Psychoanalysis and Probabilistic Thinking	190. Brief Report - Students' Problem Solving
Mezzanine Level Southern Ground B	145. Brief Session - Developing Teachers' Support of Student Thinking in the Classroom	176. English Language Learner Students' Development of the Mathematics Register During a Problem-Solving Lesson	191. Stem Undergraduates' Structural Conception of Rate of Change
Lobby Level Symphony Ballroom III		177. Teacher Language and Gesture in an Intervention Focused on Developing Kindergarteners' Understandings of the Equal Sign	192. Conducting a Whole-Class Discussion About an Instance of Student Mathematical Thinking
Mezzanine Level The Castle			
Mezzanine Level Tracking Room	146. Examining how undergraduate students describe the Standards for Mathematical Practice	178. Functional Concerns that Shape Teachers' in-the-Moment Decision-Making	193. Designing an Online Video-based Environment for Promoting Mathematical Argumentation

Saturday, November 19, 2022 1:20 – 2:50 – Working Groups and Colloquia

Abstracts for all working groups and colloquia can be found at the end of the program.

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

133. Brief Report - Social Justice and Teacher Identity in Mathematics Teacher Education
Pre-Service Teacher Education
Brief Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A
Participants:

Practice-based and Social Justice Approaches to Teacher Education: Moving from Dissonance to Harmony *Kristin Doherty, Michigan State University*

The dissonance in the field between practice-based and social justice approaches to teacher education motivated my review of the literature on the relationship between these approaches, specifically in the context of mathematics teacher education. I reviewed the literature to better understand the reasons for this dissonance and to determine if and how these two approaches could be harmonized within mathematics teacher education. Building on this review, I present a framework for integrating social justice teacher education with practice-based mathematics teacher education. I argue that studying social foundations can help preservice teachers develop a critical lens to apply in their enactment of mathematical practices through practice-based approaches.

Recruiting and Retaining Minoritized Preservice Teachers: Critical Resistors *Nicholas Kim, University of Tennessee-Knoxville; Lynn Hodge, The University of Tennessee, Knoxville; Shande King, Trevecca Nazarene University*

The primary purpose of this research was to provide insight into the narratives and experiences of minoritized (based on race) preservice teachers (PST) interested in teaching mathematics and how those experiences impact recruitment and retention of those minoritized teachers. Narrative inquiry framed through equity and identity lenses were chosen as the methodology for gathering and analyzing data from one-on-one, structured interviews as well as a focus group interview. A finding from the data analysis resulted in one specific resonant thread, Critical Individuals: Resistors. In summary, the PSTs' minoritized identities clearly impacted their decisions to pursue and remain in mathematics teacher education. All participants could recall "aha moments" when dealing with important people in their lives who either supported or attempted to resist their journeys to pursue teacher education.

134. Brief Report - Graduate Teaching Assistants In Undergraduate Mathematics
Pre-Calculus, Calculus, and Higher Math
Brief Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B
Participants:

Graduate Teaching Assistants' Engagement of Students' Errors *Jungeun Park, University of Delaware*

Graduate Teaching Assistants (TAs) play an important role in undergraduate students' learning of mathematics, especially Calculus, and spend significant time evaluating students' work. This study examined TAs' engagement of students' errors by following the process of their identifying students' errors, planning to address them, and implementing the plans in teaching. Our results showed that (a) TAs only identified a small portion of errors that students made, (b) errors TAs identified often did not include the ones made most frequently by their students, (c) many errors that TAs identify were procedural in nature and addressed with plans to provide the "correct" procedure, (d) the levels of specific details of students' errors dropped from identifying, to planning, to teaching, and (e) even with drops, in many cases, the levels of details of students' errors involved in TAs' identifying was the same as the levels of their planning and teaching.

Beliefs and Values: Teaching Assistants in an Introductory Proof Course *Royce Olarte, University of California Santa Barbara; Micah Swartz, Texas State University; Sarah A. Roberts, University of California, Santa Barbara*

This study examined the beliefs that teaching assistants (TAs) of an introductory proof course had about their students, about how their students learned, about their teaching, and about mathematics. We drew on the perspective that teacher beliefs underscore pedagogical practices to examine TAs' beliefs and better understand their approaches to teaching. Five mathematics TAs participated in the study and we qualitatively analyzed their responses to semi-structured interviews. We found that TAs understood that their students learned in various ways and they believed they should be able to support students' multiple ways of engaging with proofs. They also understood that introductory proof courses necessitate higher levels of cognitive demand and that many students struggle in these courses. Our preliminary findings can inform future efforts that more critically examine the beliefs of mathematics teaching assistants.

135. Students' Intuitive Meanings for Infinite Series Convergence and Corresponding Implications
Pre-Calculus, Calculus, and Higher Math
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold

This paper describes our work to determine the naturalistic images that first-time second-semester university calculus students possess for series convergence. We found that the students we interviewed most frequently determined whether a series converged by imagining a process of appending summands into a running total and examining whether this running total appeared to approach an asymptotic value. We provide examples and three corresponding implications of this "asymptotic running total" that informed students' actions while determining series convergence or the value of convergence. Our paper adds to the research literature by confirming students' meanings for limits reported for other topics (e.g., limit of sequence, function, Taylor series) apply to infinite series and proposing relationships between previously reported meanings for series convergence.

Participants: *Derek Eckman, Arizona State University; Kyeong Hah Roh, Arizona State University*

136. Journal Session: Reviewing For And Submitting To The Journal For Research In Mathematics Education
Special Event
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

In this session I will describe the role that JRME plays in our research field and how scholars can benefit from reviewing, submitting, and publishing in the Journal. The session will serve to

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

answer questions from prospective authors and reviewers and also for experienced authors and reviewers to share their experiences with others.

Presenter: ***Pat G Herbst***, University of Michigan

137. How Transitions Between Related Artifacts Support Students' Covariational Reasoning

Technology and Learning Environment Design
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Many studies utilize instructional designs that include two or more artifacts (digital manipulatives, tables, graphs) to support students' development of reasoning about covarying quantities. While students' forms of covariational reasoning and the designs are often the focus of these studies, the way students' interactions and transitions between artifacts shape their actions and thinking is often neglected. By examining the transitions that students make between artifacts as they construct and reorganize their reasoning, our study aimed to justify claims made by various studies about the nature of the synergy of artifacts. In this paper, we present data from a design experiment with a pair of sixth-grade students to discuss how students' transitions between artifacts provided a constructive space for them to reason about covarying quantities in graphs.

Participants: *Erell Germia, Montclair State University; Toni York, Montclair State University; Nicole Panorkou, Montclair State University*

138. Investigating preservice teachers' mathematical knowledge for teaching: Focus on lesson planning and reflection

Mathematical Knowledge for Teaching
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Mathematics teacher educators have suggested that preservice mathematics teachers' (PMTs') practices provide evidence of their Mathematical Knowledge for Teaching (MKT). In an effort to explore connections between MKT and PMTs' practices, we developed a framework that operationalizes Ball et al.'s (2008) six MKT domains in terms of approximations of practice. We then used our framework to investigate which domains were evidenced in eleven PMTs' lesson plans and how PMTs described MKT in their lesson plan reflections. We found Knowledge of Content and Teaching most evidenced and Horizon Content Knowledge least evidenced. Also, PMTs made few instances of Knowledge of Content and Students as they struggled to address students' mathematical thinking in their plans. We propose alternative forms of approximations of practice to optimize PMTs' opportunities to demonstrate and conceptualize MKT.

Participants: *Bima Kumari Sapkota, Purdue University; Amanda Huffman, Purdue University*

139. "This One is That": A Semiotic Lens on Quantitative Reasoning

Mathematical Processes and Practices
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Despite significant research exploring students' quantitative reasoning, few studies have explored the semiotic processes that mediate its development. In this report, we present a case study to show how one student constructed a semiotic chain for a quantity as he worked with a mathematical task. Importantly, we connect frameworks for quantitative reasoning and semiotics to make sense of this process. Our findings show how our case student constructed a sign for a chunk of change in a triangle to support his later construction of the quantity of amount of change of area. We also describe how the case student leveraged these signs to bolster his development of the quantity of total area. We emphasize the role of artifacts, such as physical manipulatives, a digital applet, and a diagram, in this process. Finally, we discuss the implications of this analysis for future studies that explore students' constructions of quantity.

Participants: *Allison L. Gantt, University of Delaware; Teo Paoletti, University of Delaware; Steven Greenstein, Montclair State University*

140. Brief Report - Students' Mathematics Identity and Classroom Experiences

Student Learning and Related Factors
Brief Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Fifth Grade Students' Mathematics Identity, Student Achievement, and Classroom Experiences *Jennifer Cribbs, Oklahoma State University; Juliana Utley, Oklahoma State University*

Drawing from a sample of 63 fifth grade students in one school setting, we conducted a pilot study exploring students' mathematics identity and how it correlated with math achievement and experiences in their mathematics classroom. Data were analyzed using linear modeling to determine which variables were predictive of mathematics identity. Results indicate that achievement and students' classroom experiences associated with assessments, a focus on memorization, and teacher strategies were predictive of their mathematics identity. This work informs the field by expanding on our understanding of how important aspects of students' classroom experiences contribute to their mathematics identity development.

Mathematics Identity and Gender Differences in STEM Persistence: A Latent Growth Curve Model *Dalton Dayne Marsh, California State University, San Bernardino*

This study uses data from three waves of the High School Longitudinal Study of 2009 and latent growth curve modeling to investigate how STEM students' mathematics and science identities change from high school through college. Results show that while male STEM students tend to maintain high levels of mathematics identity throughout, female STEM students' mathematics identity tends to start lower and decline over time. Implications for how these results can inform initiatives aimed at broadening participation in STEM will be discussed.

141. Mathematics teacher emotional knowledge

Professional Development/ In-Service Teacher Education
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Emotions come into play as teachers make decisions, act, and reflect on the different purposes, methods, and meanings of math teaching. In order to learn more about the emotions of mathematics teachers, this paper shows the emotions experienced by 81 Mexican teachers who teach mathematics in middle school and high school. Emotions are contextualized by the theory of the cognitive structure of emotions, narrative and drawings were used

to express their emotions. According to the results, three frequent and common emotions were identified in the teachers, happy-for, satisfaction, and disappointment. Fear was the only frequent emotion in high school teachers; it occurred at the beginning of their teaching, due to the lack of pedagogical content knowledge.

Participant: *María García González, Universidad Autónoma de Guerrero*

142. Brief Report - Changes in Pre-Service Secondary Teachers' Understanding

Pre-Service Teacher Education
Brief Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Participants:

Extension of the asymptote universe in a community of mathematics teachers in initial training / ampliación del universo de asíntota en una comunidad de profesores de matemáticas en formación inicial *Henry Brian Chávez Martínez, Cinvestav; Francisco Cordero Osorio, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional*

This article presents the results of a research that addresses the disconnection between school mathematics and reality, particularly recognizing that this disconnection has forced to privilege the graphical representation of asymptote as a straight line, denying other types of asymptotic behaviors. A school design that favored to modify the treatment of the asymptote was built with 5 mathematics teachers in initial training. It was implemented in a virtual environment using zoom. The theoretical framework was the socioepistemological theory of educational mathematics. It was an instrumental case study. As a result, the universe of asymptotics in the study community was expanded and a framework for teaching asymptotics was formed.

Preservice Mathematics Teacher Beliefs Regarding Procedural Versus Conceptual Teaching Before and After Methods Courses *Derek Pope, Stony Brook University; Angela Kelly, Stony Brook University*

After a two-semester graduate mathematics pedagogy sequence, nine preservice mathematics teachers showed significant changes in their beliefs away from mathematics as a set of rules and procedures and towards mathematics as a process of enquiry. Interviews corroborated quantitative findings and pointed towards practical conceptually-focused strategies in the courses as a driving factor in affecting students' beliefs. Implications for preservice mathematics teacher education are discussed.

143. Potential of an MEA to Advance Business Students' Modeling Skills / Potencial de una MEA Para Impulsar Habilidades de Modelación de los Estudiantes en Negocios

Student Learning and Related Factors
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

The development of modeling skills in mathematics is essential for individuals to understand, describe, control, and predict phenomena around them. This article describes the results of an investigation to find out how an activity -based on the Models and Modeling Perspective- stimulates the mathematics modeling skills of students who are in the first quarter of the business career. As a result, it was shown that the MEA enabled students to exhibit, develop, and refine different modeling skills, such as: identification of variables, assumptions based on the real-life context, identification of patterns, and construction of mathematical representations.

Participants: *Luis E Montero-Moguel, The University of Texas at San Antonio; Veronica Vargas-Alejo, University of Guadalajara; Cynthia Lima, The University of Texas at San Antonio; Guadalupe Carmona, University of Texas at San Antonio*

144. College Students' Input on The Design of Worked Examples for Online Environments

Student Learning and Related Factors
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Worked examples have been shown to improve student learning in algebra. However, less is known about how to design worked examples to support student learning in online settings. We explore how college students react to worked examples that vary in their degree of extensiveness and dynamicness. In an online, within-subjects study, 109 college students viewed six worked example presentations: 1) static concise, 2) static extended, 3) sequential concise, 4) sequential extended, 5) dynamic history, and 6) dynamic no history. Students then rated the perceived usefulness of each worked example and explained their rating. Results showed that students rated the static concise presentation as the most helpful and the dynamic no history presentation as the least helpful example. Responses were coded by researchers for common themes and revealed insights that may inform how researchers and teachers design worked examples.

Participant: *Avery Harrison Closser, Purdue University; Jenny Yun-Chen Chan, Worcester Polytechnic Institute; Hannah Smith, Worcester Polytechnic Institute; Erin Ottmar, Worcester Polytechnic Institute*

145. Brief Session - Developing Teachers' Support of Student Thinking in the Classroom

Curriculum, Assessment, and Related Topics
Brief Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Participants:

Analyzing Curriculum for Learning to Professionally Notice: A Variation Theory of Learning Approach *Alees Lee, Weber State University; John Bragelman, University of North Georgia*

Using the lens of Variation Theory of Learning we consider what could be made possible to learn about professional noticing in a curriculum designed for an elementary mathematics content course.

Elementary Mathematics Teachers' Assemblage of Number Talks: An Inquiry Guided Approach *Hilary Tanck, Utah State University; Beth L. MacDonald, Utah State University*

This inquiry explores elementary mathematics teachers' curriculum work as they integrated a new component, Number Talks, into their existing curriculum assemblages. Number Talks are short 5-10 minute whole group discussions with specific procedures focusing on students' strategies for mental computations. Assemblage theory was used to frame how participants modified Number Talks when incorporating them into their classrooms. Participants described how they integrated Number Talks into their existing curriculum assemblages, collaborated with colleagues creating overlapping assemblages, and deterritorializing Number Talks to

change their functionality. We discuss the implications of participants changes to Number Talks and the adjustments participants made to their existing curriculum assemblages.

146. Examining how undergraduate students describe the Standards for Mathematical Practice
Mathematical Processes and Practices
Research Report Session
12:25 to 1:05 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room
While the Common Core State Standards for Mathematical Practice are a focal point of K-12 mathematics education, there is limited research examining how future teachers' (e.g., undergraduate students, teacher candidates) develop their conceptions of these standards. We investigate how opportunities within a mathematics-focused bridge course within a teacher education program provided opportunities for undergraduate students to develop their conceptions of the Standards for Mathematical Practice. Specifically, we explore how undergraduate students drew upon the Common Core provided descriptions to describe key practice ideas. This study contributes to the scholarship on mathematics teacher education and how teacher educators can support students in developing their understanding of mathematical practice.
Participants: *Elyssa Stoddard, Oregon State University; Rebekah Elliott, Oregon State University*

Saturday, November 19, 2022 Working Groups and Colloquia 1:20 – 2:50

Abstracts for all working groups and colloquia can be found at the end of the program.

Saturday, November 19, 2022 Afternoon Snack Break 2:50 – 3:20

Join us for an afternoon snack break in the Starstruck Gallery or Ballroom Foyer

164. Navigating the White Space of Mathematics: Lessons Learned from Mathematics Teacher Educators of Color
Professional Development/ In-Service Teacher Education
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A
As critical race theorists would remind us, those most impacted have the greatest insight to create change. This paper applies a critical race theory framework to explore the leadership experiences of two African American and one Japanese American mathematics teacher educator and how they address issues of race, racism, and (in)justice in teacher professional development. Data analysis from semi structured interviews, publicly available webinars and podcasts, and other published materials from the educators (eg. articles and books) reveal how they engaged teachers to attend to issues of race and racism by challenging persistent masternarratives about mathematics and mathematics ability; centering on counternarratives on the cultural identities and mathematical understanding of students of Color, and engaging in community-based pedagogies to promote coalitional resistance.
Participants: *Cathery Yeh, Chapman University; Kathryn Bianco, Portland State University; Kayla Asato, Chapman University; Eva Thanheiser, Portland State University; Manqing Gao, Portland State; Nicole Roady, Chapman University; Bree Victoria, Chapman University; Rebekah Elliott, Oregon State University; Ruth Heaton, Teachers Development Group*

165. Brief Report - Using Desmos to Support Mathematics Learning
Technology and Learning Environment Design
Brief Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B
Participants:
The Adapted X Framework: Designing Desmos Tasks *Kayla Chandler, East Carolina University; Charity Cayton, East Carolina University*
Research has identified specific frameworks that focus on the design and evaluation of mathematics technology tools and tasks (Author et al., 2021a). One of those identified, the X Framework (Author et al., 2015), has proven to be a useful tool to assist teachers in designing technology tasks that use the affordances of a specific math tool as a reorganizer (Pea, 1985) to support students' high-level thinking (Authors et al., 2017; Authors, Under Review). This study adapted the X Framework to examine in-service teachers' design of Desmos tasks in an asynchronous, paid professional development. Findings indicate when teachers designed a task that used Desmos as a reorganizer along an explicitly stated goal for student thinking, the result was a task of high potential cognitive demand.
The Teacher's Role in Sustaining Cognitive Demand with Desmos *Victoria Delaney, Stanford University*
Teachers play a crucial role in influencing students' cognitive demand during mathematics tasks. This study investigates the interaction between teachers and cognitive demand when digital technologies are integrated during students' enactment of such tasks. The research includes a video analysis of two eighth grade teachers' task launches and enactments of six student small groups using Desmos to solve a high-demand task. The findings indicate that the teachers' launches had less overall impact on students' cognitive demand and Desmos use than their ensuing small-group interactions, including how they related Desmos to the task's goals.

166. Invented Strategies Changing Teachers' Pedagogical Content Knowledge
Mathematical Knowledge for Teaching
Research Report Session

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold

This study investigates how utilizing student-invented strategies in the classroom can inform teachers' pedagogical content knowledge. Two elementary school teachers participated in professional development discussing the benefits of invented strategies. Data was then gathered as the participants implemented this practice in their classrooms. Data was analyzed qualitatively to show the ways in which invented strategies can be useful in a teacher's development of their pedagogical content knowledge, including their Knowledge of Content and Students, Knowledge of Content and Teaching, as well as Knowledge of Content and Curriculum.

Participant: *Jana Lunt, Southern Utah University*

167. Brief Report - Online Professional Development
Professional Development/ In-Service Teacher Education
Brief Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Participants:

Correlating Teachers' Engagement in Online Discussions with their Persistence in Professional Development *Anthony Matranga, California State University San Marcos; Jason Silverman, Drexel University*

Sustained participation continues to be an important factor of effective teacher professional development. This paper reports on a correlation analysis of two cohorts of mathematics teachers' patterns of participation in online asynchronous discussions and their persistence in a sequence of professional development workshops. Findings indicate that increased access to colleagues' knowledge resources and more frequent dispersion of these resources across the social network related to persistence. The findings have implications for network-based instructional strategies that can enhance teachers' engagement and increase their potential to persist in online professional developments. We also discuss how variations in the implementation of online workshops may impact teachers' potential to persist in professional development.

Tracking Mathematics Teacher Identity Development in Online Simulations: The Case of the Online Practice Suite *Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Pavneet Kaur Bharaj, Indiana University Bloomington; Calli Shekell, ETS; Heather Howell, Educational Testing Service; Meredith Park Rogers, Indiana University; Adam Maltese, Indiana University*

In this study, we examined how participation in a suite of practice-based simulations designed to support PSTs in developing the skills to facilitate discussions focused on argumentation influenced secondary math teachers' professional identity. Findings indicated that identity development was related to PSTs' opportunities to practice teaching in the simulations. For some PSTs, their math teacher identity became more central during the semester, while for others it foregrounded other sub-identities

168. Exploring the Impact of Discussion-Leading Professional Development on Teachers' Practice
Professional Development/ In-Service Teacher Education
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

This paper examines the impact of an intensive professional development on practicing teachers' mathematics discussion-leading practice. A tool for examining specific discussion-leading moves was used to measure change in teachers' practice as observed through submitted video recordings of mathematics discussions. Participants included 33 teachers from three school districts who submitted a total of 193 videos across the study. The findings reveal that the professional development had differential impact on participating groups. We explore group attributes that could contribute to these differential outcomes.

Participants: *Nicole Garcia, University of Michigan - Ann Arbor; Meghan Shaughnessy, Boston University; Merrie Blunk, University of Michigan; Jillian Peterson Mortimer, University of Michigan - Ann Arbor; Kristen D'Anna Pynes, University of Michigan - Ann Arbor; Darrius Robinson, University of Michigan*

169. Iceberg of Culturally Relevant Mathematics and Science Pedagogy: A Pedagogical and Analytical Tool for Teacher Education
Equity and Justice
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

There is a clear need for an operational framework that captures the difficulty of implementing culturally relevant pedagogy (CRP) and supports teachers to imagine new forms of pedagogy. In this report, we present the Iceberg of Culturally Relevant Mathematics and Science Pedagogy (CRMSP), a tool, grounded in the tenets of CRP, that delineates practices ranging from the most accessible and easy-to-implement, to the most subversive yet arguably the most significant in terms of their potential to re-characterize the acts of doing and being competent at mathematics and science. We provide examples of CRMSP that re-position marginalize learners in relation to mathematics and science. We discuss the levels in which this tool can serve to disrupt dominant, inequitable systems of instruction and preview ways it can support teachers' efforts to provide meaningful mathematics and science learning experiences for youth.

Participant: *Craig J Willey, Indiana University, IUPUI; Paula Magee, Indiana University-Purdue University Indianapolis*

170. Brief Report - Curriculum Analysis
Curriculum, Assessment, and Related Topics
Brief Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Using Abstraction as a Lens to Analyze Instructional Materials *Kevin Moore, University of Georgia; Amy Ellis, University of Georgia; Anne Nyarotso Waswa, University of Georgia; Michael Hamilton, University of Georgia; Halil Ibrahim Tasova, California State University San Bernardino; Aytug Ozaltun Celik, Pamukkale Unversity; Erin Wood, University of Georgia*

Over the past few decades, researchers have adopted forms of abstraction introduced by Piaget to build explanatory models of student and teacher knowledge. Although Piaget's forms of abstraction have proved productive for developing models of knowledge, their broader applicability to mathematics education remains an open question. In this brief report, we extend these forms of abstraction in order to analyze hypothetical outcomes of teachers' enactment of instructional materials.

Interactive Dynamics in Task-Based Curricular Materials *Allison*

L. Gantt, University of Delaware

Given the importance of students' interactions to their opportunities to learn mathematics, I investigate the interactive dynamics that are encouraged in two task-based written curricular materials and the purposes for interaction that they communicate. I conduct a thematic analysis to organize the functions of dynamics that encourage students to interact with peers' ideas (e.g., through dialogue) and with their own ideas (e.g., through reflection). Peer-interactive dynamics in this sample focused on sense-making, negotiation, and comparison. Self-interactive dynamics focused on developing awareness of thinking, formalization of new algebraic ideas, exploration, and precise language. I discuss how patterns among these themes across who interaction is designed for and across curricular materials could generate future lines of inquiry connecting the design of curriculum to student learning.

171. Professional learning at scale: Designing a boundary object

Policy, Instructional Leadership, Teacher Educators
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Education policies and innovations that aim to improve instructional quality often fail to produce any meaningful or sustained changes to teaching when implemented at scale because of the significant learning demands they place on the individuals, groups, and organizations that comprise an educational system. In this paper, we describe an implementation resource developed to promote professional learning and cross role discussions about new state mathematics standards and report on the ways educators at different levels of the state system used them. Results demonstrate how implementation resources designed to be a boundary object for educators at multiple levels of an educational system have the potential to support learning and create systemic conditions conducive of change.

Participants: *Allison McCulloch, University of North Carolina at Charlotte; Katherine J Mawhinney, Appalachian State University; Cathy Holl-Cross, UNC Charlotte; P. Holt Wilson, UNCG; F. Paul Wonsavage, University of Florida*

172. Explore teachers' collective learning through Chinese lesson study from a perspective of networking theories

Professional Development/ In-Service Teacher Education
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Although the effects of Lesson study (LS), a teacher collaborative professional development approach, on teacher professional learning and students learning have been widely documented, the theories for understanding of LS has just emerged as a research field. Interconnected Model of Teacher Professional Growth (IMPG) and Documentational Approach to Didactics (DAD) have been used individually to document teachers' professional learning. In this study, a networked framework is proposed by locally integrating these two theories. A lesson study facilitated by a researcher was conducted in Shanghai China. The data sets including all videotaped meetings and research lessons are collected and analyzed. The results show that the teachers' resource system evolved from adoption to adaptation with consideration of student learning. This study contributes to networking theories and its usefulness in LS context.

Participants: *Rongjin Huang, Middle Tennessee State University; Xingfeng Huang, Shanghai Normal University*

173. Brief Report - Research Methods and Literature Synthesis

Curriculum, Assessment, and Related Topics
Brief Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

Participants:

Gathering validity evidence to support mathematics education scholarship *Jonathan David Bostic, Bowling Green State University; Erin E. Krupa, North Carolina State University; Brianna Bentley, North Carolina State University; David Stokes, North Carolina State University; Timothy Donald Folger, Bowling Green State University*

Validity and validation is central to conducting high quality quantitative mathematics education scholarship. This presentation aims to support scholars engaged in quantitative research by providing information about the degrees to which validity evidence related to their instrument use or interpretation, were found in mathematics education scholarship. Findings have potential to steer future quantitatively focused scholarship and support equity aims.

A Critical Literature Synthesis on Methodological and Dissemination Considerations around Mathematics Specialists *Kristin E. Harbour, University of South Carolina; Margret Hjalmarson, National Science Foundation; Stefanie D. Livers, Missouri State University; Courtney K. Baker, George Mason University; Evthokia Stephanie Saclarides, University of Cincinnati*

Mathematics specialists are prominent figures in calls to advance the teaching and learning of mathematics. While the calls for mathematics specialists have gone on for decades, research in this area of study is still emerging. Because of this, there is a need for the field of mathematics education to better understand the research that has been conducted to move the field forward. As such, we present preliminary findings of a literature synthesis investigating the ways in which mathematics specialists are studied within empirical research between the years 1981 and 2018. Our findings document the quality of the research, the research methods used, and the journal outlets research is disseminated around mathematics specialists, as well as discussion and implications based on our results.

174. Brief Report - Secondary Students Algebraic Thinking

Mathematical Knowledge for Teaching
Brief Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

Participants:

Papel de la reflexión en el crecimiento del conocimiento de profesores de matemáticas *Miguel Angel Huerta-Vazquez, Cinvestav Mexico; Olimpia Figueras, Centro de Investigación y de Estudios Avanzados del IPN; Sandra Areli Martínez Pérez, Colegio de Ciencias y Humanidades*

Un grupo de profesores de matemáticas de nivel medio superior buscan mejorar su labor docente, para lo cual crean una comunidad profesional de aprendizaje, en dónde los docentes producen de manera colectiva secuencias didácticas mediante un ciclo reflexivo de varias etapas que llaman 'Enseñanza-Reflexión'. En este reporte se describe cómo surge el conocimiento para la

enseñanza de las matemáticas durante un ciclo de la función cuadrática, así como impacto de la reflexión en el conocimiento de los docentes. Un resultado importante de este trabajo es el uso del marco del Cuarteto del Conocimiento (KQ) de Rowland y colaboradores como herramienta de análisis del conocimiento de profesores que se organizan autogestivamente como el de esta investigación.

Towards the constitution of the mental object of system of linear equations in pre-university students/Hacia la constitución del objeto mental sistema de ecuaciones lineales en estudiantes preuniversitarios *Xochitl Josefina García López, CINVESTAV; Hugo Rogelio Mejía Velasco, Cinvestav*

The conformation of a mental object in a student implies his competence to make an adequate reading and execute processes in the different contexts in which it is possible to find the related concept. For the constitution of the mental object about system of linear equations we consider that pre-university students must be competent in the use of a resolution method that allows them to recognize a system of equations as a mathematical object and identify the nature of its solution set. In addition, we consider necessary the competence to identify the elements of the systems of equations in different systems of mathematical signs. La conformación de un objeto mental en un estudiante implica su competencia para hacer una lectura adecuada y ejecutar procesos en los diferentes contextos en los que es posible encontrar el concepto relacionado. Como parte de la constitución del objeto mental sistema de ecuaciones lineales consideramos que los estudiantes preuniversitarios deben ser competentes en el uso de un método de resolución que permita reconocer un sistema de ecuaciones como un objeto matemático e identificar la naturaleza de su conjunto solución. Además, estimamos necesaria la competencia para identificar los elementos de los sistemas de ecuaciones en diferentes sistemas de signos matemáticos.

175. Psychoanalysis and Probabilistic Thinking

Statistics, Probability, and Data Science
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Psychoanalysis is largely overlooked in mathematics education, yet is relevant to many aspects of the field, such as the institution of the school, curriculum and instruction, and content. Specifically, one content area where psychoanalysis is both exceedingly relevant and absent is that of probability education. In this critical literature review, I resurface important literature on the topic of psychoanalysis and probabilistic thinking, providing a Lacanian synthesis of its relevance in the future of probability education research. Important concepts such as subjectivity, epistemology, and linguistics are explored, all of which hold massive implications for probability education researchers in their interpretations of students' probabilistic thinking.

Participant: *Alexander S. Moore, Virginia Polytechnic Institute and State University*

176. English Language Learner Students' Development of the Mathematics Register During a Problem-Solving Lesson

Teaching Practice and Classroom Activity
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

This paper describes how fifth-grade English Learner students (ELs) in an urban school district develop the mathematics register during a problem-solving lesson. It provides examples of students' work to illustrate how they use the mathematics register to communicate their mathematical ideas orally and in writing. The teacher implemented teaching practices such as mathematics discourse to facilitate their students' development of the mathematics register during the problem-solving lesson. Students were engaged in a problem-solving task that involves fractions. Findings provide insights into EL students' challenges when learning the mathematics register and inform instruction about the importance of incorporating teaching practices such as paraphrasing assessing others' reasoning to support students in learning the mathematics register through problem-solving.

Participants: *Karla Valesca Matute, University of Wyoming; Richard Kitchen, University of Wyoming; Libni Castellón, University of Wyoming*

177. Teacher Language and Gesture in an Intervention Focused on Developing Kindergarteners' Understandings of the Equal Sign

Early Algebra, Algebraic Thinking, and Function
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This research reports on the teacher language and gesture that contributed to shifts in thinking about the equal sign and equations observed in twenty kindergarteners who took part in an early algebra intervention. Our analysis revealed ways in which the teacher used language and gesture to support students in moving from describing and working with the equal sign operationally (i.e., as a signal to compute) to describing the symbol as indicating the equivalence of two amounts and successfully working with equations of various forms. We detail four kinds of language and two kinds of gesture specifically related to mathematical equivalence that we believe contributed to students' growth.

Participants: *Yewon Sung, California State University – San Bernadino; Ana Stephens, University of Wisconsin-Madison; Ranza Veltri Torres, University of Wisconsin-Madison; Susanne Strachota, Tufts University; Maria Blanton, TERC; Angela Murphy Gardiner, TERC; Rena Stroud, Merrimack College; Eric Knuth, University of Texas at Austin*

178. Functional Concerns that Shape Teachers' in-the-Moment Decision-Making

Teaching Practice and Classroom Activity
Research Report Session
3:20 to 4:00 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

As a field, we have a limited understanding of what teachers do, what motivates them, and how they learn (Kennedy, 2016). Here, we develop a grounded framework of inquiry-based teaching in mathematics classrooms by beginning with primary evidence of teachers teaching. We seek to articulate an evidence-based account of teachers' functional (rather than aspirational) concerns so that those who support teachers — such as curriculum writers, professional learning specialists, coaches, and teacher educators — can ground their support in the realities of the work of teaching. Our research question is: "What are the functional concerns that shape teachers' decision-making in-the-moments of teaching?".

Participants: *Lara Jasien, CPM Educational Program; Lisa Amick, University of Kentucky*

179. Obscuring Racial Inequities through Gender-Focused Discourse: An Intersectional Analysis of Participation in a Calculus Class
Equity and Justice
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

Inequities in STEM participation for people of color and women are documented extensively, often highlighting issues of representation and/or achievement. This study adds to the literature by looking at participation inequities that occurred through interactions in a virtual high school calculus class. Equity is conceptualized as a fair distribution of opportunities for students to engage in rich mathematical experiences. Discourse analysis revealed participants' dialog about participation focused primarily on gender patterns, even when pertaining to only one race-gender intersection of students (i.e., White males). Intersectional analysis of whole-class participation showed White dominance superseded male dominance; White males had the most opportunities to participate followed by White females, females of color, and males of color. Findings suggest participants' gender-focused discourse obscured racial inequities in classroom participation.

Participant: *Heather Fink, UC Berkeley*

180. Brief Report - Exploring Implementation of Activities for Secondary Pre-Service Teachers
Pre-Service Teacher Education
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Participants:

Designing Simulations of Student Thinking for Preservice Secondary Teacher Education *Duane Graysay, Syracuse University; Hillary Bermudez, Syracuse University*

This brief report describes initial results of a design project to create live interactive clinical simulations of student thinking for use in secondary mathematics teacher education. We report the theoretical grounding of the design and an analysis of data collected from four implementations of three simulations. We present implications of our preliminary analysis for revisions of the design.

Engaging Prospective Secondary Teachers In Geometry Ethnomodeling Explorations *Siddhi Desai, University of Central Florida; Farshid Safi, University of Central Florida; Sarah B. Bush, University of Central Florida; Janet Andreasen, University of Central Florida; Trena Wilkerson, Baylor University; Daniel Clark Orey, Universidade Federal de Ouro Preto*

More than 50% of students in the United States are students of color and/or from historically underrepresented populations (NCES, 2020). Yet for so long, mathematics curriculum has not been representative of diverse student populations or inclusive of their backgrounds and their identities (AMTE, 2015; D'Ambrosio, 2017; TODOS, 2020). Through a focus on the intersections of mathematical modeling, ethnomathematics and cultural and historical practices, this ethnomodeling research study intentionally connects ways to engage and value each and every students' identity while emphasizing critical geometry content. During this presentation we will share results from a study examining how a sequence of geometry-focused ethnomodeling tasks informed secondary mathematics prospective teachers' perceptions of valuing their own as well as their future students' cultures and identities.

181. Brief Report - Programmatic Aspects of Pre-Service Teacher Education
Pre-Service Teacher Education
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Participants:

Listening to Teachers: Harmony and Dissonance in Taking Research to Practice *Susan Cannon, Mercer University; Tiara Mensinger, Mercer University; Brittney Castanheira, Mercer University; Ashlee Lee, Mercer University*

In this paper, we report on two years of collaboration with inservice teachers to rethink field work in elementary mathematics education. We engaged teachers who had completed the K5 Mathematics endorsement to serve as university supervisors. Their unique position as practicing teachers and agents of the university provided insight into program improvement. The teacher mentors shared equity tools and rubrics with the preservice teachers. Inservice teachers, preservice teachers, and the researchers interrogated their practice with these tools and provided insight into each other's practices. At times there was harmony in our thinking and at other times productive dissonance between researchers, inservice teachers, and preservice teachers.

Student Voices and Preservice Mathematics Teacher Programmatic Improvement / Votes de los Estudiantes y Mejora Programática del Profesor de Matemáticas en Preservicio *Nicholas Fortune, Western Kentucky University; Natasha E. Gerstenschlager, Western Kentucky University; Hope Marchionda, Western Kentucky University*

Supporting our teachers means that we must continually improve our teacher preparation programs. This improvement is influenced by various sources (e.g., state policies, university culture, program environment, faculty, needs of local schools, research). An overlooked perspective on teacher preparation programs is students' voices. We conducted a multi-stage survey to inquire into students' perspectives about their mathematics teacher preparation program. We discuss mathematics teachers' beliefs about the strengths and weakness of their preparation program. Findings from both stages indicated that students experienced disconnects between what they expected to get out of certain courses and what we, as faculty, expected them to learn. Although these are not novel issues, they are pertinent issues related to improvement of teacher education and serve as the impetus for conversations around programmatic improvement.

182. Offloading Cognitive Demands of Fractional Tasks on Working Memory Through Drawings
Student Learning and Related Factors
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

This study examined the role of student generated drawings to offload cognitive demands of a mathematical problem. We used Unit Transformation Graphs to compare students' thought processes when they had to solve the problem mentally, and when they were allowed to use pen and paper. The results indicated that

* The blue frame indicates a paper highlighted for meaningfully incorporating the conference theme, Critical Dissonance and Resonant Harmony.

the possibility to rely on drawings helped the participants to free up working memory resources and complete a cognitively demanding fractional task.

Participant: *Rachael Stryker, Virginia Tech; Vladislav Kokushkin, Virginia Tech; Anderson Norton, Virginia Tech; Sarah Kerrigan, Virginia Tech*

183. Brief Report - Measurement Validity in Mathematics Education

Mathematical Knowledge for Teaching
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Participants:

Structural Validity of 2021 Knowledge for Teaching Early Elementary Mathematics (K-Teem): A Psychometric Study *Ahmet Guven, Florida State University; Gizem Solmaz, Florida State University; Robert Schoen, Florida State University*

In this paper, we will describe the process and results of the structural validity phase of the 2021 Knowledge for Teaching Early Elementary Mathematics (K-TEEM) test. K-TEEM measures teachers' mathematical knowledge for teaching (MKT) at the early elementary level. The 2021 K-TEEM test is a measure of MKT used in a long-term, randomized controlled trial of the effect of a CGI professional-development program on teachers, teaching, and students. Our sample includes data collected in spring 2021 from 651 grades K–2 elementary educators in Florida. We conducted exploratory factor analysis (EFA), analyses based on classical test theory (CTT) and item response theory (IRT) with the resulting data to examine the psychometric properties of the test. The factor analysis results suggest one-factor solution.The marginal reliability for response pattern scores was 0.84, and the test difficulty appears to align well with the levels of MKT of the population of interest.

Teacher-Responses: Highlighting Characteristics of Low Response Process Validity for Items Measuring Teachers' Pedagogical Content Knowledge *Martha Epstein, UMass Dartmouth; Hamza Malik, UMass Dartmouth; Kun Wang, University of Massachusetts Dartmouth; Chandra Hawley Orrill, UMass Dartmouth*

Response Process Validity (RPV) reflects the degree to which items are interpreted as intended by item developers. In this study, teacher responses to constructed response (CR) items to assess pedagogical content knowledge (PCK) of middle school mathematics teachers were evaluated to determine what types of teacher responses signaled weak RPV. We analyzed 38 CR pilot items on proportional reasoning across up to 13 middle school mathematics teachers per item. By coding teacher responses and using think-alouds, we found teachers' responses deemed indicative of low item RPV often had one of the following characteristics: vague answers, unanticipated assumptions, a focus on unintended topics, and paraphrasing. To develop a diverse pool of items with strong RPV, we suggest it is helpful to be aware of these symptoms, use them to consider how to improve items, and then revise and retest items accordingly.

184. Brief Report - Examining Student Thinking

Curriculum, Assessment, and Related Topics
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Contrasting Cases In Geometry: Opportunities To Explore Different Student Solution Strategies *Erin E. Krupa, North Carolina State University; Brianna Bentley, North Carolina State University; Joshua P Mannix, Ball State University*

Utilizing an innovative and theoretically-grounded approach, we extend the work of cognitive scientists and mathematics educators who have previously documented the impact of comparison on students' learning in algebra with the goal of transforming the learning that occurs in eighth-grade geometry classrooms. The purpose of this paper is to examine the types of comparisons participants made during think aloud interviews when engaging with curricular materials that have them examine multiple solution strategies. This research seeks to extend the work of using comparisons in algebra to determine if using comparisons in geometry will help improve students' mathematical understanding.

How do Multi-Digit Multiplication Problems Promote Procedural Flexibility? An Analysis of Two Fourth Grade Textbooks *Elena Marie Silla, University of Delaware*

Procedural flexibility promotes efficient problem solving in mathematics. However, it is unclear whether and how elementary-grades textbooks promote this skill. The current study investigated lessons within two fourth grade math textbooks to determine how math tasks promote procedural flexibility within the domain of multi-digit multiplication. I developed and applied two frameworks to analyze the multiplication strategies and instructional strategies that might promote procedural flexibility that were presented in textbooks. The textbooks differed in the number and types of multiplication strategies included. Neither textbook showed much variability in terms of instructional strategies, and there was little alignment between multiplication and instructional strategies. Future research could investigate additional textbook features such as teachers' guides and study additional avenues for promoting procedural flexibility.

185. Brief Report - Elementary Pre-Service Teachers' Instructional Practices

Pre-Service Teacher Education
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Ambitious Mathematics Instruction from Teacher Preparation to Elementary Classrooms: An Examination Across Case Studies *Casedy Ann Thomas, University of Virginia; Faith Peddie, University of Virginia*

This study cross analyzes the results of two multiple case studies that focus on ambitious mathematics instruction within two institutions. The first study examines how three elementary mathematics methods instructors in the same teacher education program (TEP) provide their teacher candidates with learning opportunities. The second study examines how two elementary teachers who graduated from that TEP enact mathematics instruction. Findings suggest that teacher beliefs influence both the content that students have the opportunities to learn and the nature of the learning opportunities. The results

describe how instructors and teachers perceive the purpose of elementary mathematics instruction and how their beliefs align with the enactment of ambitious mathematics instruction with learners.

Deciding Quality: Lenses, Challenges, and Opportunities
Jonathan Norris Thomas, University of Kentucky; Walker Mask, University of Kentucky; Edna O'Brien Schack, Morehead State University; Molly Fisher, University of Kentucky; Cindy Jong, University of Kentucky

This study is focused on different lenses that may be used to make quality determinations with respect to prospective elementary teachers' instructional decisions. Using a professional noticing framework, we analyze individuals' deciding responses within a video-anchored case to explore the varying ways that quality of such decisions might be determined. Specifically, we examine how quality may be ascribed to decisions via holistic and analytic lenses. Our findings suggest key differences and tensions in quality determinations when using analytic and holistic lenses to make quality determinations with respect to instructional decisions.

186. Brief Report - Mathematics Teacher Noticing of Student Small Groups
Teaching Practice and Classroom Activity
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lower Level - Platinum
Participants:

Expanding Professional Noticing to Examine Teachers' Decision-making during Intervention in Small Groups
Byungeun Pak, Dixie State University

This study explores what affects teachers' decision-making when they intervene in small groups. I draw specifically on professional noticing to examine teachers' decision-making. Working with two novice teachers, I observed their mathematics lessons in which both teachers used small groups as an instructional structure to teach mathematical concepts and conducted follow-up interviews to have them elaborate on their intervention. The analysis of both teachers' elaboration on their specific intervention indicates that two teachers decided to intervene in small groups based on interpretations of certain actions as patterns, meaning what teachers have constructed working with students over weeks or months, not only what happened at the moment. This finding suggests that conceptualization of profession noticing needs to be expanded. Implications for research and teacher educators are offered.

Exploring the Relationship Between Preservice Teachers Mathematical Noticings and Their 360 Video Viewing
Christine Kathryn Austin, Kent State University; Jennifer Lynn Heisler, Kent State University; Karl Wesley Kosko, Kent State University

This study discusses the difference in a preservice teachers' (PSTs) mathematical noticings and the relationship between where they attend in a 360 video. Using a convergent mixed methods approach, our evidence provides support that PSTs who are more explicit in their written noticing of mathematical references are more focused in their viewing of a 360 video on a group of students or area of the classroom than those who look around more often.

187. Brief Report - Student Understandings of Parentheses
Early Algebra, Algebraic Thinking, and Function
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA
Participants:

An Exploration Of How College Students Think About Parentheses in the Context of Algebraic Syntax *Claire Wladis, BMCC/CUNY, CUNY Graduate Center; Benjamin D. Sencindiver, City University of New York; Kathleen Offenholley, BMCC/CUNY*

In this paper we explore how college students across different courses appeared to interpret the meaning of parentheses or brackets in the context of algebraic syntax. This work was influenced by theories of computational vs structural thinking, and also considered the extent to which students' definitions, computational work, and explanations appeared to be consistent with specific normative definitions of parentheses. In analyzing student work, several categories of students' conceptions emerged, which may be helpful in diagnosing which conceptions may be more productive or problematic as students progress through algebra. For students who appear to conceptualize parentheses as a cue to non-normative procedures, several categories of procedures were found, which could have implications for instruction.

Elementary Students' Emergent Use of Parentheses When Writing Expressions in a Sandbox Style Learning Game
Christopher Engledowl, New Mexico State University; Ted Stanford, New Mexico State University

Developing competency with writing numeric expressions that include grouping symbols is an important goal of early algebra (Stephens et al., 2017). In this study, we draw on numeric expressions written by 473 fourth and fifth grade students from 10 schools and 29 teachers as they played a digital learning game in order to examine their use of grouping symbols. We describe use of parentheses as being of three types: Type 1 are trivial, Type 2 indicate the order things should be done in, but are unnecessary, and Type 3 are necessary. Preliminary results show that regardless of whether a student played the game for much longer, the use of Type 2 and Type 3 parentheses increased as students became more experienced players. The sand box style of the game design appears to have played a role in students feeling free to experiment with different types of parentheses.

188. Elementary Mathematics Specialists: Preparation and Engagement in Teacher Leadership
Professional Development/ In-Service Teacher Education
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

This 5-year mathematics professional development project involves 27 elementary teachers prepared and supported as Elementary Mathematics Specialists (EMSs) in high-need urban schools. They complete a university's K-5 Mathematics and Teacher Supporting & Coaching Endorsement programs and participate in Professional Learning Communities and individual mentoring. Described here are data collected at the end of Year 1, illuminating the ways in which they are engaging in teacher

leadership, especially coaching. The EMSs are a distinctive population as informal teacher leaders, with a primary responsibility of teaching students. Central to the project is the university-school-community partnership, with findings illuminating reciprocity with mutual benefits, such as high quality clinical experiences for teacher candidates, coaching for novice teachers, and engagement with families and caregivers.

Participants: *Susan Swars Auslander, Georgia State University; Kayla Myers, Georgia State University; Carla Lynn Tanguay, Georgia State University; Gary Bingham, Georgia State University; Shani Jackson, Gwinnett County Public Schools*

189. Influence of Context on Teachers' Assessment Practices

Curriculum, Assessment, and Related Topics
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

The process of assessing students is a fundamental part of teaching and learning mathematics. The assessment practices a teacher chooses are shaped by their values while also being shaped by the context of the school, district, state, and country where the teaching takes place. This can result in gaps between teachers' values and practices. In this study, we use student work sample interviews with five secondary mathematics teachers to illustrate their values around assessment, the factors that influence their assessment practices, and how their agency influences the decisions they make around assessment. These findings have implications for teacher education and further research around how assessments are used. In particular, we focus on the important role contextual factors can play in shaping teachers' agency and choices.

Participants: *Kamala Stack, University of Minnesota - Twin Cities; Erin E. Baldinger, University of Minnesota*

190. Brief Report - Students' Problem Solving

Mathematical Processes and Practices
Brief Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Participants:

Problem Solving with Understanding *Siqi Huang, University of California, Berkeley*

It is not well understood when, how, and why students seek a deep understanding of the underlying mathematics relevant to the problems they try to solve. This study of five pairs of UC Berkeley students (undergraduate n=4, graduate n=6) solving challenging mathematics problems indicated consequential differences in the degree to which they worked to understand underlying principles. Drawing on Schoenfeld's (1985) research on problem solving and his (2010) model on decision making, I developed an observation system with a coding scheme to investigate students' orientations with respect to deep understanding. Preliminary results show that the proposed system captures students' divergent choices of moves and illuminates aspects of their understanding-related orientations that are not otherwise evident. This approach holds further potential as both a teaching and a learning tool in mathematics classrooms.

Transition from problem solving to modeling in students in Honduras / Tránsito desde la resolución de problemas hasta la modelización en estudiantes de Honduras *Noé Fernando Aguilar Perdomo, Cinvestav-IPN; Claudia Margarita Acuña, Centro de Investigación y Estudios Avanzados del IPN*

The present work aims to analyze the elements of problem solving that could allow the transition to mathematical modeling, with the purpose of supporting students who require it. Two students from Honduras with standard instruction in problem solving participated in the present study and one of them has participated in mathematical olympiads. The organization of the information, the explanation of the results and the validation processes could be points of contact between these positions and their adequate management would allow transit between them. We found that the students handle themselves adequately in problem solving, but they needed the support of the researcher to develop activities of analysis, validation and determination of the conditions to obtain the solution, thus achieving their approach to modeling.

191. Stem Undergraduates' Structural Conception of Rate of Change

Mathematical Processes and Practices
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Using data from teaching experiments and theories from quantitative reasoning, we built second-order accounts of students' mathematics with regards to how they conceived rate of change through operating on existing quantities. In this report, we explain three different ways STEM undergraduates structurally conceive rate of change as they constructed mathematical models for real-world scenarios.

Participants: *Sindura Subanemy Kandasamy, Texas State University; Jennifer A Czocher, Texas State University*

192. Conducting a Whole-Class Discussion About an Instance of Student Mathematical Thinking

Teaching Practice and Classroom Activity
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

Productive use of student mathematical thinking is a critical aspect of effective teaching that is not yet fully understood. We have previously conceptualized the teaching practice of building on student mathematical thinking and the four elements that comprise it. In this paper we begin to unpack this complex practice by looking closely at its third element, Conduct. Based on an analysis of secondary mathematics teachers' enactments of building, we describe the critical aspects of conducting a whole-class discussion that is focused on making sense of a high-leverage student contribution.

Participants: *Shari L Stockero, Michigan Technological University; Blake E Peterson, Brigham Young University; Keith R. Leatham, Brigham Young University; Laura R. Van Zoest, Western Michigan University*

193. Designing an Online Video-based Environment for Promoting Mathematical Argumentation

Technology and Learning Environment Design
Research Report Session
4:15 to 4:55 pm
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

During the past two years, the COVID-19 pandemic forced teachers to shift their instruction online, further exacerbating the challenge for teachers in orchestrating rich math discussions. To combat this issue, this study explored an approach that integrates online video-sharing culture (e.g., YouTube) into mathematical

practices. Specifically, I designed an environment to engage children in creating how-to videos and then sharing their videos online for subsequent discussions with peers. Guided by design research principles, this qualitative study recruited four upper elementary children in the United States. Preliminary analysis showed that the environment created unique opportunities for the children to communicate their ideas in a multimodal way and engage in mathematical argumentation. The findings provide insights into how an online environment can be designed to reshape children's argumentative discourse.

Participant: *Ho-Chieh Lin, The Ohio State University*

Saturday, November 19, 2022

5:00 – 6:15

Poster Session 2

Symphony Ballroom I and II

Saturday, November 19, 2022

5:30 – 7:00

Conference Reception and Entertainment

Join us for appetizers and entertainment in the Symphony Ballroom Foyer.

Cash Bar will be available in the Symphony Ballroom Foyer.

Live music provided by Brother and the Hayes.

http://www.brotherandthehayes.com/

Sunday, November 20, 2022 – Morning Program

7:30 to 8:30am
197. Sunday Breakfast - Lobby Level Symphony Ballroom I & II

7:30 to 8:30am
196. PME-NA Steering Committee Meeting - Lobby Level Green Room

	8:30 – 9:10am	9:30 – 10:10am
Mezzanine Level Blackbird Studio A	198. Brief Report - Pre-Service Teachers Developing Culturally Responsive Lessons	212. Conceptions Of Honduran High School Teachers About The Number Line In Tasks Of Symbolic Management/Concepciones De Profesores Hondureños De Secundaria Sobre La Recta Numérica En Tareas De Gestión Simbólica
Mezzanine Level Blackbird Studio B	199. Opportunities for Reasoning-and-Proving in Mathematical Tasks: A Discursive Perspective	213. Brief Report - Synchronous Online Mathematics Education Courses
Lower Level Gold	200. A Catalyst for Change: A Teacher's Experiences with Supplementary Curricular Materials Enriched with Interactive Simulations	214. Brief Report - Undergraduate Students Attitudes about Mathematics
Lobby Level Green Room		215. Brief Report - Introductory University Mathematics Instruction and Learning
Lobby Level Lyric	201. A 2D Shape Composition Learning Trajectory of a Student with Difficulty in Mathematics	244. Brief Report - Challenges of Teaching SJM
Lobby Level Melody	202. Early Mathematics Teacher Preparation Evaluation Rubrics for the Context of Live Discussion Forums	217. Brief Report - Interactions and Experiences in Online Mathematics Instruction
Mezzanine Level Ocean Way	203. Brief Report - Professional Development Strategies	218. Brief Report - Interdisciplinary Perspectives on Mathematics Education
Lower Level Platinum	204. Brief Report - Secondary Students' Experiences in Mathematics Learning	219. Brief Report - Teaching Mathematics for Social Justice
Mezzanine Level RCA	205. Mathematicians' Language for Isomorphism and Homomorphism	220. Brief Report - Student Learning in Undergraduate Mathematics
Mezzanine Level Sound Emporium A	206. Brief Report - Critical Perspectives in Transcription Research Methods	221. Brief Report - Teacher's Statistical Knowledge
Mezzanine Level Sound Emporium B	207. How Many Angles Do You See? Prospective Teachers' Assimilatory Domains for Angularity	222. Brief Report - Sociocultural Perspectives in Mathematics Learning
Mezzanine Level Southern Ground A	208. Digitalized interactive item components in computer-based assessment in mathematics for K12 students: a research synthesis	223. What's In A Name? Seeking Geometry in Geometric Sequences
Mezzanine Level Southern Ground B	209. Designing Instructional Sequences for Ethical, Critical, and Mathematical Reasoning	224. Supporting Communities Of Inquiry In Asynchronous, Online Mathematics Professional Development
Lobby Level Symphony Ballroom III	210. Brief Report - Measuring Teacher Practices using Observational Tools and Rubrics	225. Building Community In A Research Project Team Through Identity Sharing
Mezzanine Level The Castle		
Mezzanine Level Tracking Room	211. Brief Report - Algebra and Algebraic Thinking in Middle Grades	226. Brief Report - Mathematics Learning in a Pandemic
Working Groups and Colloquia – 10:30 – 12:00 Abstracts found at the end of the program.		

198. Brief Report - Pre-Service Teachers Developing Culturally Responsive Lessons
Pre-Service Teacher Education
Brief Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A
Participants:

Culturally Relevant for Whom? Reflecting on Culture and tasks With Preservice Teachers *John Bragelman, University of North Georgia; Kathryn Mary Rupe, Western Washington University; Rebecca Borowski, Western Washington University*

To prepare preservice teachers (PTs) to create equitable, culturally responsive mathematics classrooms, mathematics teacher educators must support them in making connections between theory and practice. Critical examination of culture, its role in the mathematics classroom, and PTs own culture and experiences can be an entry point for this important work. In this study, preservice elementary teachers at various points in their teacher preparation programs engaged in activities that supported their understanding of culturally responsive and relevant mathematics. Using a Culturally Relevant Cognitively Demanding (CRCD) rubric (Matthews et al., 2013) to evaluate tasks and reflect upon the various issues that the tasks illuminate can be transformative experiences for PTs as they develop their identities as equitable mathematics teachers. This multiple case study examines how PTs' understanding of cultural relevance and responsiveness evolved over both content and methods courses.

PTs' Experience Developing Culturally Responsive Mathematics Lessons in a Middle School Mathematics Methods Course *Zareen Gul Rahman, James Madison University*

The proposed presentation describes 20 prospective teachers' (PTs) experience developing culturally responsive mathematics lessons in their middle school mathematics methods course. One mathematics teacher educator guided the PTs in developing and implementing lessons as they engaged in micro-teaching episodes. During Spring 2020, Fall 2020 and Spring 2021 semesters, the PTs engaged in micro-teaching guided by the lesson analysis tool developed by Aguirre and Zavalla (2013) to make culturally responsive mathematics teaching (CRMT) explicit. Engagement in the activity allowed the PTs to learn about developing and implementing lessons that are mathematically rigorous as well as sensitive to social justice issues. The proposed presentation aims to deconstruct how micro-teaching guided by the CRMT tool was employed and to describe the opportunities for PTs' learning.

199. Opportunities for Reasoning-and-Proving in Mathematical Tasks: A Discursive Perspective
Mathematical Processes and Practices
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

In this paper, we offer a novel framework for analyzing the Opportunities for Reasoning-and-Proving (ORP) in mathematical tasks. By drawing upon some tenets of the commognitive framework, we conceptualize learning and teaching mathematics via reasoning and proving both as enacting reasoning processes (e.g., conjecturing, justifying) in the curricular-based mathematical discourse and as participation in the meta-discourse about proof, which is focused on the aspects of deductive reasoning. By cluster analysis performed on 106 tasks designed by prospective secondary teachers, we identify four types of tasks corresponding to four types of ORP: limited ORP, curricular-based reasoning ORP, proof related ORP, and fully integrated ORP. We discuss these ORP and the contribution of this framework in light of preparing beginning teachers to integrate reasoning and proving in secondary mathematics classrooms.

Participants: *Merav Weingarden, University of New-Hampshire; Orly Buchbinder, University of New Hampshire; Jinqing Liu, University of New Hampshire*

200. A Catalyst for Change: A Teacher's Experiences with Supplementary Curricular Materials Enriched with Interactive Simulations
Professional Development/ In-Service Teacher Education
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold

This study aims to understand a middle school mathematics teacher's instruction and reflections on her experiences with supplementary curricular materials enriched with interactive simulations—PhET interactive simulations (sims) and sim-based materials—over two years. We conceptualize Linda's (pseudonym) teaching in terms of both thinking and doing. Regarding Linda as doer, results show significant differences in Linda's instruction, favoring sim lessons compared to non-sim lessons. Regarding Linda as thinker, results show increased attention to problems of practice related to teaching, as well as more productive framing of problems of practice. When these two findings are taken together, shifts in what Linda did and thought illustrate the potential for high-quality supplementary materials to function as a catalyst for change as we map the flow of shifts in what Linda thought and did across two years.

Participants: *Sebnem Atabas, University of Southern California; Ian Whitacre, Florida State University*

201. A 2D Shape Composition Learning Trajectory of a Student with Difficulty in Mathematics
Student Learning and Related Factors
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

This study explores a spatial reasoning learning trajectory of a student with difficulty in mathematics. Using a teaching experiment methodology across 15 instructional sessions, we observed how the student responded to instruction based on an established 2D shape composition learning trajectory (Sarama & Clements, 2009). A narrative microgenetic analysis identified conditions that were likely to have promoted learning. The analysis shows the student's actual trajectory was similar to that of the hypothesized learning trajectory. Challenges to progress emerged around teacher-guided components of instructional support. We describe how a student-centered approach and mathematizing through specific praise was generative of learning, while explicit guidance was not. We discuss how the guiding conjecture of the teaching experiment evolved and how it is situated within the broader literature base.

Participants: *Angela R Crawford, Boise State University; Aysia Kernin, Boise State University*

202. Early Mathematics Teacher Preparation Evaluation Rubrics for the Context of Live Discussion Forums

Pre-Service Teacher Education
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Teacher candidates bring many beliefs and interpretations of mathematics teaching and learning at the start of their teacher preparation coursework (e.g. methods courses, field experiences, assessment). Well-prepared beginning teachers in many instances requires programs and designed experience to breakdown unproductive beliefs and/or improve dispositions to align to best practices and equitable dispositions for the teaching and learning of mathematics. Our study focused on developing and validating two rubrics to evaluate teacher candidates' talk during live discussion forums in the first month of their initial teacher preparation program coursework with the intent to inform to varying degrees, where teachers candidate talk is situated (or not) in alignment to foundational readings and productive beliefs. Early validity evidence for rubric use is presented with suggestions for informative use and practice.

Participants: *Jeremy Zelkowski, The University of Alabama; Tye Campbell, The University of Alabama*

203. Brief Report - Professional Development Strategies

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

Incremental Change as an Alternative to Ambitious Professional Development *Samuel Otten, University of Missouri at Columbia; Zandra de Araujo, University of Florida; Amber Grace Candela, University of Missouri - St. Louis; Courtney Vahle, University of Missouri - Columbia; Maria Elizabeth Nielsen Stewart, University of Missouri - Columbia; F. Paul Wonsavage, University of Florida; Faustina Baah, University of Missouri at Columbia*

Mathematics professional development (PD) has had many small victories but has not brought about a widespread change in what constitutes typical mathematics instruction. This theoretical essay argues that many PD projects have been based on an assumption that the aims of the PD should be ambitious, but ambitious PD requires that a large set of criteria be satisfied (active learning, coherence, duration, teacher buy-in, etc.). Even then, ambitious PD may only reach a minority of teachers who are ready to make the transformation. An alternative approach is incremental PD, which starts with a teacher's contextual constraints and ubiquitous practices, offering modest but meaningful "nudges" for their instruction. These nudges are intended to be easily taken up by teachers, providing a sense of success that leads to them sustaining the practices and being portable enough to be easily shared with other teachers, allowing for scale.

Japanese Instructional Circles *Matthew Melville, University of Delaware*

Japanese instructional circles are a form of professional development, outside of lesson study, done in Japan. This report discusses the structural features of instructional circles that enable learning opportunities. It also explores how teachers engage in those opportunities to support those learning opportunities.

204. Brief Report - Secondary Students' Experiences in Mathematics Learning

Equity and Justice
Brief Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

Black Students' Tensions When Freedom Dreaming About an Ideal Mathematics Education in Rural Appalachia *Sean P. Freeland, West Virginia University; Matthew P Campbell, West Virginia University*

This preliminary work is from a larger study on the experiences of Black students learning mathematics in rural Appalachia. Following previous findings, this piece analyzes a series of interviews with Black students from West Virginia who were asked to imagine their ideal mathematics education through the lens of critiquing injustices. These freedom dreams were intended to develop features of a new mathematics education; however, there were tensions present in their re-imagination. They were often constrained by dominant notions of achievement and race in mathematics education. These tensions and student voices need to be taken into consideration in reform and change in mathematics education in rural Appalachia and beyond.

Translanguaging as a Source of Mathematical Sense-Making Practice during Problem-Solving *Ayse Ozturk, The Ohio State University,Newark*

This study focuses on how strategic translanguaging occurs when bilingual students engage in a real-life-oriented problem-solving process and communicated their reasoning. Data for this report came from an after-school program for bilingual high school students. Action-research methodology guided data collection from classroom sessions that consisted of problem-solving with quantities. Analysis revealed that translanguaging can be a source of the sense-making process in mathematical problem-solving that leverages bilingual students' linguistic repertoire to combine everyday and mathematical registers while bridging multiple solution pathways.

205. Mathematicians' Language for Isomorphism and Homomorphism

Pre-Calculus, Calculus, and Higher Math
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

Isomorphism and homomorphism appear throughout abstract algebra, yet how algebraists characterize these concepts, especially homomorphism, remains understudied. Based on interviews with nine research-active mathematicians, we highlight new sameness-based conceptual metaphors and three new clusters of metaphors: sameness/formal definition, changing perspectives, and generalizations beyond algebra. Implications include a way to articulate a conceptual purpose for homomorphism beyond its relationship to isomorphism: namely, as a tool for changing perspectives when problem-solving.

Participants: *Rachel Rupnow, Northern Illinois University; Brooke Randazzo, Northern Illinois University*

206. Brief Report - Critical Perspectives in Transcription Research Methods

Equity and Justice
Brief Research Report Session
8:30 to 9:10 am

Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A
Participants:

Opportunities and Limitations of Poetic Transcription as a Critical Qualitative Methodology for Mathematics Education *Rachel Tremaine, Colorado State University*

This work presents an exploration of poetic transcription as a promising critical methodology for use in mathematics education research. I make the case for mathematics education as a specific space in which such methodology could be valuable, and provide a use case for poetic transcription through the poetic analysis of three students' definitions of student success within mathematics. Following a reflection on some of the critiques and limitations of re-presenting data in this way, I conclude that poetic transcription offers mathematics education an imaginative and simultaneously grounded method of understanding, while still necessitating critical thought and adaptation.

The Worlds that Transcripts Hide in Mathematics Education Research *Higinio Dominguez, Michigan State University; Sofia Abreu, Michigan State University*

This brief research report showcases an alternative to transcript analysis that halts the process of reducing participants' expressive worlds to an orderly regime of words. Drawing from a philosophical conversation with grade-five students on the concept of space, the paper advances a methodological/analytical perspective that recalls transcripts and reissues them as liminal spaces of possibility while interrogating the limitations of conventional approaches to transcript analyses for generating new knowledge. Several philosophies inform our contribution, including Indigenous Knowledges, Feminisms, New Materialisms, and Posthumanism. The paper describes the process of constructing a transcript and coming to see it beyond its static, linear nature. The findings suggest that the encounter of researcher with data constitutes an opportunity to re-encounter possibility, embrace generosity, and engage imagination in research

207. How Many Angles Do You See? Prospective Teachers' Assimilatory Domains for Angularity
Geometry and Measurement
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

Given the centrality of angle in mathematics curricula and lack of research in this area, we investigated 64 PTs' assimilatory domains of angularity by analyzing the angles they indicated when presented four segments with a mutually shared endpoint. In both interview and written settings, we found PTs were more likely to recognize convex angles than reflex angles. Additionally, they were more likely to assimilate disjoint angles than angles formed via additive angular compositions. In particular, we found that PTs were unlikely to recognize full angles or additive compositions involving reflex angles. We consider future directions and implications

Participants: *Hamilton Hardison, Texas State University; Hwa Young Lee, Texas State University; Lino Guajardo, Texas State University; Mai Bui, Texas State University*

208. Digitalized interactive item components in computer-based assessment in mathematics for K12 students: a research synthesis
Technology and Learning Environment Design
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

We conduct a research synthesis to investigate the availability of digitalized interactive tools in mathematics computer-based assessment. These tools like digitalized ruler, drag-and-drop method of responding or answering, language pop-up glossary, animated shapse, etc. We have stated several criteria for including a study. For example, it has to be a published study and about mathematics assessment. A systematic search identified ten studies that categorized existing DICs according to the tools that provided language assistance to students and tools that supported students problem solving. We report on the one study that involved students with learning disabilities and three studies involved English Language Learners. One study focused on assessing geometry content and four studies targeted on number and operations understanding. For other studies included a mixture of mathematics domains. Mixed results were reported as to the effectiveness of the availability of DICs. The research suggests that older children were more likely to benefit from availability of the DIC than younger children, and that DICs have greater impact on students with special needs.

Participants: *Moosa Ali Abdullah Al Hadi, Rutgers University; Dake Zhang, Rutgers University; Ting Wang, ETS; Carolyn A. Maher, Rutgers University*

209. Designing Instructional Sequences for Ethical, Critical, and Mathematical Reasoning
Curriculum, Assessment, and Related Topics
Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Designers of critical mathematics instruction have documented difficulties in simultaneously fostering the development of critical consciousness while supporting students in developing understandings of new mathematics. However, confining justice-oriented tasks to applications of previously learned mathematics limits the degree to which these tasks will be taken up by teachers. We describe our attempt to employ heuristics from the instructional design theory of realistic mathematics education [RME] to create a sequence aimed at developing students critical and ethical reasoning while also developing new mathematical understandings of ratio, proportion and percents. We propose emergent adaptations to two of the realistic mathematics education design principles then propose an additional ethical principle to guide the development of future RME sequences.

Participants: *Luke Reinke, UNC Charlotte; Michelle Stephan, UNC Charlotte; Jordan Register, UNC Charlotte*

210. Brief Report - Measuring Teacher Practices using Observational Tools and Rubrics
Teaching Practice and Classroom Activity
Brief Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III
Participants:

A Classroom Observation Tool for equity-oriented teaching of mathematical modeling in the elementary grades *Erin Turner, University of Arizona; Mary Carlson, Montana State University; Elizabeth Fulton, Montana State University; Julia Aguirre, University of Washington Tacoma; Jennifer M. Suh, George Mason University*

Mathematical modeling can be a lever for equity in the elementary math classroom, as it empowers teachers to

build on the knowledge and cultural resources that children bring to the classroom and empowers students to draw on their experiences and identities to inform their mathematical work. To better support this transformative synergy between mathematical modeling and equity-oriented practices, we need a tool to deepen our understanding of variations and potential trajectories of teacher practice. In this report, we briefly describe our process for developing an equity-oriented mathematical modeling classroom observation protocol. We then discuss two sample dimensions from our tool to illustrate our integrated attention to equity-focused and mathematical modeling-specific teaching practices.

Scoring with Classroom Observational Rubrics: A Longitudinal Examination of Raters' Responses and Perspectives *Temple A. Walkowiak, North Carolina State University; Jonee Wilson, North Carolina State University; Elizabeth L. Adams, Southern Methodist University; Annie Wilhelm, Southern Methodist University*

This study examines the utilization of cognitive interviews longitudinally over a one-year period to collectively trace raters' response processes as they interpreted and scored with observational rubrics designed to measure teaching practices that promote equity and access in elementary and middle school mathematics classrooms. We draw on four rounds of cognitive interviews (totaling 14 interviews) that involved four raters at purposeful time points spread over the year. Findings reported in this study focus on raters' responses about one rubric, positioning students as competent. The findings point to the complexities of utilizing observational rubrics and the need to track response processes longitudinally at multiple time points during data collection in order to attend to rater calibration and the reliability and validity of resulting rubric scores.

211. Brief Report - Algebra and Algebraic Thinking in Middle Grades

Early Algebra, Algebraic Thinking, and Function
Brief Research Report Session
8:30 to 9:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

Participants:

Developing Meanings for Graphs from Number Lines: The Case of Mike *Halil Ibrahim Tasova, California State University San Bernardino*

In this study, I report on developmental shifts of a middle school student's (Mike) graphing activity as I implement an instructional sequence that emphasizes quantitative and covariational reasoning. The results suggest that representing quantities' magnitudes as varying length of directed bars on two parallel lines, forming a new space by making those lines orthogonal, and generating a point by joining those bars were an integral part of Mike developing productive meanings for graphing quantities in a Cartesian plane.

Uses of the Equal Sign and Equation Types in Middle School Mathematics Textbooks *Daniel Siebert, Brigham Young University; Chelsea Dickson, Brigham Young University*

Research suggests that students' difficulties in studying algebraic topics can be remedied at least in part by teaching students to use a relational meaning for the equal sign to reason about equations. However, little empirical research has been done to investigate what meanings for the equal sign and equation types are common in middle school mathematics. This study examines two series of 7th and 8th grade mathematics textbooks to identify what equal sign meanings and equation types are being used in middle school mathematics. Three meanings for the equal sign were used in all four textbooks, and each equation type was typically associated with only one meaning of the equal sign. The results imply that students need to develop three different meanings for the equal sign to succeed in middle school mathematics, and that recognizing equation types can help indicate which meaning of the equal sign is being used.

212. Conceptions Of Honduran High School Teachers About The Number Line In Tasks Of Symbolic Management/Concepciones De Profesores Hondureños De Secundaria Sobre La Recta Numérica En Tareas De Gestión Simbólica

Teaching Practice and Classroom Activity
Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

"The number line is a model that in teaching is used to measure, count, order and even operate, which requires a symbolic interpretation, so we investigated the conceptions of 72 teachers when they manage the model of the number line associated with order, spatial location and relative position between numbers and marks. In a workshop organized via the Internet, we found that the participants consider the benefit of the model to be utilitarian as an artefact and do not see the need to modify it as a semiotic tool, despite the requirements of the problem, taking for granted the domain that can give them resources such as changing the numerical scale. They do not notice the symbolic properties of the model that support the ideas of order, the numerical value according to the relative position and spatial location of the numbers and their marks, which give numerical coherence to the representation. La recta numérica es un modelo que en la enseñanza es usado para medir, contar, ordenar e incluso operar, lo que requiere de una interpretación simbólica, por ello indagamos las concepciones de 72 profesores cuando gestionan el modelo de la recta numérica asociada al orden, la ubicación espacial y la posición relativa entre números y marcas. En un taller organizado vía internet, encontramos que los participantes consideran que el beneficio del modelo es utilitario como un artefacto y no ven la necesidad de modificarlo como una herramienta semiótica, pese a los requisitos del problema, dando por sentado el dominio que les puede dar recursos como el cambio de la escala numérica. No se percatan de las propiedades simbólicas del modelo que apoyan las ideas de orden, el valor numérico según la posición relativa y la ubicación espacial de los números y de sus marcas las que dan coherencia numérica a la representación.

Participants: *Sharon Samantha Membreño Estrada, CINVESTAV-IPN; Claudia Margarita Acuña, Centro de Investigación y Estudios Avanzados del IPN*

213. Brief Report - Synchronous Online Mathematics Education Courses

Professional Development/ In-Service Teacher Education
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

Participants:

Lessons Learned During Two Teacher Educators' Shift to

Synchronous Online Mathematics Education Courses *Lynda R. Wiest, University of Nevada - Reno; Teruni Lamberg, University of Nevada, Reno*

This paper describes a self-study conducted by two K-8 teacher educators in relation to their shift to teaching synchronous online mathematics education courses. They each wrote three independent self-reflections for a total of four courses (one undergraduate, three graduate) that they later analyzed and discussed for common themes in relation to the following topics: challenges (online teaching in general and for mathematics education courses), instructional adjustments, favorable aspects of teaching mathematics education courses online, skills gained that would benefit future teaching in any mode, equity considerations in teaching courses online, and recommendations for future online mathematics education courses. They report their findings in relation to these broad categories and use structured reflection on their experiences to recommend practices for online mathematics education teaching and learning.

Modeling Ambitious Teaching in Synchronous Online Mathematics Education Courses *Nicholas Kochmanski, UNC Greensboro; Terrie Galanti, University of North Florida; Alees Lee, Weber State University; Jonathan D Watkins, Ball State University*

There is a prevailing notion that online course modalities present challenges to teaching in ambitious ways, and thus to modeling ambitious teaching for pre-service and in-service teachers. In this paper, we report on the results of an exploratory analysis of one mathematics teacher educator's efforts to model ambitious teaching in a synchronous, online mathematics education course. We describe both the online tools central to this effort and the teaching moves for using those tools effectively

214. Brief Report - Undergraduate Students Attitudes about Mathematics

Student Learning and Related Factors
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Lower Level - Gold

Participants:

Changing First-Year Mathematics Students' Perspectives: Community, Affect, and Assessment *Karina Uhing, University of Nebraska at Omaha; Keith Gallagher, University of Nebraska at Omaha; Nicole Infante, University of Nebraska at Omaha*

Student experiences in first-year mathematics (FYM) courses are crucial to their success in college. In recent years, there has been a push to improve FYM courses by centering and engaging students. The purpose of this study is to examine how students perceive their experiences with active learning and standards-based grading in FYM courses. In this paper, we present our analysis from end-of-semester Mathographies written by students who were enrolled in FYM courses in Fall 2021. We discuss three key findings: community, affect, and assessment. We compare these findings to a framework relating to students' experiences with active learning and provide questions for future exploration.

College Algebra Students' Attitudes Toward Math and Graphs: An Exploratory Factor Analysis *Livvia Bechtold, University of Colorado Denver; Courtney Donovan, University of Colorado Denver; Heather Lynn Johnson, University of Colorado Denver*

We report on results from a mixed methods study investigating a measure of students' attitudes toward math and graphs. At the beginning of eight consecutive fall and spring semesters, we distributed a fully online attitude survey, adapted from Pepin (2011), to undergraduate College Algebra students. Our report includes two samples, Validation (n=1256) and Calibration (n=712). Our research team qualitatively coded students' responses into five categories: positive, mixed, ambiguous, negative, detached. Next, we quantitized those qualitative codes into a four category scale, which condensed the mixed and ambiguous categories. Conducting an Exploratory Factor Analysis, we found that students' attitudes grouped by topics (math and graphs). We conclude with implications for research and practice.

215. Brief Report - Introductory University Mathematics Instruction and Learning

Student Learning and Related Factors
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

Participants:

The Use of Self-Regulation Strategies in First-Semester Calculus: The Case of Sunny *Kyle Russell Turner, University of Texas at Arlington; James A. Mendoza Álvarez, The University of Texas at Arlington*

This case study explores self-regulation strategies used by Sunny, a high-achieving first-semester freshman student in calculus and aims to identify how she uses self-regulation strategies while in the course. Individual and group interviews were analyzed using categories of self-regulation strategies previously identified in the research literature. Findings suggest that Sunny's specific self-regulation habits for mathematics centered on mastering course concepts and shifted from focusing on memorization to focusing on understanding. This provides leverage for continued efforts to help foster productive self-regulation strategies for success in first-semester calculus.

College Instructors' Perceptions of Barriers & Drivers that Impact the Implementation of Active Learning *Jessica Gehrtz, University of Texas at San Antonio; Stephen Lee, University of Texas at San Antonio; Priya Vinata Prasad, The University of Texas at San Antonio*

College mathematics instruction that leverages evidence-based instructional practices, such as productive group work, can lead to many positive outcomes for students. In order to support instructors in adopting more evidence-based instructional practices, it is important to understand what barriers and drivers can impact their decision to implement such practices. In this study, we interviewed four introductory mathematics instructors teaching the same course in order to understand, in context, what aspects served as barriers and drivers. Transcripts were analyzed using thematic analysis. Initial results highlight how course coordination and weekly project meetings served as drivers, and the impact of the pandemic was seen as both a driver and a barrier to implementing evidence-based instructional practices.

216. Conceptual reorganization, from count-up-to to break-apart-make-ten: A case of a 6th grader struggling in mathematics

Number Concepts and Proportional Reasoning
Research Report Session
8:00 to 8:40 am THURSDAY (see grid for Thursday)
Loews Vanderbilt Hotel: Floor Mezzanine – Tracking Room

Through a constructivist teaching experiment, we studied how a 6th-grade student (Adam, pseudonym) struggling in mathematics may reorganize his available additive scheme (count-up-to) into a more advanced scheme involving the decomposition of composite units (break-apart-make-ten, or BAMT). First, we posed a task that led us to infer Adam was yet to construct the BAMT scheme at the anticipatory stage (solving a task without prompting). We thus turned to promote reorganization of his anticipatory, count-up-to scheme used to solve missing-addend tasks. Through reflection on the relationships between his goal, count-up-to actions, and effect of those actions, Adam independently brought forth what he called "number-pairs" (i.e., 10+X = X-teen). This seemed to afford his reorganization of count-up-to into the BAMT scheme. We discuss implications of this reorganization for theory building and practice.

Participants: *Ron Tzur, University of Colorado Denver; Cody Harrington, University of Colorado Denver; Dennis J DeBay, University of Colorado Denver; Alan Davis, University of Colorado Denver*

217. Brief Report - Interactions and Experiences in Online Mathematics Instruction
Technology and Learning Environment Design
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Melody

Participants:

Interaction Types in Online and Hybrid Mathematics Instruction *Michael Hoyes, Jr., North Carolina State University; Erin E. Krupa, North Carolina State University; Karen Hollebrands, NC State*

Engagement in the mathematics classroom through interactions with the instructor, peers, and content are necessary for an effective learning experience. As such, it is important to understand the types of interactions that teachers utilize to engage students, especially as they have had to shift from a complete face-to-face setting to various remote modalities. Utilizing four interaction types (learner-content, learner-instructor, learner-learner, and learner-interface) this paper analyzes 35 videos of classroom instruction with the purpose of describing the interactions that take place throughout the course of the mathematics lesson. While there was not a significant difference in the type of interaction and the modality of instruction, there was a significant difference in the type of interaction enacted and the modality of instruction.

Connecting Problems of Practice to Technology Solutions During Emergency Remote Teaching *Rachel Harrington, Western Oregon University; Ann Wheeler, Texas Women's University; Shannon O. S. Driskell, University of Dayton; Steve Rhine, Pacific University*

This report focuses on the results of an electronic survey completed in spring 2020 documenting the experiences of 212 mathematics teacher educators (MTEs) as they transitioned to emergency remote teaching. From the data, eight problems of practice emerged: changing pedagogy to account for online contexts, rehearsals of teaching, monitoring in class student learning, student engagement, assessment, student needs, sense of community, digital manipulatives, and digital tools for instruction. Results indicate that MTEs addressed these problems, altering their teaching by adopting many new technology tools and functions. These included: video conferencing applications, Desmos, virtual manipulatives, GeoGebra, Google Slides, Google Docs, Flipgrid, videos and webinars, and discussion boards. Implications for MTEs who teach or are interested in teaching online will also be discussed.

218. Brief Report - Interdisciplinary Perspectives on Mathematics Education
Curriculum, Assessment, and Related Topics
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

Participants:

'ME or IdME': How Interdisciplinary Mathematics Education (IdME) Contributes to Students' Learning Experiences with Mathematics *Midhat Noor Kiyani, McGill University; Limin Jao, McGill University; Cinzia Di Placido, McGill University; Sun Jung Choi, McGill University; Dawn Wiseman, Bishop's University*

Traditionally, mathematics is taught without a connection to the real world which makes it abstract and difficult for students to understand, thereby resulting in low mathematics achievement. This study investigated the learning experiences of Grade 8 students as they participated in project-based learning (PBL) as part of an interdisciplinary mathematics education (IdME) unit of study. Qualitative data were collected in the form of student self-reflections and interviews. Findings suggest that students were able to improve their mathematics knowledge and understanding by implementing mathematics concepts in real-world contexts. We argue that students not only understand mathematics better but also realize its importance as a discipline when it is taught through real-world projects.

Linguistic Tensions in Generalizing a Mathematics Education Framework for STEM Education *James Drimalla, University of Georgia; AnnaMarie Conner, University of Georgia; Jenna Menke, University of Georgia; Anna Gillespie-Schneider, University of Georgia; Timothy Foutz, University of Georgia; Lorraine Franco, University of Georgia; Aida Alibek, University of Georgia; Barbara Crawford, University of Georgia; Shaffiq N Welji, University of Georgia*

Research processes are often messy and include tensions that are unnamed in the final products. In our attempt to update and generalize a framework from mathematics education to interdisciplinary STEM contexts, we have experienced significant linguistic tensions because of the context-dependent nature of language. We aim to acknowledge the difficulty of generalizing research beyond the mathematics education community, describe our attempts to resolve the problem we face, and discuss potential conclusions pertaining to the feasibility of generalizing frameworks beyond mathematics education.

219. Brief Report - Teaching Mathematics for Social Justice
Equity and Justice
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Participants:

An Exploratory Action Research Study of Social Justice Mathematics in Undergraduate Precalculus *Abigail Erskine, Syracuse University; Brian Odiwuor, Syracuse University; Nicole L.*

Fonger, Syracuse University

In this exploratory action research study we investigated teaching mathematics for social justice in undergraduate mathematics. We asked: How if at all do undergraduate students consider the importance of local social justice issues as embedded in the context of a precalculus course assignment?; As instructors, how might feedback from students' experiences of a social justice mathematics lab inform our future teaching and research practices? In this paper we discuss emerging findings from our initial analyses. We also elaborate how these findings will inform our ongoing efforts to link research and practice at the intersection of supporting students' math cognition and exploring social justice issues through teaching mathematics for social justice.

The Integration of Mathematical and Social Content in Secondary Lessons for Social Justice *Meghan Riling, Vanderbilt University; Leslie Dietiker, Boston University; Xi Yu, Boston University; Erin Barno, Boston University*

In recent years, mathematics lessons addressing social justice have been increasingly published and taught, but little is known about how mathematical and social content unfolds within them. In this study, we interpret five secondary social justice mathematics lessons (SJMLs) as stories and analyze the questions that arise within them. We found that most of these lessons began and ended with a focus on social matters, while shorter mathematical questions arose in the middle of the lessons. However, the lessons varied in terms of what proportion of the questions overall were focused on social or mathematical thinking. Finally, we found that narrative devices were used in several lessons when the focus transitioned from social issues to mathematics, or vice versa. This way of thinking about lessons could enable the design of SJMLs that meaningfully integrate social and mathematical thinking.

220. Brief Report - Student Learning in Undergraduate Mathematics

Pre-Calculus, Calculus, and Higher Math
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA
Participants:

The reasoning of engineering students when they face problems involving the fundamental theorem of calculus *Omar Arenas Bonifacio, Center for Research and Advanced Studies (CINVESTAV); Ernesto Alonso Sánchez, Departamento de Matemática Educativa, Cinvestav-IPN; Mario Sánchez Aguilar, CICATA Legaria, Instituto Politécnico Nacional; Francisco Sepulveda, CINVESTAV, IPN, México*

The question is: How do engineering students who have taken a traditional calculus course reason in the face of simple liquid flow problems in which the solution process involves the fundamental theorem of calculus? A three-question questionnaire was administered to 18 engineering students from a university in Mexico City who had taken an ordinary Calculus course. From a Grounded Theory perspective, their answers were coded and three general categories were generated, which we have called procedural, transitional or conceptual reasoning. The results, as in previous studies, show that most students use procedural reasoning, however, the analysis allows us to propose features that indicate the transition towards conceptual reasoning. In addition, a framework for analyzing the reasoning of engineering students is proposed.

Understanding linear dependence: a perspective of mental structures and mechanisms with university students/ Comprensión dependencia lineal: una perspectiva de las estructuras y mecanismos mentales con estudiantes universitarios *Silvia Juliana Ballesteros, Universidad Industrial de Santander; Solange Fuentes, Universidad Industrial de Santander*

This article aims to present the design of a genetic decomposition of the concept of linear dependence based on the analysis of textbooks, previous research related to the concept and the results of an intervention with students of linear algebra from the public university in Colombia. It is sought to have a cognitive model that is the result of the first phase of the methodology proposed by APOE.

221. Brief Report - Teacher's Statistical Knowledge

Mathematical Knowledge for Teaching
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A
Participants:

Development and Measurement of Statistical Knowledge for Teaching *Stephanie Casey, Eastern Michigan University; Andrew Michael Ross, Dept. of Mathematics and Statistics, Eastern Michigan University; Jeremy F Strayer, Middle Tennessee State University*

We describe novel teacher education curriculum materials designed to develop secondary preservice teachers' Statistical Knowledge for Teaching(SKT) along with a new test for measuring teachers' SKT. We report preservice teachers' changes in SKT from learning with the materials in a preliminary study.

Teachers' Goals For Seeing With Data *Ryan Seth Jones, Middle Tennessee State University; Sara Salisbury, Middle Tennessee State University; Fonya Scott, Middle Tennessee State University; Lisa Shepherd, Middle Tennessee State University*

We present an interview study of 6th grade math and science teachers' expressed goals for engaging their students with data. We explored this across disciplinary boundaries to contribute to a body of knowledge that can support the development of a more coherent experience for students across math and science classes. Our teachers were all highly motivated to engage their students with data, and all wanted their students to see things with their data models. However, we observed consequential differences in the kinds of things they wanted students to see. Here we describe these differences and discuss potential implications for practice.

222. Brief Report - Sociocultural Perspectives in Mathematics Learning

Pre-Service Teacher Education
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B
Participants:

Using Assessment Tools for Teacher Learning Purposes *Merav Weingarden, University of New-Hampshire*

This paper offers a socio-cultural perspective on the mechanism by which research-based assessment tools

aiming at evaluating mathematics teaching, are used as pedagogical tools for teacher learning. This process is exemplified with the Realization Tree Assessment tool (RTA), showing its affordances for helping pre-service teachers communicate about pedagogical messages aligned with traditional and ambitious contextual discourses.

Ethnomathematics Testimonios: A Useful Tool In The Designing Of Syncretic Mathematical Activity *Emmanuel Nti-Asante, University of Massachusetts, Dartmouth*

The heritage practices of many communities of color have historically been and continue to be the target of deficit approaches. In Mathematics Education, the existing solutions to this problem have focused on modeling approaches to bridge cultural ways of knowing with the institutionalized forms. This article argues that solutions to deficit approaches in cultural ways of knowing in mathematics education (ethnomathematics) are not simply about modeling bridges. We must bring together and extend these domains' various activities and practices in a forward-looking third space that occurs socially for all learners to voice, personalize, challenge, and negotiate mathematical meanings. Ethnomathematics research holds an intellectual accomplishment that results from one's ability to remediate the mathematical motives in activities done by diverse ethnic groups to include the mathematics used in formal spaces.

223. What's In A Name? Seeking Geometry in Geometric Sequences

Mathematical Knowledge for Teaching
Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

Mathematical terminology is sometimes created according to conventions that are not obvious to students who will use the term. When this is the case, investigating the choice of a name can reveal interesting and unforeseen connections among mathematical topics. In this study, we tasked prospective and practicing teachers to consider: What is geometric about geometric sequences? Participants embedded their explanations within a scripted dialogue between teacher- and student-characters in a mathematics classroom, provided commentary on this dialogue, and expanded on its mathematical content. Participants most often leverage the concept of a geometric mean to explain why geometric sequences are named as such. To capture this informal arguments, we built on the work of Toulmin (1958/2003) to conceptualize and develop the Toulmin-Reversed (Toulmin-R) model.

Participants: *Andrew Kercher, Simon Fraser University; Anna Marie Bergman, Simon Fraser University; Rina Zazkis, Simon Fraser University*

224. Supporting Communities Of Inquiry In Asynchronous, Online Mathematics Professional Development

Technology and Learning Environment Design
Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Online teacher professional development (PD) opportunities are poised to play a key role in bringing meaningful, effective professional learning to teachers on a broad scale. The Video in the Middle project works to develop and research asynchronous, online PD modules designed to be implemented in both facilitated and unfacilitated formats. VIM modules are designed to align with research in teacher professional learning as well as to support communities of inquiry (e.g., Garrison et al., 2000). Participants' responses to intervention activities were analyzed using indicators of Garrison et al.'s Community of Inquiry framework, seeking to understand the ways in which modules enabled cognitive, social, and teaching presence across facilitation formats. We discuss results and implications for building the CoI framework into subsequent online asynchronous mathematics teacher PD as a way of increasing teacher learning, building community, and effectively scaling interventions.

Participants: *Angela Knotts, WestEd; Nanette Seago, WestEd; Jill Neumayer DePiper, WestEd*

225. Building Community In A Research Project Team Through Identity Sharing

Equity and Justice
Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This study presents the use of the Social Identity Wheel (SIW), to build community in a newly-formed mathematics education research team. The SIW, originally built for use in classrooms, was used to allow each team member to share about themselves which led to the team learning about each other. The research focus of the team is to connect social and political issues to mathematics in elementary classrooms. Reflecting on identity and discussing social and political issues are essential components of this work. Hence, building community is part of fostering safe, productive environments in which to build these tasks. To better understand what building a community might look like, the project team used the Social Identity Wheel to build community within the team and get to know one another.

Participants: *Molly L Robinson, Portland State University; Eva Thanheiser, Portland State University; Amanda Sugimoto, Portland State University; Danny Penner, Portland State University; Simon Byeonguk Han, Portland State University; Courtney Koestler, Ohio University; Mathew David Felton-Koestler, Ohio University; Jennifer Thompson, Ohio University; Howard E. Bartels, Ohio University; Laura Wolfe, Ohio University*

226. Brief Report - Mathematics Learning in a Pandemic

Mathematical Processes and Practices
Brief Research Report Session
9:30 to 10:10 am
Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

Participants:

Modeling COVID-19 Vaccine Hesitancy Using Research on Probabilistic Thinking *Hyunkyoung Yoon, Arizona State University; Mina Gong, University of Georgia; Cameron Byerley, Colorado State University; Min Sook Park, University of Wisconsin Milwaukee; Dru Horne, University of Georgia; Ulfa Aulyah Idrus, University of Georgia*

A number of factors contribute to vaccine hesitancy including citizens' determination of the risks and benefits of vaccination. In this study, we use interviews and surveys to understand how United States and South Korean citizens quantify the risks of COVID-19 infection and vaccination. Many citizens used benchmark values such as 0%, 50%, 100% to estimate their risks of COVID-19 infection and COVID-19 vaccination. Although neither infection nor vaccination has a 50% risk of severe outcome, the citizens' thinking is consistent with the outcome approach described by Konold (1989, 1991). In his work, a 50% risk often implied uncertainty

about if an outcome would happen in a single trial. It is important to support citizens' understanding of risk because in our sample the citizens who thought COVID-19 vaccination was riskier than COVID-19 infection were often unvaccinated.

A Mathematics Support Program: Modifications and Responses to the Pandemic *Jenna Tague, Clovis Community College*

The purpose of this report is to share the facets of a support program set in a mathematics department in a mid-sized comprehensive western university. This is an ongoing project and I use the social community framework (Mondisa & McComb, 2015) to compare the students in the mentoring program to a control group of students. The current results allowed me to examine the effect of the mentoring program on their community of practice during the 2020-2021 Covid-19 pandemic. Results include overall effects of the pandemic on mathematics students, and interventions that could help encourage a sense of belonging through the pandemic environment.

244. Challenges of Teaching SJM

Equity and Justice

Brief Research Report Session

9:30 to 10:10 am

Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

Participant:

Tensions of Knowledge and Authority: Challenges of Teaching SJM

Trevor Warburton, Utah Valley University

This study seeks to demonstrate how knowledge and authority are linked for preservice mathematic teachers and how this link may pose a challenge for teaching mathematics for social justice. A CDA of multiple preservice class discussions is presented.

Sunday, November 20, 2022 Working Groups and Colloquia 10:30 – 12:00

Abstracts for all working groups and colloquia can be found at the end of the program.

Working Group Abstracts

147. Conceptions and Consequences of What We Call Argumentation, Justification, and Proof: Interrogating our Frameworks

Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio A

Argumentation, justification, and proof are essential constructs in the field of mathematics and teaching and learning in mathematics classrooms. Research involving these constructs draws on a variety of definitions and analytic frameworks that include discursive, social, and content factors. This year, we examine frameworks used in research involving these constructs and engage working group participants in critical conversations about how these have been used, with what impact, as well as considering future directions for addressing new questions and making further progress on long-standing ones.

Organizers: AnnaMarie Conner, University of Georgia; Karl Wesley Kosko, Kent State University; Michelle Cirillo, University of Delaware; Megan Staples, University of Connecticut; Kristen N Bieda, Michigan State University

148. Adaptations to Lesson Study to Support Equitable Teaching Practices

Loews Vanderbilt Hotel: Floor Mezzanine Level - Blackbird Studio B

This working group is a follow-up initiative aimed at providing a structure for the mathematics education community to engage in various adaptations of lesson study that strive to address issues of equity in the mathematics classroom. The goals this year are to share four adaptations (Teaching Through Problem-solving, Focal Students and Equity Commentator from the California Action Network for Mathematics Excellence and Equity (CANMEE), Rights of the Learner, and Continuous Improvement Lesson Study (CILS)) and examine intersections amongst the adaptations to focus on equitable teaching practices. Participants will view a public lesson and discuss how elements of each of the four adaptations are present within the lesson. The eventual outcome of the group is for participants to develop and engage in lesson study that integrates equity across different contexts (e.g., K-12 teachers, preservice teachers, graduate students, and mathematics teacher educators).

Organizers: Melissa M. Soto, San Diego State University; Dittika Gupta, Midwestern State University; Catherine C. Lewis, Mills College; Susie W. Hakansson, CANMEE; Mollie Appelgate, Iowa State University; Lara Dick, Bucknell University

149. Working Through Dissonance: Addressing Tensions that Arise When Studying Mathematics Teacher Preparation Using an Equity Lens

Loews Vanderbilt Hotel: Floor Lower Level - Gold

We view critical dissonance as key for equity work. As such, we propose a working group session for developing appropriate methodological approaches for systematic study of phenomena related to the intersection of equity work and mathematics teaching and learning in university-based teacher preparation; we call this approach equity-focused research. In keeping with this year's conference theme Critical Dissonance and Resonant Harmony, we will create collegial, scholarly space for unpacking and addressing persistent issues that arise when research design in mathematics education research is driven from an equity perspective. The goal is to engage with fellow researchers to discuss and/or develop appropriate methods and designs for studying the ways that preservice teachers understand, implement, and/or resist culturally responsive/sustaining teaching practices after learning about them in their mathematics methods coursework.

Organizers: Jennifer B Chauvot, University of Houston; Jeannette Alarcon, University of Houston

150. Mathematics Curriculum Recommendations for Elementary Teacher Preparation Working Group: Phase II

Loews Vanderbilt Hotel: Floor Lobby Level - Green Room

In our first year of work at the PME-NA and AMTE conferences, we explored the current state of elementary teacher preparation programs and generated questions about how to create a viable recommendations document for the mathematics curriculum of elementary teacher preparation. Our current goal is to build upon this work by designing research studies to generate data and answer questions that underlie our future recommendations for elementary teacher preparation.

Organizers: Julien Corven, University of Delaware; Joseph DiNapoli, Montclair State University; Lynsey Gibbons, University of Delaware; Kim Johnson, West Chester University of PA; Valerie Long, Indiana University of Pennsylvania; Dana Olanoff, Widener University; Rachel N Starks, Boston University

151. Research Colloquia: Playful Mathematics and Learning

Loews Vanderbilt Hotel: Floor Lobby Level - Lyric

We build on findings from the working group Mathematical Play: Across Ages, Context, and Content, which met in 2018, 2019, and 2021. That group explored multiple contexts in which mathematical play occurs, and developed definitions and criteria for characterizing it. This colloquium extends these characterizations to examine relationships between play and classroom-based learning. Playifying classroom mathematics increases student agency and autonomy, opening spaces that challenge status-quo classroom norms. A tension can thus arise between the open-ended nature of play and the highly directed nature of typical classroom instruction. We explore this tension by identifying design principles for infusing play into classroom spaces, and by discussing theoretical and methodological constructs for characterizing the mathematical play that can arise in and out of classroom spaces. In doing so, we explore mathematical play phenomena across ages (pre-kindergarten through college), contexts (informal and classroom settings), and domains (early number, algebra, geometry, probability, and calculus).

Organizers: Robert Ely, University of Idaho; Amy Ellis, University of Georgia; Wager Anita, Vanderbilt University; Aaron Weinberg, Ithaca College; Janet Walkoe, University of Maryland, College Park; Mariana Levin, Western Michigan University; Candice Love, Vanderbilt University; Madison Knowe, Vanderbilt University; Melissa Gresalfi, Vanderbilt University; Amy Noelle Parks, Michigan State; Dru Horne, University of Georgia; Anna Bloodworth, University of Georgia; Annelise W Nielsen, University of Idaho; Caro Williams-Pierce, University of Maryland; David Plaxco, Clayton State University; Paul N. Reimer, AIMS Center for Math and Science Education

152. Research Colloquia: Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium

Loews Vanderbilt Hotel: Floor Lobby Level - Melody

The Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium offers hands-on individual and collaborative mathematics activities; technological, curricular, and pedagogical demonstrations; and open spaces for exploration and discussion regarding the embodied nature of mathematics education. At PME-NA 44 we will use the conference theme of "critical dissonance and resonant harmony" to invite the community to directly experience some of the many ways embodied perspectives challenge the status quo through expanded notions of mathematical activity and assessment, and to explore some current contributions, future potential, and challenges for more inclusive educational experiences for learners and teachers.

Organizers: Mitchell J. Nathan, University of Wisconsin - Madison; Candace Walkington, Southern Methodist University; Avery Harrison Closser, Purdue University; Erin Ottmar, Worcester Polytechnic Institute; Martha W Alibali, University of Wisconsin-Madison; Hannah Smith, Worcester Polytechnic Institute

153. Latine Studies in Mathematics Education Working Group: Exploring the Borderlands of Latine Learners Estudios De Latines En Educación Matemática: Grupo Explorando Las Fronteras De Latine Aprendices

Loews Vanderbilt Hotel: Floor Mezzanine Level - Ocean Way

The inaugural meeting of the working group focusing on Latine studies in mathematics education will highlight how issues including immigration, language, sexuality, culture, phenotype, and other forms of border crossings are investigated and considered within mathematics education. Participants will be able to share their work, network with others in this area, and develop new trajectories for collaboration and areas of study.

Organizers: Carlos Nicolas Gomez Marchant, The University of Texas at Austin; Alexandra Aguilar, University of Texas at Austin; Stacy R Jones, The University of Texas at Austin; Gerardo Sanchez Gutierrez, University of Texas at Austin; Luis Antonio Leyva, Vanderbilt University - Peabody College of Education & Human Development; Rosa Chavez, Stanford University; Maria del Rosario Zavala, San Francisco State University; Amy Rae Johnson, UT Austin; Chandel Burgess, The University of Texas at Austin

154. Aesthetic and Affective Dimensions of Mathematics Learning

Loews Vanderbilt Hotel: Floor Lower Level - Platinum

Students' aesthetic and affective responses are interrelated and both central to mathematics learning. This new working group will bring together researchers as a community to explore the connection between affect and aesthetic, and how this connection can help to understand how students experience mathematics. The goals of this working group are to evaluate the state of the field, build shared terms, and identify research questions for further inquiry.

Organizers: V. Rani Satyam, Virginia Commonwealth University; Leslie Dietiker, Boston University; Meghan Riling, Vanderbilt University

155. Complex Connections: Reimagining Units Construction and Coordination with Algebraic and Covariational Reasoning

Loews Vanderbilt Hotel: Floor Mezzanine Level - RCA

A powerful aspect of using neo-Piagetian frames to examine students' construction, coordination, and abstraction of units is their potential to apply across mathematical domains. This working group aims to facilitate collaborations between scholars of algebraic and covariational reasoning, with the particular aim of extending research on units coordination and construction across these contexts. An ultimate goal of this working group will be to develop a Special Issue.

Organizers: Beth L. MacDonald, Utah State University; Karen Zwanch, Oklahoma State University; Sarah Kerrigan, Virginia Tech; Steven Boyce, Portland State University; Cameron Byerley, Colorado State University; Diana L. Moss, University of Nevada, Reno; Claudia Marie Bertolone-Smith, California State University Chico; Christopher Orlando Roman, Portland State University; Jeffrey Grabhorn, Portland State University

156. Myths of Objectivity in Mathematics Education / Mitos en torno a la Objetividad en la Educación Matemática

Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium A

This Working Group was occasioned by a convergence of concerns over the widespread de facto acceptance of notions of objectivity in the field of mathematics education. Because the ideologies of the field continue to be based largely in elements of scientism, we propose that the mathematics education arena familiar to researchers must shift and take up the work of philosophy and critique for the field to remain relevant in current and future times. This scientism structures, for example, the common belief in the usefulness of mathematics and the subjectivity of the soft science research in which we engage (e.g., using inter-rater reliability). This working group provides participants the opportunity to engage in active learning experiences and critical discussions about the ways in which objectivity infiltrates aspects of our field, and to expose oneself to new viewpoints about the philosophy of mathematics education.

Organizers: Sofía Abreu, Michigan State University; Aida Alibek, University of Georgia; David Matthew Bowers, University of Tennessee, Knoxville; James Drimalla, University of Georgia; Beth Herbel-Eisenmann, Michigan State University; Alexander S. Moore, Virginia Polytechnic Institute and State University; Lee Melvin Madayag Peralta, Michigan State University

157. Conceptualizing Ethics, Authenticity, and Efficacy of Simulations in Teacher Education

Loews Vanderbilt Hotel: Floor Mezzanine Level - Sound Emporium B

This working group explores the ethics of simulations of practice in teacher education. This working group expands on the work of a 2019 and 2021 PME-NA working group with a goal of disseminating conversations around the ethics of simulations of practice. The working group organizers have reached out to different publishers with the goal of collaboratively editing a book. Working group participants will be invited to contribute chapters to the book. During our time together we will construct common themes with participants and develop an action plan for the completion of the book.

Organizers: Carrie W Lee, East Carolina University; Heather Howell, Educational Testing Service; Liza Bondurant, Delta State University; Minsung Kwon, California State University Northridge; Yvonne Lai, University of Nebraska-Lincoln; Bima Kumari Sapkota, Purdue University

158. Taking up Mathematics Education Research Spaces as Resistance: Toward Disability Justice

Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground A

The purpose of this working group is to build upon our previous working group and to take up and move forward towards solidarity, interdependence, and collective action with the disabled community in our research agenda. We are mathematics education researchers and practitioners demanding radical changes within and beyond our field to center issues of/with/by the disabled. Research on mathematics and disabilities traditionally has been conducted within a special education paradigm, which often implicitly or explicitly adopts a deficit and dehumanizing model locating the "problem" within the individual student rather than in the social, discursive, political, and structural context. We demand that mathematics education researchers and practitioners address this critical dissonance by taking up equity-oriented approaches to understanding disability and its intersections as well as resonant harmony frameworks that honor the voice, agency, and leadership of those most impacted. We welcome all who are interested to join this working group.

Organizers: Paulo Tan, Johns Hopkins University; Cathery Yeh, Chapman University; James Richard Sheldon, University of Arizona; Kai Rands, Independent Researcher; Katherine Elizabeth Lewis, University of Washington; Amber Grace Candela, University of Missouri - St. Louis; Jessica H. Hunt, North Carolina State University; Rachel Lambert, University of California Santa Barbara; Erica N. Mason, University of Illinois, Urbana-Champaign; Alison Mirin, University of Arizona; Alexis Padilla, University of New Mexico; Anette Bagger, Örebro University; Juuso Nieminen, University of Hong Kong

159. Gender and Sexuality Working Group: Applying Theory to Data

Loews Vanderbilt Hotel: Floor Mezzanine Level - Southern Ground B

Gender research in mathematics education continues to be important work for gender equity in mathematics and STEM, more broadly. Additionally, authors recently called for research on sexuality, identified a dearth of research in this area, and a need to theorize and operationalize such research (Dubbs, 2016; Moore, 2021; Wiest, 2021). Building upon working group discussions of emerging theories and methodologies during PME-NA 2021, in the 2022 working group sessions, we will apply these theories and methods to interview and classroom data to explore concrete ways of studying gender and sexuality in mathematics education that utilize different perspectives. Our goals are to (a) explore how gender and sexuality may be "seen" through different methods of data collection, focusing on how different meanings of gender and sexuality, as they are described and performed, may lead to new insights; and (b) produce a list of research questions and potential projects for future research.

Organizers: Przybyla-Kuchek, University of Georgia; Brent Jackson, Michigan State University; Katrina Piatek-Jimenez, Central Michigan University; Jennifer Hall, Monash University; Ana Dias, Central Michigan University; Weverton Ataide Pinheiro, Indiana University Bloomington

160. Coming Out On The Other Side of "The Equity Group": From Choque to Harmony

Loews Vanderbilt Hotel: Floor Lobby Level - Symphony Ballroom III

This working group, which is a continuation of a regular working group space dedicated to goals of equity at PME-NA since 2009, invites scholars actively engaged in antiracist research and teaching practices to come together to strategize around how to respond to choques and dissonance in order to work towards harmony. This year, the aim is to dismantle or deconstruct instances of dissonance and harmony that have emerged from a choque, or a confrontation within our field.

Organizers: Juanita M Silva, Texas State University; Melissa Adams Corral, California State University-Stanislaus; Ricardo Martinez, University of Nebraska - Lincoln; Gladys Krause, William and Mary; Marrielle Myers, Kennesaw State University; Luz Angelica Maldonado Rodriguez, Texas State University; Joel Amidon, University of Mississippi

161. Philosophical Underpinnings of Mathematics Teacher Educators' Work / Bases Filosóficas del Trabajo de los Educadores de Matemáticas

Loews Vanderbilt Hotel: Floor Mezzanine Level - The Castle

"Mathematics teacher educators (MTEs) are turning research lens on themselves to explore their practice and with that contribute knowledge to the field of mathematics teacher education. In this working group we build from our exploration of MTEs' work. MTEs will describe their work and their views of knowledge and being in their work as MTEs. We invite MTEs to join our working group and assert that MTEs' discussions of their work will provide opportunities for professional learning that reveals how their knowledge and identity informs their practice. Los educadores de matemáticas (EMs) están volviendo los lentes de investigación a ellos mismos para examinar su practica y con ello contribuir conocimiento al campo de la enseñanza de la educación matemática. En este grupo de trabajo vamos a construir a partir de nuestra exploración del trabajo de los EMs. Invitamos a EMs a unirse a nuestro grupo de trabajo y afirmar que las discusiones del trabajo de los EMs proporcionan oportunidades para el aprendizaje profesional que revelan como el conocimiento y la identidad informan sus practicas."

Organizers: Elizabeth Suazo-Flores, Purdue University; Signe Kastberg, Purdue University; Melva R Grant, Old Dominion University; Olive Chapman, University of Calgary

162. Teaching and Learning with Data Investigation

Loews Vanderbilt Hotel: Floor Mezzanine Level - Tracking Room

With a renewed focus on data investigation and its relationship to issues of equity and justice, we build on past statistics education working groups to co-develop a syncretic space in which new knowledge can emerge while embracing the tension between critical and dominant views. To do so, we invite a wide range of discussions and collaborations within the domain of statistics and data science education. The primary goal of this working group is to initiate cross-institutional collaborative subgroups based on overlapping research interests. The first two sessions will focus on identifying mutual interests among participants, and the third session will be devoted to planning for collaborative activities over the coming year.

Organizers: Sunghwan Byun, North Carolina State University; Christopher Engledowl, New Mexico State University; Travis Weiland, University of Houston; Susan Cannon, Mercer University

Doctoral Consortium Posters

1	**Examining Critical Factors in Parent-Child Math Engagement** Anastasia Betts, University of Buffalo SUNY	Saturday
2	**A Study of Learners' Inventiveness with Immersive Spatial Diagrams** Camden Glenn Bock, The University of Maine	Friday
3	**Mathematics, Mathematics Education, And Citizenship: Conceptions, Professional Practice Views, And Figured Worlds** Amy Brass, Pennsylvania State University	Friday
4	**Developing Combinatorial Meaning for Algebraic Structure: Lessons From a Design-Research Cycle** Lori Burch, Indiana University	Saturday
5	**Access to Cognitively Demanding Mathematical Learning Opportunities in Co-Taught Elementary Mathematics** Laurel Dias, University of Utah	Saturday
6	**Multilingual International Students' Experiences in Proof-Based Collegiate Mathematics Courses: Using Narrative Inquiry** Jihye Hwang, Michigan State University	Saturday
7	**Una Propuesta Didáctica Para Promover El Razonamiento Proporcional, En El Nivel Secundaria, Con Apoyo De La Tecnología Digital** Erasmo Islas-Ortiz, Cinvestav IPN, México	Saturday
8	**The Role of Students' Gestures in Offloading Cognitive Demands on Working Memory in Proving Activities** Vladislav Kokushkin, Virginia Tech	Saturday
9	**Rules of Engagement: The Role of Graduate Teaching Assistants as Agents of Mathematics Socialization** Kristyn Lue, University of Maryland	Friday
10	**Beyond Predetermined Answers: What Kind of Experiences and Engagement Do Open-Ended Mathematics Tasks Elicit for Preservice Elementary Teachers?** Emily Mainzer, Penn State University	Saturday
11	**Rupturing Anti-Blackness in Mathematics Education Research: Quantcrit as Theory, Methodology, & Praxis** Blake O'Neal Turner, University of Maryland	Saturday
12	**The Black Woman's Toolkit: Stories of Persistence in Undergraduate Mathematics Courses** Olanrewaju Oriowo, of North Carolina at Charlotte	Friday
13	**An Intrapreneurial Approach to Spatializing the Curriculum** Robyn K Pinilla, Southern Methodist University	Friday

14	**Explaining the Mathematical Models Undergraduate STEM Majors Develop During Mathematization** Elizabeth Roan, Texas State University	Friday
15	**Fostering a Growth Mindset in Mathematics: Faculty and Student Experiences** Yolanda Gail Rush, Illinois State University	Friday
16	**How Mathematics Self-Efficacy Develops, Changes, And Is Related To Achievement** Bridgette Russell, Central Michigan University	Friday
17	**Assessing Preschool Teacher Self-Efficacy and Attitudes Toward STEM Through a Professional Development Program** Hannah Smith, Worcester Polytechnic Institute	Saturday
18	**Secondary Mathematics Teachers' Decision-Making with Online Social Justice-Oriented Curricular Materials** Anita Sundrani, University of Houston	Friday
19	**Using Everyday Aesthetics to Study Student-Constructed Themes Across the Mathematics Curriculum** Brady A Tyburski, Michigan State University	Saturday
20	**Investigating Synergies and Take Up when Practice-Based Professional Development and Collaborative Lesson Design are used in Tandem** Jennifer Lynn Valerio, University of Pennsylvania	Friday
21	**Using Video Tagging to Understand Facilitator Noticing During Video Clubs** Margaret Walton, University of Maryland College Park	Saturday
22	**Investigating Secondary Pre-Service Teachers' Mathematical Creativity** Anne Nyarotso Waswa, University of Georgia	Friday
23	**Prospective Mathematics Teachers' Technological Pedagogical Content Knowledge in Pieces** Nicholas Witt, Western Michigan University	Friday

Posters

24 **Surveillance and Work in the Mathematics Classroom** Friday
Alexandra Rene Aguilar, University of Texas at Austin; Carlos Nicolas Gomez Marchant, The University of Texas at Austin; Stacy R Jones, The University of Texas at Austin; Gerardo Sanchez Gutierrez, University of Texas at Austin; Amy Rae Johnson, UT Austin; Chandel Burgess, The University of Texas at Austin; Sarah Breidenich, The University of Texas at Austin; Karina Mendez Perez, The University of Texas at Austin

25 **"I'm Only Six.": Exploring Young Children's Mathematics Identity Development** Friday
Mari Altshuler, Northwestern University, School of Education and Social Policy

26 **Coaches' Noticing Before, After, and During Video Clubs** Friday
Julie Amador, University of Idaho; Jeffrey Choppin, University of Rochester; Cynthia H Callard, University of Rochester; Cynthia Carson, Warner School of Education - University of Rochester; Jennifer Kruger, University of Rochester; Ryan Gillespie, University of Idaho; Stephanie Martin, University of Rochester; ADAM HANAN, University of Idaho

27 **How Algebra Teachers' Perception of the Illustrative Mathematics Curriculum Evolved over Three Years** Friday
Mollie Appelgate, Iowa State University; Ji Yeong I, iowa state university of science and technology; Anne Foegen, Iowa State University; Betsy Araujo Grando, Iowa State University

28 **Development of Teacher Leaders in High-need Schools** Friday
Adem Ekmekci, Rice University; Mahtob Aqazade, Rice University; Anne Papakonstantinou, Rice University

29 **Bridging Professional Development and Mathematics Teachers' Contexts** Friday
Erin E. Baldinger, University of Minnesota; Jen Munson, Northwestern University

30 **Conceptualizing High-Uptake Practices** Friday
Zandra de Araujo, University of Florida; Mitchelle Mbete Wambua, University of Missouri-Columbia; F. Paul Wonsavage, University of Florida; Samuel Otten, University of Missouri at Columbia; Amber Grace Candela, University of Missouri - St. Louis

31 **A Characterization of College Algebra Assessment During the Transition to Emergency Remote Teaching** Friday
Ashraf F Demian, Texas State University

32 **Developing Expertise in Teaching that is Responsive to Children's Mathematical Thinking: A Case Study** Friday
Amy Dunning, University of Illinois Springfield; Victoria R. Jacobs, University of North Carolina at Greensboro

33 **Data Science Students' Development of Computational Action: A Design-Based Research Study** Friday
Karle Flanagan, University of Illinois at Urbana-Champaign

34 **Developing Elementary School Principals' Noticing Towards a Shared Vision of High-Quality Mathematics Instruction** Friday
Patricia Cristina Fuentes Acevedo, University of California, Irvine; Christina Kimmerling, University of California, Irvine; Rossella Santagata, UC Irvine

35 **Leveraging a Case to Disrupt the Over-Identification of Black Males in Mathematics Special Education** Friday
Monica Lyn Gonzalez, East Carolina University; Alesia Mickle Moldavan, Fordham University; Annie George-Puskar, Fordham University

36 **Examining Content and Structure of Flipped Algebra I Videos** Friday
Jaepil Han, University of Missouri; Zandra de Araujo, University of Florida; Courtney Vahle, University of Missouri - Columbia; Samuel Otten, University of Missouri at Columbia

37 **Creativity in Proving: Implementing a Group Reflection Activity** Friday
Amanda Lake Heath, Middle Tennessee State University; Sarah K Bleiler-Baxter, Middle Tennessee State University; Jordan Kirby, Middle Tennessee State University

38 **Fostering Mathematical Thinking Using Dynamic Applets: Intercepts' Role in the Linear Regression Model/Promoviendo el Pensamiento Matemático Usando Applets Dinámicos: El Papel del Intercepto en el Modelo de Regresión Lineal** Friday
Diana Elizabeth Hernandez Ceja, Universidad de Guadalajara; Claudia Orozco, Universidad de Guadalajara; Carlos Valenzuela, Universidad de Guadalajara

39 **Teacher Learning Through Cross-Cultural Lesson Study** Friday
Rongjin Huang, Middle Tennessee State University; Joanna Weaver, Bowling Green State University; Christine Painter, Bowling Green State University; Gabriel Matney, Bowling Green State University; Joshua Wilson, Middle Tennessee State University

40 **A Survey on Elementary Teachers' Uses of Manipulatives/Une Enquête Sur Les Pratiques D'utilisation Du Matériel De Manipulation Au Primaire** Friday
Doris Jeannotte, UQAM; Claudia Corriveau, Université Laval; Anne-Sophie Charest, Université Laval; Simon Bilodeau-Carrier, Université Laval; Xavier Serra, Université Laval; Catherine Verret, Université Laval

41 **Linear or Nonlinear? Relating College Algebra Students' Covariational Reasoning and Graph Selection** Friday
Robert Knurek, University of Colorado Denver; Heather Lynn Johnson, University of Colorado Denver

42 **Comparing Expert and Novice Teachers' Noticing with Eye-Tracking in 360 Video** Friday
Karl Wesley Kosko, Kent State University; Chris Lenart, Kent State University; Qiang Guan, Kent State University

43 **Geometric Reasoning of K-5 In-service Teachers** Friday
Teruni Lamberg, University of Nevada, Reno; Lynda R. Wiest, University of Nevada – Reno

44 **Exploring Dissonance and Harmony among Mentees and Mentors' Conceptualizations of Effective Peer Teaching Mentorship** Friday
Melinda Lanius, Auburn University; Leigh Harrell-Williams, University of Memphis; Rakissa Manzanares, University of Colorado Denver; Kelsey Funkhouser, University of Colorado Denver; Josias Gomez, University of Memphis

45 **Recommendations from Latinx, Indigenous, LGBTQ+, and/or Women STEM-major Students Toward One Rehumanizing Dimension** Friday
Kelly (she/her) MacArthur, Montana State University

46 **"Convincing Arguments" in Problem-Solving Contexts: Prospective K-8 Teachers' Interpretations** Friday
Marta T. Magiera, Marquette University

47 **A Comparative Study of Trigonometry Standards Between Ghana, South Africa, the United States, and Zambia** Friday
Rose Mbewe, Purdue University; Amanda Huffman, Purdue University; Emmanuel K Adjei, Purdue University

48 **Co-Designing for Statewide Alignment of a Vision for High Quality Mathematics Instruction** Friday
Katherine J Mawhinney, Appalachian State University; Catherine S. Schwartz, East Carolina University; P. Holt Wilson, UNCG; Michelle Stephan, UNC Charlotte; Allison McCulloch, University of North Carolina at Charlotte; Olu Adefope, East Carolina University; Christine Fisher, UNC Greensboro; Cathy Holl-Cross, UNC Charlotte; Olanrewaju Oriowo, University of North Carolina at Charlotte

49 **Black Teachers' Trajectories: Stories of Early Learning, Navigating Inequities, and Teaching Elementary Mathematics Today** Friday
Kayla Myers, Georgia State University; Susan Swars Auslander, Georgia State University; Sterline Caldwell, Georgia State University; Shani Jackson, Gwinnett County Public Schools

50 **An Analysis of Topics Included in Introductory College Mathematics Courses** Friday
Josh Evan Naddor, North Carolina State University

51 **Facilitating Multilingual Learners' Fraction Division Problem Solving: Impact Study Findings** Friday
Johannah Nikula, Education Development Center; Jill Neumayer DePiper, WestEd; David Bamat, Research for Action

52 **Adapting the Knowledge Quartet for Non-didactic Classrooms** Friday
Chandra Orrill, UMass Dartmouth; Rachael Eriksen Brown, Penn State Abington; Rohini Thapa, UMass Dartmouth; Emmanuel Nti-Asante, University of Massachusetts, Dartmouth

53 **Creating Data Stories: Students' Reasoning Skills When Working with an Online Data Platform** Friday
Franziska Peterson, University of Maine

54 **"I Am Good at Math When…": Pre-Service Teachers' Mathematics Efficacy Beliefs** Friday
Christine M Phelps-Gregory, Central Michigan University; Gabrielle Elizabeth Mynatt, Central Michigan University; Martha Frank, Central Michigan University

55 **A Narrative Inquiry of A Beginning Mathematics Content Instructor** Friday
Kelsey Quaisley, University of Nebraska-Lincoln

56 **Variable Types in Middle School Mathematics Curricula** Friday
Daniel Siebert, Brigham Young University; Ashlyn Rounds, Brigham Young University

57 **Noticing Students' Mathematical Strengths in Written Work and Verbal Explanations** Friday
Lisa Skultety, University of Central Arkansas

58 **Exploring Successful Measurement Estimation Strategies Among Novice and Advanced Learners** Friday
Hannah Smith, Worcester Polytechnic Institute; Luisa Perez, Worcester Polytechnic Institute; Avery Harrison Closser, Worcester Polytechnic Institute

59 **A Case Study Examination of the Relationship Between Pre-Service Teachers' Noticing and Questioning** Friday
Christine M Phelps-Gregory, Central Michigan University; Sandy M Spitzer, Towson University

60 **The Effects on Preservice Teachers' Self-efficacy from Engaging in a Mathematical Modeling Task** Friday
Zachary Stepp, University of Florida; Hyunyi Jung, University of Florida; Megan Wickstrom, Montana State University

61 **Exploring Methodologies Used in the Study of (Mathematics) Teacher Identity** Friday
Molly Sutter, Washington State University; William Hall, Washington State University; Ashley Whitehead, Appalachian State University

62 **Examining Video Selections that Focus Prospective Teachers' Noticing of Student Resources to Support Productive Struggle** Friday
Christine Alyssa Herrera, California State University, Chico; Shawnda Smith, Texas Woman's University; Christina Starkey, Kentucky Wesleyan College; Hiroko Kawaguchi Warshauer, Texas State University

63 **Charting a Viable Learning Trajectory for the Development of Preservice Elementary Teachers' Understanding of Hierarchical Geometric Relationships** Friday
Ian Whitacre, Florida State University; Domonique Caro-Rora, Florida State University

64 **"I Am Petrified. Everyone Seems So Much More Knowledgeable Than Me." - Undergraduate Research Perspectives** Friday
James Willingham, James Madison University

65 **Content Knowledge and Teacher Noticing: The Case of Vertical Asymptotes** Friday
Demet Yalman Ozen, Middle Tennessee State University; Nina Gabrielle Bailey, University of North Carolina Charlotte

66 **The Role of Self-efficacy, Leadership, School-work Environment, Diversity Beliefs, and Social Network in Teacher Retention** Saturday
Adem Ekmekci, Rice University; Mahtob Aqazade, Rice University; Cynthia H Callard, University of Rochester; David Gibson, Southern Illinois University-Carbondale; Greg Rushton, Middle Tennessee State University; Rebecca McGraw, University of Arizona

67 **Analyzing the Levels of Cognitive Demands of the Tasks in Mathematics Textbooks and University Entrance Exams** Saturday
Seyedehkhadijeh Azimi Asmaroud, Illinois State University

68 **Investigating Critical Statistical Literacy Habits of Mind** Saturday
Nina Gabrielle Bailey, University of North Carolina Charlotte

69 **Changing Populations: Using the PSMs with Teachers** Saturday
Jonathan David Bostic, Bowling Green State University; Timothy Donald Folger, Bowling Green State University; Gabriel Matney, Bowling Green State University; Toni Ann Sondergeld, Drexel University; Kristin Koskey, Drexel University; Gregory Ethan Stone, MetriKs Amerique LLC

70 **Impact of Covid Instruction Shifts on Students' Perception of Themselves as Mathematicians** Saturday
Brian Bowen, West Chester University

71 **Proportional Reasoning: Visualizing a Knowledge Resources Framework** Saturday
Aaron Brakoniecki, Boston University; David Glassmeyer, Kennesaw State University; Julie Amador, University of Idaho

72 **Rethinking Classroom Data Collection** Saturday
Amber Grace Candela, University of Missouri - St. Louis; F. Paul Wonsavage, University of Florida; Zandra de Araujo, University of Florida; Samuel Otten, University of Missouri at Columbia

73 **Exploring the Affective Trajectories of Preservice Elementary Teachers During a Fraction Unit** Saturday
Domonique Caro-Rora, Florida State University; Lama Jaber, Florida State University; Jessica Smith, Florida State University; Ian Whitacre, Florida State University

74 **Teachers' Use of "Rough Draft Math" as a Cure for Teaching During the Pandemic** Saturday
Crystal Collier, University of Delaware; Amanda Jansen, University of Delaware

75 **Leveraging Technology in a Social Justice Mathematics Lesson: Modeling Healthy Food Priority Areas with Scratch** Saturday
David Johnson, Towson University; Jean Ciscell, Towson University; Kimberly Chang Corum, Towson University

76 **Exploring Dissonance and Harmony in Elementary Mathematics Teachers' Curricular Use, Autonomy, Decision-making, and Coherence** Saturday
Kristin Doherty, Michigan State University; Emmanuel K Adjei, Purdue University; Jill Newton, Purdue University; Corey Drake, Michigan State University; Marcy B Wood, University of Arizona; Amy Olson, Duquesne University

77 **Mathematicians' Understanding: An Argument For The Value Of Pseudo-Objects** Saturday
Kyle Flanagan, Virginia Tech

78 **What Knowledge is Needed for Teaching Mathematics? Using Topic Modelin**g Saturday
Eunhye Flavin, Stonehill College, Sunghwan Hwang, Seoul Gaju Elementary School

79 **Identity and Positioning During a Technology-Enhanced Mathematics Task: Who Takes the Stage?** Saturday
Samantha Fletcher, Middle Tennessee State University; Kristen Fye, University of North Carolina – Charlotte

80 **Teaching for Social Justice: Supporting Pre-service Mathematics Teachers to Grow from Awareness to Advocacy** Saturday
Monica Grillo, Virginia Commonwealth University

81 **Dimensions Of Care: A Different Approach to Analyze Teachers' Interaction with Curriculum** Saturday
Ana-Maria Haiduc, Purdue University

82 **Examining Algebra Teachers' Unit Planning Processes** Saturday
Jaepil Han, University of Missouri

83 **Leveraging Family Stories to Support the Meaningful Learning of Mathematics and Computational Thinking** Saturday
Lynn Hodge, The University of Tennessee, Knoxville; Elizabeth Yoon, The University of Tennessee; Rebecca Layton, Knox County Schools; Nicholas Kim, University of Tennessee-Knoxville; Shande King, Trevecca Nazarene University

84 **Using Variation Theory to Develop Secondary Teacher Mathematical Knowledge Connected to Diophantine Equations** Saturday
Veronica Hoyos, National Pedagogical University, Mexico; Christina Eubanks-Turner, Loyola Marymount University (LA); David Silva-Bautista, National Pedagogical University, Mexico

85 **Developing a Shared Vision of High-Quality Mathematics Instruction Among School Leaders** Saturday
Christina Kimmerling, University of California, Irvine; Patricia Cristina Fuentes Acevedo, University of California, Irvine; Rossella Santagata, UC Irvine

86 **What Undergraduate Students Make Decisions About When Collaboratively Proving** Saturday
Jordan Kirby, Middle Tennessee State University; Samuel D Reed, Lander University; Sarah K Bleiler-Baxter, Middle Tennessee State University

87 **Pre-Service Teachers' Classification and Modification of Tasks** Saturday
Ji-Eun Lee, Oakland University

88 **Features of High-Quality Mathematics Materials: Variations in Appropriateness for Different Groups of Students** Saturday
Erica N. Mason, University of Illinois, Urbana-Champaign; Camille Griffin, University of Illinois at Urbana-Champaign

89 **The Beliefs and Practices of Graduate Student Tutors Engaged in Online Tutoring During the Pandemic** Saturday
Taylor Mule, The University of Memphis; Scotty Houston, The University of Memphis; Justine Piontek, The University of Memphis; Jessica Webb, The University of Memphis; Leigh Harrell-Williams, University of Memphis

90 **Systemic Barriers to Collaboratively Designing for High Quality Mathematics Instruction** Saturday
Olanrewaju Oriowo, University of North Carolina at Charlotte; Christine Fisher, UNC Greensboro; P. Holt Wilson, UNCG

91 **Spatializing the Early Mathematics Curriculum** Saturday
Robyn K Pinilla, Southern Methodist University

92 **Integrations of Technology and Culturally Sustaining Mathematics Pedagogy for Preservice Teachers** Saturday
Idrissa Presley-Peterson, University of Florida; Hyunyi Jung, University of Florida

93 **Teacher Opportunities to Interpret and Respond to Children's Mathematical Ideas** Saturday
Sam Prough, University of Delaware; Amber Webster, University of Delaware; Lynsey Gibbons, University of Delaware

94 **Supporting A Teacher Residency Program Emphasizing STEM Education in Rural Communities** Saturday
George J. Roy, University of South Carolina; Kristin E. Harbour, University of South Carolina; Thomas E Hodges, University of South Carolina

95 **Investigation of Mathematical Mindset, Identity, and Self-Efficacy of College Students** Saturday
Yolanda Gail Rush, Illinois State University; Amanda L Cullen, Illinois State University

96	**Global and Task-Specific Mathematics Self-Efficacy and Performance: A Qualitative Study in Intermediate College Algebra** Bridgette Russell, Central Michigan University; Christine M Phelps-Gregory, Central Michigan University	Saturday
97	**Spatial Anxiety Moderates the Effect of Spatial Ability in Geometric Reasoning** Kelsey E. Schenck, University of Wisconsin - Madison; Mitchell J. Nathan, University of Wisconsin – Madison	Saturday
98	**Examining the Role of Subscribed Identities in Social Context Data Analysis Tasks** Jennifer Seat, Middle Tennessee State University	Saturday
99	**World of Pattern: Geometry, Body, and Beauty** Mina Sedaghatjou, Alfred University; Colleen Wahl, Alfred University; Chen Lin, University Western Ontario	Saturday
100	**Have We Cut Ourselves Off at the Neck? Centering Relationality and Humanity in Our Research** Charlotte J Sharpe, Syracuse University; Nicole L. Fonger, Syracuse University	Saturday
101	**Exploring Administrators' Visions of Equitable Math Instruction** Lisa M Siciliano, University of Illinois Chicago; Enisa Akgul, University of Illinois at Chicago	Saturday
102	**Using Rehearsals to Support Prospective Teachers in Teaching with Technology** Alyson E. Lischka, Middle Tennessee State University; Barbara Burns, Canisius College; WenYen Huang, SUNY New Paltz; Dexter Lim, Tusculum University; Christopher Parrish, University of South Alabama; Karoline Smucker, Eastern Oregon University	Saturday
103	**Mathematics Teachers' Identity Formation During the First Years of Teaching** Molly Sutter, Washington State University; William Hall, Washington State University; Ashley Whitehead, Appalachian State University	Saturday
104	**When Math Acts as a Gatekeeper: Narrative Identities of Community College Students in Remedial Math** Ranza Veltri Torres, University of Wisconsin-Madison	Saturday
105	**Investigating Secondary Preservice Teachers' Mathematical Creativity During Problem Solving** Anne Nyarotso Waswa, University of Georgia; Kevin Moore, University of Georgia	Saturday
106	**Supports and Constraints for LGBT+ Students Seeking College Degrees in STEM** Kellie J. Pop, University of Nevada, Reno; Lynda R. Wiest, University of Nevada – Reno	Saturday
107	**Scale It Up? I Do Not Know What That Means** Lili Zhou, Purdue university	Saturday

Participant Index

Appendix: Conference Q&A

General Registration

How can I change my registration from in-person to virtual?

In-person attendees may change their attendance type from in-person to virtual and will be given a refund of the difference between the in-person and virtual fee, minus a $50 handling fee. To change your registration, email your request to pmenaloc@gmail.com

I can no longer attend PME-NA, can I get a refund for my conference registration?

In line with the PME-NA Refund Policy, all cancellation requests for any attendance type received by conference organizers thirty days or more prior to the opening day of the conference will be given a full refund, minus a $50 handling fee.

Cancellation requests received by conference organizers **less than thirty days** prior to the opening day of conference will only be eligible for a modification of attendance type. Virtual attendees will not receive a refund within thirty days of the conference.

To request a cancelation/refund please email: pmenaloc@gmail.com

What registration information will be displayed on name badges or in the CVent Website?

As part of registration, your name as you would like it displayed was asked as a specific question along with an option to provide your pronouns. Both the pre-printed name badge and the CVent Website (tinyurl.com/NashPMENA) will display this information provided. When completing on-site registration, you will have the option to revise and print a different name badge, and the CVent Website will allow you to change your display name and/or pronouns.

Conference Venue & In-Person Attendance

Where will conference sessions take place?

The conference is hosted at the Loews Vanderbilt Hotel on the Lobby, Mezzanine, and Lower Level floors. PME-NA is the only group that will be in the hotel's conference space.

How can I see where sessions are or the physical layout of the conference venue?

The map of the conference venue is available; it indicates the location of all rooms that will host sessions, bathrooms, and elevators on the 3 floors of the conference space. A map of the conference space will also be available on the CVent Website.

What restrooms are available for conference attendees?

All gender restrooms, single gender restrooms, and a single use or family restroom are available in the conference space. The locations of bathrooms in the space can be seen in the map of the conference venue, indicating bathroom type. All people are welcome to use the all gender bathrooms.

Is there a lactation space available in the conference venue?

The Quonset Hut room on the Mezzanine level of the conference venue is designated for lactation. A sink is available in the all gender restroom past the elevators and the single use family restroom down the hall. The room will be open during conference hours; 5-8PM Thursday; 7AM-9PM Friday; 7AM-9PM Saturday; 7:30AM-12PM Sunday.

Is there a quiet space or room available in the conference venue?

The Castle room on the Mezzanine level is available during parts of the conference as a quiet space for attendees to use. The quiet room is available:

- Friday 8:00 - 8:40AM; 10:50AM - 6:00PM
- Saturday 8:00 AM - 1:05PM; 3:20PM - 7:00PM
- Sunday 8:30AM - 10:10AM

The unavailable times are during working group sessions since a working group will use the room.

What internet connectivity will the conference venue have?

Attendees will have free access to WIFI throughout the conference venue. Our aim is for this WIFI network to support in-person attendees to connect to the virtual conference platform, such as to gain access to closed captioning or translation. To support the hybrid nature of the conference, technology supporting the hybrid aspects of the conference will use a separate dedicated network. The network name and password for conference attendees in the conference space is **PMENA44.**

When are food and drinks are available during the conference?

The following meals and snacks are provided by the conference:

- Thursday: Evening light reception (7:30-9PM)
- Friday: Breakfast (7-8AM); Lunch (11:30AM-12:15PM); Afternoon light snack (3:20-3:50PM)
- Saturday: Breakfast (7-8AM); Lunch (11:20AM-12:20PM); Afternoon light snack (2:50-3:20PM); Evening light reception (5:30-7PM)
- Sunday: Breakfast (7:30-8:30AM)

Water will be available in all conference venue rooms whenever sessions are taking place and in the main registration area. In addition, coffee and tea are available:

- Friday 7-9AM; 11:30AM-12:15PM (with Lunch); 3-4PM
- Saturday 7-10AM; 11:30AM-12:20PM (with Lunch); 2:30-3:30PM
- Sunday 7:30-8:30AM

Is there a way to eat conference-provided meals outside of the conference venue?

All conference breakfast and lunch meals can be taken as a to-go option instead of eating meals in the ballroom; to-go containers will be provided for any attendee choosing that option.

Virtual and Hybrid Virtual Conference Experience

How will I access virtual aspects of the conference?

PME-NA will use a dedicated CVent Website (tinyurl.com/NashPMENA), which will provide access to each of the virtual zoom-based sessions for the conference and conference information.

To attend a session virtually, conference attendees will need to access the CVent conference website through a web browser; accessing the CVent mobile app will not allow participants to attend sessions.

How can I access closed captioning or translation through the virtual platform?

Attendees can access automatically generated closed captioning through connecting to a session virtually using the CVent Website (tinyurl.com/NashPMENA). To attend or join a session virtually, you will need to access the CVent Website through a web browser. Both virtual and in-person attendees will access these features the same way.

What parts of the conference are accessible virtually?

All conference presentations, including keynotes, research reports, and brief research reports can be attended (or presented) virtually or in person. Similarly, the informal chat with the learning trajectories keynote panel can be attended virtually or in person. All poster presenters have been asked to make their poster available virtually through the CVent Website (tinyurl.com/NashPMENA), as well as an optional video presentation of their poster. Affinity and interest group sessions, organized by attendees, may be hybrid, virtual, or only in-person depending on the request of the organizers.

I am attending PME-NA in person. Is it possible to attend sessions virtually?

Yes. All conference presentations can be attended virtually through the CVent Website (tinyurl.com/NashPMENA), even if you are attending the conference in person. To attend or join a session virtually, you will need to access the CVent Website through a web browser.

When will the CVent Website be available?

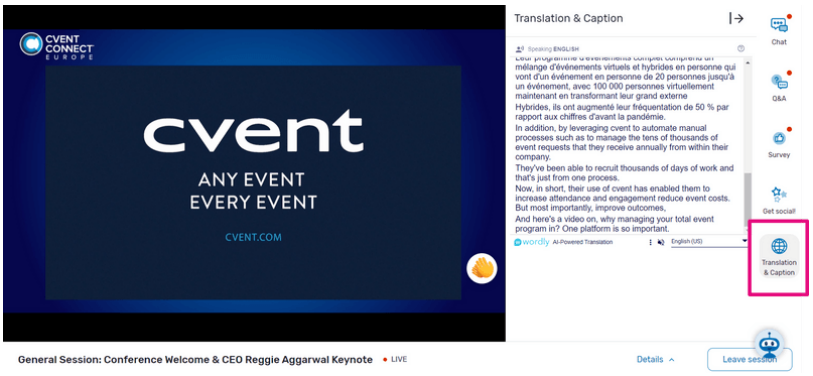
The CVent Website (tinyurl.com/NashPMENA) will be available at least 1 week prior to the start of the conference. Registered attendees will be emailed a welcome link from CVent with login information approximately one week prior to the conference. .

Health, Safety, Accessibility and Special Needs

Is closed captioning and/or translation available for PME-NA sessions?

Automatically generated closed captions (from Zoom) are available for **all** PME-NA sessions. In addition to closed captions, automatically generated translation to Spanish (from Wordly) is available for all keynote sessions. Any session with Spanish translation will be indicated as such in the CVent Website and program.

Both closed captions and translation is accessed by connecting to sessions through the CVent Website. To attend or join a session virtually, you will need to access the CVent Website through a web browser at tinyurl.com/NashPMENA. Detailed instructions for accessing translation and captioning will be provided in advance of the conference.



Is reserved or designated seating available based on accessibility needs?

All conference rooms will have reserved seating close to speakers and/or screens for all sessions. If you have need for accommodations regarding proximity (e.g., limited mobility, hearing impairment, vision impairment, etc.), we encourage you to use these designated seats.

What if I have a disability or special need?

If you have a disability or special need that could affect your participation during the PME-NA 44 in Nashville, please contact pmenaloc@gmail.com to how your needs can be accommodated.

What are the COVID health and safety protocols?

Information can be found at Conference Health Measures.

Does PME-NA have a way to report inappropriate conduct or other conference incidents?

The larger PME-NA organization does not have a standard reporting mechanism for its events or a code of conduct. We fully support the goal of inclusion as "welcoming and making spaces for members of our community that have previously been othered" from the PME-NA equity statement, and believe that all of our attendees have the right to be treated with respect. In support of this goal, the PME-NA 44 conference has an incident reporting form in addition to reporting incidents to a member of the Local Organizing Committee (pmenaloc@gmail.com).

Attendees can use the incident reporting form to report conference experiences that are counter to the goal of inclusion to create a safe and welcoming environment to provide documentation. Reports can be submitted anonymously. Submitted reports will be viewed by a single Local Organizing Committee member and provided to the PME-NA steering committee. Currently, PME-NA does not have a documented procedure for following up on reported incidents at PME-NA conferences.

Immediate concerns about or needed assistance related to safety and/or security should be directed to hotel staff.