Conference Program

Forty-Third Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education

PME-NA 43



Philadelphia

Productive Struggle

Persevering Through Challenges

Conference Chairs: Sandy Spitzer, Kim Johnson, & Dana Olanoff

Welcome to Philadelphia

Thank you for attending the 2021 PME-NA 43 Conference

Table of Contents

Welcome Message	3
Schedule At-A-Glance and Floor Plans	4
Conference Information	5
Conference Mobile App	6
Plenary Speakers	7
Discussion Sessions	9
Local Organizing Committee	10
Conference Program	11
Appendix 1: Working Group Abstracts	63
Appendix 2: Poster Titles, Location, and Abstracts	67
Session Facilitators	
Participant Index	

Thank you for attending the 2021 PME-NA 43 Conference

Welcome Message

Welcome to #PMENA43, the Forty-Third Annual Conference of the North American Chapter of the International Group for the Psychology of Mathematics Education. We are thrilled to host you, either in-person in the beautiful and historic city of Philadelphia, Pennsylvania, USA, or virtually through our conference hub. No matter whether you are joining in-person or virtually, we hope you have an enjoyable and thought-provoking time. The theme of the conference, *Productive Struggle: Persevering through Challenges*, has also summarized the project of planning a conference during an ongoing and ever-shifting pandemic. We aim to provoke new ways of thinking about our work as researchers and teacher educators in this time of change and challenge. We sincerely appreciate each one of you for attending and sharing your ideas for growth and perseverance.

We would like to thank the many people who put a tremendous amount of work into making this a successful conference, including the reviewers, the Strand Leaders, an incredible team of volunteers, and graduate assistants Rachael Talbert, Kayla Begen, and Sarah Gill. We appreciate the assistance of the PME-NA Steering Committee, and are particularly grateful to Aaron Brakoniecki for building and maintaining the conference website, José Martínez Hinestroza for supporting Spanish-language authors, as well as Steering Committee Chair Julie Amador and past LOC Member Samuel Otten for their assistance and advice. Carly Sullivan was invaluable in planning the in-person events, and the Cvent support team went above and beyond to support us. We would specifically like to highlight the herculean efforts of Kimberly Corum (Towson University) in developing the online conference hub. Of course, most of all, this conference would not be a success without the work of the many authors, presenters, attendees, and working group participants. Thank you all and welcome to #PME-NA43!

Yours in service, scholarship, and struggle, Sandy Spitzer, Dana Olanoff, and Kim Johnson #PMENA43 Local Organizing Committee <u>2021pmena@gmail.com</u> @PMENA43



Schedule At-A-Glance and Floor Plans

The schedule grid is color-coded to the venue floor plan:



4

Conference Information

Conference Hotel

Sheraton Philadelphia Downtown Hotel 201 N 17th St Philadelphia, PA 19103 (215) 448-2000

Contact Information

If you have any issues or questions, please visit us at the registration desk located in the Ballroom Lobby (just outside Liberty Ballroom BCD) on the ballroom level. You can also send an email to <u>2021pmena@gmail.com</u>.

Meeting Rooms Wifi Information

To use the wireless internet in the conference meeting rooms:

- 1. Connect to the network named "Sheraton Meeting"
- 2. When prompted for the access code/password, enter Meeting2021

Online Conference Hub and Website

Visit the conference hub to view the conference program, join sessions remotely, and participate in the virtual poster session at <u>https://cvent.me/9Kn5NL</u>. The conference hub 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. Full details for using the conference hub can be found at https://bit.ly/PMENAhubinfo

Or visit the conference website for general information at <u>http://www.pmena.org/pmena-</u>2021/.

Please Follow us on Twitter!

- Twitter: @PMENA43
- Hashtag: #PMENA43

Conference Mobile App

Both virtual and in-person attendees can use the conference hub (<u>https://cvent.me/9Kn5NL</u>) to plan their schedule, view posters, read proceedings papers, 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 app, only from the 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 43** 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.

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.*
- 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!



Plenary Speakers



Thursday, October 14 Toya J. Frank *George Mason University*



Friday, October 15 Caro Williams-Pierce *University of Maryland*



Friday, October 15 Crystal Kalinec-Craig University of Texas - San Antonio



Friday, October 15 Sam Prough *University of Delaware*



Friday, October 15 Rachel Tremaine Colorado State University



Friday, October 15 Samuel Otten University of Missouri

Plenary Speakers



Friday, October 15 Carlos Nicolas Gomez Marchant *University of Texas*



Saturday, October 16 Cathery Yeh *Chapman University*



Saturday, October 16 Maria Zavala San Francisco State University



Friday, October 15 Stacy R. Jones University of Texas



Saturday, October 16 Robert Berry University of Virginia



Saturday, October 16 Christopher Jett University of West Georgia

Discussion Sessions

In order to provide some of the feeling of those informal conversations that make a conference special, we have planned 11 Discussion Sessions, specifically aimed at engaging our virtual attendees (although they are open to all attendees). Please feel free to join for an informal chat about an issue related to mathematics education. These discussions sessions will all take place virtually and can be accessed using the conference hub at https://cvent.me/9Kn5NL.

Thursday, October 14

- 4:45-5:25pm: Fostering Mathematical Creativity in the Classroom for Everyone Hosted by Ayman Aljarrah, Acadia University
- 5:30-6:10pm: Political *Conocimiento* for Math Teacher Educators—Change Making and Creative Insubordination Across Professional Contexts *Hosted by Alexa W.C. Lee-Hassan, University of Illinois Chicago*
- 6:15-6:55pm: Navigating the Mathematics Education Job Market Hosted by Bima Sapkota, Purdue University

Friday, October 15

- 1:00-1:40pm: Pandemics, scholarship, and rethinking what counts Post-Provocation Session hosted by Crystal Kalinec-Craig, University of Texas-San Antonio
- 5:15-5:55pm: Let us be the healing of the wound/Seamos la curación de la herida Post-Provocation Session hosted by Carlos Nicolas Gomez Marchant & Stacy R. Jones, University of Texas
- 7:15-8:05pm: Parents are not a scapegoat for math learning loss Post-Provocation Session hosted by Sam Prough, University of Delaware

Saturday, October 16

- 8:20-9:00am: Failure is not an F-word: If you're not failing, you're not learning Post-Provocation Session hosted by Caro Williams-Pierce, University of Maryland
- 12:40-1:20pm: Defining Mathematics Literacy Hosted by Amanda Reinsburrow, Drexel University
- 5:15-5:55pm: Diversifying the "Top Tier" of Mathematics Education Journals Post Provocation Session hosted by Samuel Otten, University of Missouri
- 6:00-6:40pm: Exploring the Use of Makerspace Technology in Mathematics Classrooms Hosted by Kimberly Corum & Rachael Talbert, Towson University

Sunday, October 17

10:00-10:40am: Explicit & Expansive: The Importance of (Re)Defining Student Success in Mathematics *Post Provocation Session hosted by Rachel Tremaine, Colorado State University*

Local Organizing Committee

Sandy Spitzer, Towson University (Chair) Dana Olanoff, Widener University (Co-Chair) Kim Johnson, West Chester University (Co-Chair)

Kimberly Corum, Towson University (Technology Coordinator)

Carly Sullivan (Event Coordinator)

Graduate Assistants: Rachael Talbert, Towson University Kayla Begen, Towson University Sarah Gill, West Chester University

Conference Program

THURSDAY, OCTOBER, 14

001. Registration

4:00 to 7:00 pm Sheraton: Floor Ballroom Level - Ballroom Lobby

002. Virtual Poster Session

Poster Session 4:00 to 7:00 pm Sheraton: Virtual Poster Session Visit https://cvent.me/9Kn5NL to participate in the asynchronous virtual poster session. Virtual poster pdfs and videos will be available for viewing throughout the whole conference. Use the Q&A button to ask questions of poster authors.

Thursday, 7:00-8:00pm – Plenary Session

003. Thursday Plenary - From Practice to Theory: Listening to and Learning with Black Mathematics Teachers

Toya Frank, George Mason University Plenary Session 7:00 to 8:00 pm Sheraton: Floor Ballroom Level - Liberty Ballroom BCD

Research on race and racism with respect to Black teachers' experiences is undertheorized in mathematics education. Due to social, historical, political, and cultural forces, Black mathematics teachers at particular social intersections (e.g., racial, socioeconomic, linguistic) experience teaching mathematics in ways that are unique from those in dominant communities. Without a critical and racialized analysis of issues that could potentially influence the attrition of Black mathematics teachers and how they experience mathematics teaching, conversations about the Black mathematics teacher pipeline, and teacher diversity broadly, run the risk of commodifying teachers and reducing their presence to ahistorical notions of diversity solely for the purposes of race matching. In this presentation, I will use data from an NSFfunded mixed-methods research project, Examining the Trajectories of Black Mathematics Teachers, to share what our research team has learned from centering Black mathematics teachers' racialized experiences to theorize about race and racism in mathematics teacher education. Additionally, I will share how this work informs research methodology in mathematics education by integrating untapped, yet appropriate, methodologies suitable for challenging issues of recruitment, retention, and praxis of other underrepresented racial and ethnic groups across time periods and school contexts.

004. Welcome Reception

8:00 to 9:15 pm

Sheraton: Floor Ballroom Level - Liberty Ballroom A Please join us at a reception with hot and cold hors d'oeuvres to celebrate the opening of the conference.

FRIDAY, OCTOBER, 15

005. Morning Coffee/Tea & Snacks

8:40 to 9:00 am

Sheraton: Floor Ballroom Level - Ballroom Lobby

006. Virtual Poster Session

Visit <u>https://cvent.me/9Kn5NL</u> to participate in the asynchronous virtual poster session. Virtual poster pdfs and videos will be available for viewing throughout the whole conference, and you can ask questions through the conference hub.

Friday, 9:00-9:40am – Research Sessions

007. Curriculum, Assessment, and Related Topics Brief Reports A

Curriculum, Assessment, and Related Topics Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom E Participants:

r urticipulits

- Investigation Opportunities of Common Core Theorems Prior to Proof in High School Geometry Textbooks *Brian Boyd, Wright State University; Wayne Nirode, Miami University* Even though prior research has found that textbooks
 - provide limited opportunities for students to engage in proof in high school geometry, there is little research on the opportunities that textbooks provide for students to investigate and make conjectures prior to proof. This study addresses that gap in analyzing investigation opportunities for 17 theorems in the CCSSM across five textbooks. Overall, the five textbooks provide opportunities for investigation about half of the time, although there is a great deal of variation among the number of opportunities offered for each textbook. Theorems about parallel lines and triangles are more likely to have investigations than theorems about parallelograms and converses of theorems.
- The Introduction and Development of Triangle Congruency in Chinese and US Textbooks Jane Jane Lo, Western Michigan University; lili zhou, Purdue university; Jinqing Liu, Indiana University In this paper, we report findings from a comparative analysis of the introduction and development of triangle congruency from two textbooks: a grade 8 mathematics textbook from China and a high school geometry textbook from the U.S. While both textbooks considered triangle congruency as a fertile setting for the development of ability in reasoning and proving, there are both similarities and differences in their approaches to achieve this goal. Building from the transformation conception of congruency, the U.S. textbook provides students with more opportunities to practice writing proofs. Drawing from multiple conceptions of corresponding conceptions of congruency, the Chinese textbook provides students with more varied opportunities to write proofs and make connections to a real-life context.

008. Mathematical Processes Research Report E

Mathematical Processes Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom F

Participant:

Understanding Joint Exploration: The Epistemic Positioning in Collaborative Activity in a Secondary Mathematics Classroom *Elizabeth B* Dyer, Middle Tennessee State University; Erika David Parr, Rhodes College; Nessrine Machaka, University of Illinois at Urbana Champaign; Christina Krist, University of Illinois at Urbana Champaign

This study examines how joint exploration is established and maintained among students and the teacher in secondary mathematics classrooms. We use the theoretical perspective of positioning to conceptualize joint exploration as involving the negotiation and coordination of among participants to position students with epistemic agency and authority. Using a constant comparative method, we use classroom video data of two episodes containing joint exploration and closely analyze the shifts in epistemic positioning within them. We find that shifts in epistemic positioning, especially with respect to students positioning one another with and taking up epistemic authority, help to support continued joint exploration. We also find that the teacher can play an important role in decentering themselves as the epistemic authority

009. PD/In-Service Teacher Education Research Report C

Professional Development/In-Service Teacher Education Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom G

Participant:

Identifying and Recontextualizating Problems of Practice in Learning to Facilitate Discussions With Argumentation Eric Cordero-Siy, University of Wisconsin-Madison; Sam Prough, University of Wisconsin-Madison; Burcu Alapala, UW Madison; Hala Ghousseini, University of Wisconsin-Madison

In this paper, we describe how a community of teachers and one teacher within this community made sense of facilitating argumentation. We use the construct of problems of practice as an indicator of teachers' sensemaking and learning. We contend that problems of practice are highly situated within teachers' contexts. The teachers identified participation as a broad problem of practice for facilitating argumentation and we identify three aspects of participation salient for teachers. Moreover, we show how Amanda, one of the teachers recontextualizes these problems to her thinking and practice.

010. Pre-Service Teacher Education Brief Reports B

Pre-Service Teacher Education Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom H Participants:

How Math Anxiety Affected My Teaching Philosophy: Perspectives from Pre-service Secondary Mathematics Teachers Joshua P Mannix, North Carolina State University; Brianna Bentley, North Carolina State University Teachers with math anxiety can pass their anxiety on to students and even affect student achievement. In this project, we attempt to analyze pre-service secondary mathematics teachers' (PSMTs) feelings about how their math anxiety affects the way they view teaching as a profession. Preliminary findings indicate that math anxiety could affect multiple areas of a teacher's career, including preparing for class, engaging with students, and their overall philosophy about teaching. This case study can serve as a launching point for further research into how math anxiety affects both pre-service and in-service secondary mathematics teachers.

Middle School Math Pre-Service Teachers and Ability-Based Course Assignment: Experiences, Beliefs, and Dispositions *Kateri A Sternberg*, *University of Delaware*

This session focuses on the beliefs middle school math PSTs hold about tracking practices in the middle grades and potential influential experiences, both as students and as PSTs, that have lead to the development of these beliefs. It will include implications for teacher preparation focused on developing equity-oriented beliefs.

011. Mathematical Knowledge for Teaching Research Report A

Mathematical Knowledge for Teaching Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Independence A Participant:

Characterizing Prospective Secondary Teachers' Foundation and Contingency Knowledge for Definitions of Transformations Yvonne Lai, University of Nebraska-Lincoln; Alyson E. Lischka, Middle Tennessee State University; Jeremy F Strayer, Middle Tennessee State University

One promising approach for connecting undergraduate content coursework to secondary teaching is using teacher-created representations of practice. Using these representations effectively requires seeing teachers' use of mathematical knowledge in and for teaching (MKT). We argue that Rowland's (2013) Knowledge Quartet for MKT, in particular, the dimensions of Foundation and Contingency, is a fruitful conceptual framework for this purpose. We showcase an analytic framework derived from Rowland's work and our analysis of 85 representations of practice. These representations all featured geometry. We illustrate examples of combinations of "high" and "low" Foundation and Contingency, and show results of coding juxtaposed with performance on an instrument previously validated to measure MKT. We describe the potential for generalizing this framework to other domains, such as algebra and mathematical modeling.

012. Mathematical Content Early/Middle Years Research Report A

Mathematical Content Early/Middle Years (Grades

preK-8)

Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Independence B

Participant:

Elementary Patterning Problems: Visual and Numerical Structuring *Leah Michelle Frazee*, *Central Connecticut State University; Adam Scharfenberger, The Ohio State University* Research on elementary students' reasoning on patterning problems with pictorial representations has illustrated that students can visualize structure in the patterns in different ways. In this paper, we offer a characterization of students' spatial structures and numerical structures and explain how the link between these two structures can support students' generalization of a pattern or prediction of a future value.

013. Equity and Justice Brief Reports B

Equity and Justice

Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Independence C Participants:

Participants:

Black Students' Mathematics Identities in Rural Appalachia Sean P. Freeland, West Virginia University

The ways in which Black students identify with and experience mathematics is contextual, so it is necessary to explore the peculiarities and complexities of the experiences of Black learners of mathematics in various spaces and geographies while also attending to the intricacies of individual and schoolwide interactions. One context that needs this attention is rural Appalachia. The region is defined by a normative Whiteness and by economic issues, resulting in issues of race being made invisible. This study explores the mathematics identities and experiences of Black students in rural Appalachia. One in-progress counterstory of a Black student in the region is presented here. This highlights the necessity to explore mathematics identity and socialization in the context of rural Appalachia.

(Un)Productive Struggle in Mathematical Spaces: Women's Perceptions of Competence and Belonging Seyda Uysal, Florida State University; Kathleen Michelle Clark, Florida State University This research is part of a pilot study in which we focused on students majoring in mathematics, all of whom were from racially/ethnically minoritized populations. We draw upon a three-dimensional model of attitude (Di Martino & Zan, 2010) to examine participants' perceived competence in mathematics and its relation to emotions during secondary school-tertiary transition in mathematics. Twelve students participated in our pilot study, which took place between Spring 2019 and Spring 2020. Here, we focus on the second seminar, which comprised one component of the WURMM study in Spring 2020. Our analysis highlights a female emerging mathematician's productive struggle in mathematical spaces reflected in her identity negotiations related to her perceived competence and sense of belonging within mathematical communities. We also address gender stereotypes that play a role in women's identity construction in

becoming a mathematician. Finally, we explore how these factors relate to women's active participation in mathematical spaces.

014. Virtual BRR Mixed Session I

Two or More Strands

Brief Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Independence D

Participants:

Embodied transmission of ideas: Mathematical thinking through collaborative construction of geometry video game content Michael I. Swart, University of Wisconsin - Madison; Veena Kirankumar, The University of Wisconsin -Madison; Hanall Sung, University of Wisconsin -Madison; Fangli Xia, University of Wisconsin -Madison; Doy Kim, University of Wisconsin -Madison; Oh Hoon Kwon, University of Wisconsin - Madison; Kelsey E. Schenck, University of Wisconsin - Madison; Candace Walkington, Southern Methodist University; Mitchell J. Nathan, University of Wisconsin -Madison

In one classroom of a Title 1 high school, students (n=12) were separated into groups and participated in a three-part study in which they: (1) played a 3D motion-capture video game, The Hidden Village (THV), to assess the veracity of geometric conjectures (i.e., always true or false), (2) collaborated to design a series of movements called "directed actions" to depict the structure and transformation of a geometric object using the upper body and, (3) re-played a new version of THV with an updated curriculum that included all the conjecture designed by the student peer groups. Video recordings of group's work provided evidence of students' intuitions, insights, and explanations (including their gestures) of how they conceptualized the geometric transformations. Researchers present multiple cases studies demonstrating how students embodied their ideas about geometry and how those ideas "traveled" (via directed actions) within and between student groups. These cases revealed ways that simulated enactment and collaborative construction can help communicate mathematical ideas in a classroom setting.

Undergraduate students' interactions with dynamic diagrams while solving proof tasks *Deniz Ozen Unal, Aydin Adnan Menderes University; Karen Hollebrands, NC State*

The purpose of this study was to investigate undergraduate students' interactions with diagrams while they were solving dynamic geometry-based proof tasks. Some of the tasks included a diagram while others did not. The participants in this case study included two senior college students, enrolled in an undergraduate geometry course at a public university. Differences in the way students interacted with the diagrams in each of these settings are described.

015. Student Learning and Related Factors Brief Reports D

Student Learning and Related Factors Brief Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Philadelphia North Participants:

Developmental Mathematics Students' Perceptions of (Re)Learning Outcomes: The Value of Algebra All Over Again Kristen Amman, Rutgers University; Juan Pablo Mejía Ramos, Rutgers University

We report findings from an exploratory study on developmental mathematics students' perceived experience re-learning content they had already studied in middle- or high-school. Our findings suggest that these experiences are largely shaped by students' expected and perceived learning outcomes associated with that content. We describe how six of those learning outcomes depend on students' confidence in their previous understanding of the content to be re-learned, and how those learning outcomes influence students' modes of engagement during (and emotional reactions to) their re-learning experience.

"That's Crazy!" An Exploration of Student Exclamations in High School Mathematics Lessons Sarina Simon, Boston University; Rashmi Singh, Boston University; Leslie Dietiker, Boston University

This research brief is an exploration of student exclamations in high school mathematics lessons. It focuses on what students say at different moments during a lesson and the reasoning behind these exclamations.

016. Mixed BRR Session A

Mathematical Knowledge for Teaching Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Philadelphia South

Participants:

Items with Potential for Covariational Reasoning across Math and Science TIMSS Assessments *Teo Paoletti, University of Delaware; Allison L. Gantt, University of Delaware; Julien Corven, University of Delaware*

Constructing quantities and coordinating covarying quantities is a central component of STEM learning and development. We examined 323 released fourthand eighth-grade math and science TIMSS items to explore the extent to which such items could potentially elicit such reasoning. We found items potentially eliciting covariational reasoning across all four assessments, as well as an increase in number and complexity of such questions from fourth to eighth grade regardless of content domain. Further, we highlight the diverse content domains that leveraged graphical representations in such items. We discuss implications of our findings for the teaching and learning of middle-school STEM and for future study of covariational reasoning through international assessments.

Mathematical Knowledge For Teaching Formative Assessment: Recommendations For Mathematics Teacher Educators From A Meta-Aggregation Rachael Kenney, Purdue University; Yukiko Maeda, Purdue University; Michael Lolkus, Purdue University

Qualitative research is used to explore the complexity

of teaching and learning in mathematics education, but there are barriers to using qualitative findings to inform practice/policy. We see a critical need to integrate findings across qualitative empirical studies to develop synthesized, actionable recommendations for mathematics teacher educators - in this paper we focus our efforts on the topic of formative assessment. Using a meta-aggregation of 11 qualitative studies, we investigated how teacher educators' mathematical knowledge for teaching can inform their support of formative assessment practices in US secondary mathematics classrooms. This study provides a clear example of an underused, but effective, methodology for bridging research findings to practice. Synthesized findings led to nine lines of action that we provide as recommendations for professional development designers and mathematics teacher educators.

017. Virtual BRR Mixed Session H

Two or More Strands

Brief Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Salon 10

Participants:

- Illuminating Purposes of Group Work Through Teachers' Language in Everyday Mathematics Lessons Brittney Ellis, Portland State University; Autumn Pham, Portland State University; Kathryn Bianco, Portland State University; Eva Thanheiser, Portland State University Teachers have responded to NCTM's (2014) charge to enact student-centered pedagogy by having their students work together on mathematical problems in small groups. While extensive knowledge exists about productive conditions for cooperative learning in small groups, less is known about the role and purposes of small group cooperative learning in everyday classroom interactions. To investigate this, we analyzed 33 video recorded 4th-5th grade mathematics lessons across one school district. Using a qualitative approach, we examined the purposes of group work evident in teachers' language. We present preliminary findings from this work to illustrate that while initiating group work, teachers' language conveyed various cognitive, social, and equity-related purposes for small group work. To conclude our presentation, we discuss directions for future work and implications for practice.
- Preservice Teachers' Learning About Elementary Students' Mathematical Reasoning Marta T. Magiera, Marquette University; Hyejin Park, James Madison University

We report on a study with 23 PSTs preparing to teach grades 1-8 mathematics who were engaged in analyzing a series of student-generated arguments for evidence of student reasoning actions. We examined PSTs' assessment of student MR prior to and after instruction designed to support PSTs' understanding of how expert-like reasoning in elementary mathematics classrooms might look like. Our results show that prior to the intervention, PSTs interpreted and assessed students' MR looking for evidence of discrete reasoning actions (ex. adapting, exemplifying, representing). After the intervention, rather than assessing student reasoning in terms of the presence or absence of specific reasoning actions, PSTs analyzed the identified reasoning actions on the continuum from less to more expert-like. We discuss the intervention and the specific nature of PSTs' assessment practices before and after class activities.

018. Virtual RR Technology A

Technology Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 2 Porticipant:

Participant:

The Geometry of Sunlight: Continuous multiplication with naturally occurring parallel lines Justin Dimmel, University of Maine; Eric Pandiscio, University of Maine; Camden Glenn Bock, The University of Maine; Emma Reedman, University of Maine

We report the design of an analog technology, what we refer to as a SunRule, that uses sunlight to model multiplication. Physical models that explore multiplication are fixtures in elementary mathematics classrooms. Our interest in physical models of multiplication was driven by an overarching design problem: How could a physical tool realize a continuous model of multiplication? That is, how could we represent continuous, variable quantities with physical things? We identify specific challenges the SunRule was designed to solve. We explain the mathematical underpinnings of the device and report a teaching experiment during which pre-service teachers explored the device in small, sociallydistanced groups. We consider how explorations with the SunRule create opportunities for mathematically rich instructional activities that are also essentially connected to being outside.

019. Virtual BRR Mixed Session E

Two or More Strands Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 3 Participants:

ranticipants.

First Teachers Talk, Talk, now they Listen, Listen: Ghanaian Teachers' Professional Readiness for Mathematics Reform Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Pavneet Kaur Bharaj, Indiana University Bloomington; Anna Cross Hinden, University of North Carolina

This study examined one Ghanaian teacher's (Eugenia) professional readiness to make significant curricula and pedagogical changes within the context of a nationwide educational reform initiative. Using Scaccia et al.'s (2015) organizational readiness framework to define and ascertain Eugenia's professional readiness (i.e., her investment in, and motivation to, implement the reform), we examined the alignment among Eugenia's professional readiness, what the reforms were asking of her, the supports provided to her to fulfil these demands, and what she was actually doing in her classroom. We found that Eugenia's beliefs, emotions, and efficacy primed her for implementing the reform. We discuss the importance of teachers' knowledge, beliefs, emotions and efficacy as indicators of professional readiness and the ways that leveraging readiness bodes well for successful reform implementation.

Mathematics Teacher Decision-Making and Their

Selection of Online Curricular Materials Anita Sundrani, University of Houston

In this conceptual paper, I reflect on the growing influence of online lesson plan sharing websites on mathematics teachers' curricular decisions. Using the theoretical frameworks of teacher decision-making and curriculum deliberation, I explore a variety of individual and group heuristics that may impact mathematics teachers' choices for lesson planning. Using this theoretical perspective, I offer a conceptual framework to discuss the various considerations mathematics teachers engage with when choosing online curricular materials. I conclude with the implications of this framework and potential contributions to the field.

020. Virtual BRR Theory and Research Methods B

Theory and Research Methods Brief Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Salon 4

Participants:

- Attending to Aims in Algebra: The Juggle Struggle Brandon K Singleton, University of Georgia; Yufeng Ying, University of Georgia There are many aims for teaching algebra. In this report, we explore the nature of aims for algebra instruction. First, we examine the major aims that have informed algebra education and curriculum reform from the 1960s into the current era. The relationships between aims are marked by compatibility as well as tension. We argue for viewing aims as enacted priorities that are revealed through the everyday choices algebra educators make. The struggle to cultivate multiple aims is a productive reality of algebra classrooms that can be informed through the development of better explanatory tools for observing tradeoffs between priorities.
- Integrating Three Planes of Teacher Learing: The Case of Side-by-side Coaching Jen Munson, Northwestern University; Mari Altshuler, Northwestern University, School of Education and Social Policy; Erin E. Baldinger, University of Minnesota; Han Sol Lee, Northwestern University; Vaynu C. Kadiyali, Northwestern University

Attempts to understand and design for mathematics teacher learning have frequently identified key disconnects between teachers' contexts, the professional development experience, and, ultimately, teachers' practice. In this paper, we offer a theoretical approach to understand these discontinuities drawing on Rogoff's (1995) three planes of analysis of sociocultural activity. We then apply these three planes to illustrate one example of a teacher learning environment designed for coherence: side-by-side coaching.

021. Virtual BRR Pre-service Teacher Education B

Pre-Service Teacher Education Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 5 Participants: Preservice Teachers' Language use for Fraction

Problems in Context Susie Morrissey, Mercer

University; Gorjana Popovic, Illinois Institute of Technology; Ozgul Kartal, University of Wisconsin-Whitewater

Authors asked preservice elementary teachers to write word problems for fraction equations, then use manipulatives and draw diagrams to model the solutions to the word problems. The contexts used by preservice teachers, as well as how the contexts facilitated or impeded their understanding of concepts, were investigated. Through analysis of problems and a follow-up group interview, authors discovered that a focus on contexts using partitive division, as well as the lack of precise mathematical language, impeded further understanding of fraction concepts.

Prospective Mathematics Teachers' Geometric Definitions and Conceptions about Properties of Two-Dimensional Shapes Suzanne R. Harper, Miami University; Shannon O. S. Driskell, University of Dayton

This qualitative study sought to investigate the understanding of middle grades prospective mathematics teachers' (PMTs) geometric definitions and conceptions about properties of two-dimensional shapes. Hierarchical classification systems for twodimensional shapes created by 18 small groups of PMTs (n=52) were analyzed. Preliminary findings document inconsistencies for the definitions of kite and trapezoid. We will share implications concerning the role participants' concept images and their experiences using dynamic geometry software.

022. Virtual RR Mathematical Content Early/Middle Years B

Mathematical Content Early/Middle Years (Grades preK-8) Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Salon 6

Participant:

Learning to Make Sense of Data in a CODAPenabled Learning Environment: Interactions Matter Gemma F. Mojica, NC State University; Heather Barker, Elon University; Christina Azmy, Catawba College; Hollylynne S. Lee, NC State University

In this study, we investigated how sixth and seventh grade students used CODAP to make sense of roller coaster data while engaged in Exploratory Data Analysis (EDA). Using instrumentation theory, we examined students' instrumentation approaches, as well as the types of instrumental orchestration utilized by teachers as they interacted with student pairs during EDA.

023. Morning Break and Snacks

Special Event 9:40 to 10:05 am Sheraton: Floor Ballroom Level - Ballroom Lobby

Friday 10:05-11:35am

Working Groups (See Appendix 1 for Abstracts)

024. Group Discussions Discussion Group Working Group

10:05 to 11:35 am

Sheraton: Floor Mezzanine - Freedom E

025. Coaching the Coaches and Other Efforts to Develop Mathematics Teacher Educators for Inservice Teachers Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom F

026. Complex Connections: Reimagining Units Construction and Coordination Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom G

027. Gender and Sexuality in Mathematics Education: Emerging Conceptual and Methodological Frameworks Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom H

028. Authenticity in Mathematics Education Assessment Working Group 10:05 to 11:35 am Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

029. Conceptions and Consequences of What We Call Argumentation, Justification, and Proof Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence B

030. Using Self-Based Methodologies to Unpack Mathematics Teacher Educators' Work Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence C

031. Creating space for productive struggle toward a more equitable future: Persevering through challenges from within Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence D

032. Mathematics Curriculum Recommendations for Elementary Teacher Preparation Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Philadelphia North

033. Mathematical Play: Across Ages, Context, and Content Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Philadelphia South

034. Continuous Improvement Lesson Study Working Group/Grupo de Trabajo en La Mejoramiento Continua del Estudio de Lecciones Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 10

035. Preservice Teacher Learning of Practice Through Simulated Teaching Experiences Before, During & After COVID

Working Group 10:05 to 11:35 am Online Working Group – Join through conference hub at <u>https://cvent.me/9Kn5NL</u>

036. Statistics Education: New Connections and Future Directions / EDUCACIÓN ESTADÍSTICA: NUEVAS CONEXIONES Y FUTURAS DIRECCIONES Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 3

037. Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium Research Colloquium 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 5

038. Models and Modeling Perspectives Research Colloquium

Research Colloquium 10:05 to 11:35 am Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

Friday, 11:45am-1:00pm – Plenary Session

040. Friday Plenary - Productive Provocations

Plenary Session 11:45 to 1:00 pm Sheraton: Floor Ballroom Level - Liberty Ballroom BCD

Sam Prough, University of Delaware: Parents are Not a Scapegoat for Math Learning Loss

Caro Williams-Pierce, *University of Maryland*: Failure is Not an F-word: If You're Not Failing, You're Not Learning

Rachel Tremaine, Colorado State University: Explicit & Expansive: The Importance of (Re)Defining Student Success in Mathematics

Crystal Kalinec-Craig, University of Texas - San Antonio: Pandemics, Scholarship, and Rethinking What Counts

Samuel Otten, University of Missouri: Diversifying the "Top Tier" of Mathematics Education Journals Carlos Nicolas Gomez Marchant & Stacy R. Jones, University of Texas: Let Us Be the Healing of the Wound/Seamos la Curación de la Herida

041. Friday Lunch (included) and Business Meeting

1:00 to 2:00 pm Sheraton: Floor Ballroom Level - Liberty Ballroom BCD

Friday, 2:15-2:55pm – Research Sessions

042. Policy, Leadership, and Misc Research Report C Policy, Leadership, and Miscellaneous Topics Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Freedom E

Participant:

Positioning of Novice Elementary Teacher Leaders in Advice and Information Networks for Mathematics *Phi Nguyen, University of Missouri; Corey Webel, University of Missouri; Brendan Dames, University of Missouri*

In this paper we examine how teachers who are pursuing their Elementary Mathematics Specialist certification-Elementary Mathematics Specialists in Training (EMSTs)-are positioned in their advice and information networks for mathematics. We analyzed the instructional networks of six elementary schools in one Midwestern school district. Our analysis suggests that EMSTs did occupy central positions in their networks. EMSTs were sought out by more individuals compared to other teachers, and when sought out by others, provided advice and information at a greater frequency than formal leaders. We also considered the school's informal and formal structure, finding that EMSTs' positioning was related to the broader school's information seeking behavior and whether there is a math-specific formal leader.

043. Mixed BRR Session C

Two or More Strands Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Freedom F

Participants:

Climate Justice Algebra: What are the Tensions between the Mathematics and Culturally Relevant Pedagogy?/Justice Climatique Algèbre: Quelles sont les Tensions entre les Mathématiques et la Pédagogie Culturellement Pertinent? Chelsea A Muhs, Portland State University

In this article I examine a new course offering at an urban high school, Climate Justice Algebra, to determine if the course is Culturally Relevant Pedagogy (CRP). I examine the tensions between academic success (grade level mathematics learning) and climate justice learning found during two tasks administered to the class. I consider the antagonism between covering grade level mathematics standards and engaging students in Culturally Relevant tasks when melding the two practices together.

Rethinking Agency in Critical Mathematics Education Jose Martinez Hinestroza, Texas State University

This paper focuses on critical mathematics education (CME) and its attention to children using mathematics to effect change and develop critical consciousness. Given these tenets, in CME common characterizations of agency as children's ability to act on the world according to their own choices are tautological. A poststructuralist perspective can strengthen and further specify a conceptualization of agency. Accordingly, I argue that in CME agency involves merging, reshaping, and relocating discourses available to the child. Recognizing these emergent discursive practices entails a paradigm shift from viewing children as incomplete individuals in transition to adulthood, toward recognizing the multiple ways in which children can transform their own lives and conditions. I draw on examples from a third-grade classroom to illustrate the analytical possibilities of this CME-aligned, poststructuralist

conceptualization of agency.

044. Mathematical Processes Research Report F Mathematical Processes Research Report Session

2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Freedom G Participant:

"What Do You Believe is True?" A Routine for Proving Theorems in Secondary Geometry Michelle Cirillo, University of Delaware; Casey Griffin, University of Delaware; Amanda Seiwell, University of Delaware; Jenifer Hummer, West Chester University of Pennsylvania

We report findings from an investigation of one teacher's instruction as he guided students through the proofs of 21 theorems in a Grade 8 Honors Geometry course. We describe a routine involving four distinct phases, including Setting up the Proof and Concluding the Proof. Results from an end-ofcourse proof test are also presented to attest to the effectiveness of the teacher's approach. By engaging with descriptions of the theorem-proving routine, one can learn about different strategies that may support students to learn to prove theorems, such as asking students to put forth claims in the form of conjectures or other statements that they believe are true and seeking justifications for these claims as well as sanctioning a theorem once proven.

045. Mathematical Processes Brief Reports E Mathematical Processes

Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Freedom H

Participants:

The Interface of Quantification and Covariational Reasoning in Real World Scenarios Carlos Ivan Acevedo, Texas State University; Jennifer A Czocher, Texas State University; Elizabeth Roan, Texas State University; Micah Swartz, Texas State University

Quantitative and covariational reasoning (QCR) are foundational to productive conceptualizations of function, especially properties belonging to first and second derivatives. The purpose of this study was to explore how QCR about derivatives and rates of change might influence mathematical model construction. Through analysis of sessions from an exploratory teaching experiment, we present reasoning illustrative of consistent, robust, and nonnormative conceptions of derivatives and conjecture how this reasoning impacts model construction.

Understanding Generalization through the Lens of Mathematical Work Spaces *Xiangquan Yao*, *Pennsylvania State University* Mathematical generalization, both as a process and a product, plays an important role in school mathematics. To help learners become more proficient at constructing, justifying, and reasoning with mathematical generalizations, it is important to understand the nature of mathematical work they engage in these processes. This study applied the theory of Mathematical Work Space (WMS) to examine learners' mathematical work in generalization activities. Data analysis has shown that the theory of MWS provided a useful tool to examine the quality of learners' mathematical work in the process of generalizing and to identify the obstacles encountered in the process of making and justifying generalizations. This study deepens our understanding of the nature of mathematical work in generalization activities and of how learners' generalization activities can be supported.

046. Mathematical Knowledge for Teaching Brief Reports B

Mathematical Knowledge for Teaching Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Independence A

Participants:

Representing Proportional Reasoning Algebraically to Problem Solve Teruni Lamberg, University of Nevada, Reno; Tejvir Kaur Grewall, University of Nevada, Reno; Alysia d Goyer, University of Nevada, Reno; Sierra Gill, University of Nevada, Reno

Proportional reasoning problems can be solved using algebraic reasoning. Therefore, making connections between proportional reasoning and algebraic thinking is important for solving problems. This study examined K-8 teachers' problem-solving strategies as they solved a real-world multi-step problem that involved proportional reasoning and algebraic thinking. The findings revealed that many teachers found this problem challenging. Particularly, some teachers had difficulty figuring out how to translate the variables into an algebraic equation. Some teachers who used variables as labels tended to engage in additive reasoning. They had difficulty representing the proportional problem context algebraically and solving the problem for the unknown quantity. Implications for further research are discussed.

Teachers' Knowledge Resources for Solving Proportions Chandra Hawley Orrill, UMass Dartmouth; Rachael Eriksen Brown, Penn State Abington

In this report, we consider whether there are differences in the fine-grained understandings teachers use to reason about proportional situations. To examine these differences, we divided a group of 32 teachers into one of three groups based on their performance on the Proportional Reasoning LMT assessment. Then, we used knowledge in pieces to analyze the teachers' performance on a series of proportional reasoning tasks. Based on that analysis, we were able to use Epistemic Network Analysis to determine which knowledge resources were most commonly connected for the groups of teachers. Implications for teacher development will be discussed.

047. Mathematical Content Early/Middle Years Brief Reports C

Mathematical Content Early/Middle Years (Grades preK-8) Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Independence B Participants: An Exploration in Children's Thinking about Learner-Generated Integer Drawings Sailer Galusha-McRobbie, George Fox University; Nicole Marie Wessman-Enzinger, George Fox University

Learner-generated integer drawings are representations for integer addition and subtraction created by children. We present a study where six grade 5 participants examined and unpacked other children's learner-generated integer drawings for integer addition and subtraction. Themes that emerge included: (a) Participants were correct about half the time;(b) participants' initial reasoning often did not align to the drawings; (c) participants justified the drawings (even incorrect solutions); (d) and, without prompting the participants critiqued the drawings. Because participants' reasoning differed from the drawings presented and they were able to justify or critique the drawings, this offers potential for learnergenerated drawings as a pedagogical tool.

Initial Insights into Children's Constructions of Integer Division Nicole Marie Wessman-Enzinger, George Fox University

This is exploratory work on how children solved integer division problems for the first time and constructed their thinking. The children's thinking is described qualitatively for three different integer division open number sentences emphasizing antideficit views of children's thinking. Due to challenges in the physical embodiment of negative integers, affordances and constraints around analogical reasoning and direct modeling specific to integer division are described. Results highlight that analogical reasoning that structurally worked for addition and subtraction broke down for integer division; but analogies did prove to be helpful for a negative number divided by a negative number. The children used direct modeling strategies with partitive definitions of division; but measurement division may have better potential with direct modeling strategies.

048. Equity and Justice Brief Reports A

Equity and Justice

Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Independence C

Participants:

"Dear Math, I'm not a fan of you": Shifting middle school girls' perceptions of mathematics Lynda Wiest, University of Nevada - Reno; Claudia Marie Bertolone-Smith, California State University Chico: Heather Crawford-Ferre, Nevada Department of Education In this study, we collected data from 48 middle school girls who attended a five-day residential summer mathematics program. At the program beginning and end, the girls wrote a brief "Dear Math" letter to share their thoughts and feelings about mathematics, and they were asked to draw a picture of themselves doing math and to explain it. Participant data were analyzed into themes, and preand post-program data were compared to look for evidence of change. The data show favorable movement, particularly in viewing mathematics as being more collaborative and less procedural.

Gender Differences in Students' Sense of Belonging in Mathematics: The Role of the Institution *Ciera Street, ciera.street@colostate.edu* A student's sense of belonging can strongly influence their decision to stay in STEM. This influence is especially strong for women, who often report a lower sense of belonging in math (Good et al., 2012; Rainey et al., 2018). In this study, we utilize sociopolitical theory to analyze select statements about students' perceived frequency of classroom activities related to sense of belonging from the Progress Through Calculus census survey. Results show that this perception differs between genders, with the majority of statements showing women constituting a higher proportion of low frequency responses and a lower proportion of high responses. We also see this relationship vary across surveyed universities, with further exploration of two particular institutions. We discuss how these results fit within previous literature in this area as well as expand on the sociopolitical perspective around institutional norms about inclusion and exclusion.

049. Virtual BRR Mixed Session F

Two or More Strands Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Independence D

Participants:

Theorizing Data Science Education: An Intersectional Feminist Perspective on Data, Power, and "Playing the Game" Laurie Rubel, University of Haifa; Lee Melvin Madayag Peralta, Michigan State University; Beth Herbel-Eisenmann, Michigan State University; Shiyan Jiang, North Carolina State University; Jennifer Kahn, University of Miami; Vivian Lim, City University of New York

The rapid growth in demand for data science skills over the past few years have led to calls to incorporate data science into the mathematics curriculum. Many such calls for reform, however, do not explicitly attend to the central role that data play in historical and ongoing systems of oppression. This paper problematizes apolitical, power-blind approaches to data science education (DSE) and explores an intersectional feminist approach to data and data science put forth in Data Feminism as an alternative. Drawing on this intersectional data feminist framework as well as equity discourses in mathematics education, we offer a theorization of the complex interplay between data and power relevant for statistics and DSE practitioners and researchers. We conclude by offering suggestions for reimagining K-12 DSE beyond "playing the game" promoted by dominant approaches to data science

The Social Community of a Mathematics Support Program Jenna Tague, Clovis Community College The purpose of this report is to share the facets of a mentoring program set in a mathematics department in a mid-sized western university. To examine the efficacy of the program, I use the social community framework (Mondisa & McComb, 2015) to compare the students in the program to a control group of students. Results indicate that the program is helping the students develop connectedness and a community of practice.

050. PD/In-Service Teacher Education Research Report B

Professional Development/In-Service Teacher Education

Research Report Session 2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Philadelphia North Participant:

Examining the Use of Video Annotations in Debriefing Conversations During Video-Assisted Coaching Cycles Ryan Gillespie, University of Idaho; Julie Amador, University of Idaho; Jeffrey Choppin, University of Rochester

This study examined how mathematics coaches leverage written annotations to support professional discourse with teachers about important classroom events during synchronous debriefing conversations. Coaches and teachers created the annotations while asynchronously watching video of an implemented lesson as part of online video-assisted coaching cycles. More specifically, this project examined the extent to which a coach and teacher discussed the annotations during a debrief conversation in a coaching cycle. We present a rationale for needing new knowledge about the relationships between video annotations and professional discourse as well as the potential implications of such knowledge.

051. Pre-Service Teacher Education Brief Reports A

Pre-Service Teacher Education

Brief Research Report Session

2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Philadelphia South Participants:

Designing a Video-Based Intervention to Elicit Teacher Candidates' Mathematical Knowledge: The Hexagon Task *Tatia Baum Totorica, Boise State University; Laurie Overman Cavey, Boise State University; Patrick R Lowenthal, Boise State University; Jason Libberton, American Falls School District*

Instructional interventions often fail. However, researchers have increasingly taken a design-based research approach to iteratively design, implement, and revise interventions. In this paper, we describe how the iterative design process has led to improvements in the operationalization of our intervention's four design principles aimed at supporting secondary mathematics teacher candidates' attentiveness development. We describe the issues we encountered and provide insights for others who are developing video-based interventions to improve professional noticing in general or attentiveness in particular.

Exploring Relationships Between Prospective Teachers' Decimal Models and their Procedural and Conceptual Decimal Knowledge *Rachel N Starks, Boston University*

Robust knowledge of the mathematics that one teaches plays an essential role in quality teaching and is therefore important for prospective teachers (PTs). For elementary PTs, this must include both conceptual and procedural decimal knowledge. Research reveals that mastery in this domain is elusive for children and adults. However, limited rich descriptions of PTs' knowledge of decimals exist. Even less research explores the role of models, though modeling is an integral part of doing mathematics. In this study, I examine 225 elementary PTs' responses, when asked to create a model for comparing 0.4 and 0.32 and explain the mathematical ideas addressed. Comparing responses by PTs who created area versus linear models reveals that procedural fluency is similar, but more users of area models demonstrate conceptual understanding.

052. Virtual BRR Student Learning and Related Factors C

Student Learning and Related Factors Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Salon 10 Participants:

Teaching Productive Struggle in Calculus Sarah Hanusch, SUNY Oswego; John Myers, SUNY Oswego

Students often lack the cognitive and metacognitive strategies to maximize their learning. However, instruction may help students use these strategies. We redesigned a calculus course to teach students metacognitive strategies, with three components: frequent in-class discussions, corrections on exams, and a student essay on metacognitive strategies. We used a mixed method study design to qualitatively analyze the students' essays and quantitatively measured changes in students' attitudes towards mathematics using a pre-post assessment. We found the students attitudes improved at a practical and statistically significant level (p<0.0001) over the course.

Struggling with Productive Struggle: Implications for Students with Diverse Cognitive Resources Angela R Crawford, Boise State University The perspectives in mathematics education and special education literature are in tension when it comes to the idea of productive struggle. This study describes how struggle surfaced for the students and researcher in teaching experiments using learning trajectories with three elementary-aged students with diverse cognitive profiles. Through 45-minute individualized instructional sessions over 2-6 months, each student's struggles with tasks and more general challenges of engaging with mathematics help to illustrate the relationships between struggle and mathematics learning. I share how students' struggle led to my own challenges in navigating the tensions between mathematics education and special education. Finally, I consider how my focus on productive struggle without attending to cognitive difference reflected ableist thinking and suggest implications of these observations for reframing productive struggle.

053. Virtual RR Pre-Service Teacher Education C

Pre-Service Teacher Education

Research Report Session

2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Salon 2

Participant:

Forms of Nascent Political Conocimiento Leveraged in a Content Course for Preservice Elementary Teachers Alexa W.C. Lee-Hassan, University of Illinois at Chicago

This study examines the nascent forms of political conocimiento demonstrated by elementary preservice teachers before and after a series of activities designed to engage them in thinking critically and quantitatively about the impacts of different grading systems. In reflections about their learning, the preservice teachers most frequently raised considerations related to knowledge with students and communities, followed by political knowledge. Many of the preservice teachers anticipated using their new knowledge in the near future to understand the implications of their professors' grading systems and in the more distant future to design grading scales in their own classrooms. A handful of reflections showed awareness of the tensions involved in grading systems, potentially a sign of Nepantla, while others evidenced more binary thinking.

054. Virtual BRR Teaching and Classroom Practice A

Teaching and Classroom Practice Brief Research Report Session 2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Salon 3 Participants:

Dimensions of Successful Elementary Mathematics Teachers' Effectiveness during Professional Development Susan Swars Auslander, Georgia State University; Kayla Myers, Georgia State University; Gary Bingham, Georgia State University; Carla Lynn Tanguay, Georgia State University; Carrie Tahlor, Gwinnett County Public Schools

This 5-year mathematics professional development project involves 27 elementary teachers being prepared and supported as Elementary Mathematics Specialists (EMSs) through completion of a university's K-5 Mathematics and Teacher Supporting & Coaching Endorsement programs, as well as participation in Professional Learning Communities and individual mentoring. Across the project, data are gathered to examine changes in mathematical content knowledge, instructional and coaching practices, beliefs, and teacher leader skills of the EMSs. Described here are Year 1 data from the participants, who have been identified as successful, experienced teachers, focusing on specific aspects of teacher effectiveness. The findings illuminate their classroom instructional practices, including those that are learner-centered and equitable, along with their early histories as learners of mathematics.

Understanding Specific Strategy Details to Select Strategies for Whole-Class Discussions Amy Hewitt, University of Illinois Springfield Whole-class discussions have become an integral part of mathematics lessons that focus on teaching that is responsive to students' thinking. Central to these discussions are the student strategies, thus it is beneficial to understand the criteria teachers consider when engaging in the practice of selecting strategies for discussions. In particular, understanding the specific strategy details for fraction story problems can make selecting strategies for whole-class discussions more purposeful. This study explored 3 teacher cases and 41 teachers participating in professional development activities who were engaged in the practice of selecting. Examination of the data revealed specific strategy detail categories which help characterize the practice of selecting strategies. This article illuminates the specific strategy details teachers can consider to make selecting strategies for whole-class discussions more

purposeful.

055. Virtual RR PD/In-Service Teacher Education B

Professional Development/In-Service Teacher Education Research Report Session

2:15 to 2:55 pm

Sheraton: Floor Mezzanine - Salon 4

Participant:

Understanding Mathematics Teachers' Collaborative Sensemaking in the Context of Teachers' Learning Ecologies Nadav Ehrenfeld, Peabody College, Vanderbilt University, Nashville, TN, USA Over the last two decades, researchers have portrayed quality professional development for mathematics teachers as collaborative and situated in teachers' instructional realities. However, empirical findings also point out various impediments to transforming teacher conversations into consequential learning. These findings illuminate the need to acknowledge additional resources that teachers bring to professional interactions and the need for ever more nuanced theories of teacher learning to inform teacher educators' work. Inspired by ecological models of learning, in this conceptual paper I work towards understanding teachers' collaborative sensemaking as part of broader teacher learning ecologies. I distinguish and name possible scopes and contexts for the study of teacher learning in conversations about instruction, and then identify directions for future research towards stronger connections between immediate and broader contexts

056. Virtual BRR Pre-service Teacher Education C

Pre-Service Teacher Education Brief Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

- Examining The Value, Importance, Self-Efficacy And Prior Experiences Of Mathematical Writing For Preservice Teachers' Erin Smith, The University of Southern Mississippi; Robert A Smith, The University of Southern Mississippi; Sarah R Powell, The University of Texas at Austin; Michael Hebert, University of Nebraska Writing in mathematics is critical to students' learning, yet few teachers assess students' mathematical writing (MW) or incorporate MW into their instruction. In an effort to increase preservice teachers (PSTs) attention to MW, we examined PSTs' experiences with MW and the impact of a content module focused on MW embedded in mathematics methods courses at four institutions. Findings indicate PSTs had limited experiences with MW in K-16, yet saw it as valuable to students' learning. After completing the module, the PSTs' self-efficacy related to MW grew, indicating a greater likeliness of incorporating MW into their future practice
- Modifying and Accommodating Instruction of Multiplication for Students with Mathematical Learning Disabilities (MLD) *Hea-Jin Lee, The* Ohio State University at Lima; Chaeeeen Han, Seoul, Korea; Hee-Jeong Kim, Hongik University, Korea; Leah M. Herner-Patnode, The Ohio State

University at Lima

This study investigates preservice mathematics teachers' instructional approaches to teach multiplication to students with mathematical learning disabilities (MLD). 17 preservice teachers' lesson design were qualitatively analyzed. Findings revealed that the PTs modified mathematical strategies by providing a variety of multiplicative concepts and various types of representations. PTs set their expectations based on individual needs, manage lesson structure, and adjust cognitive demands level of lesson tasks. Results suggest that PTs need opportunities to consider deeper responsive teaching while their modification and accommodation for students with MLD enable quality learning opportunities.

057. Virtual RR Teaching and Classroom Practice A

Teaching and Classroom Practice Research Report Session 2:15 to 2:55 pm Sheraton: Floor Mezzanine - Salon 6

Participant:

Investigating What Makes Beginning Teachers' Enactment of Number Talks More or Less Ambitious Jillian M Cavanna, University of Hartford; Byungeun Pak, Dixie State University; Brent Jackson, Michigan State University Number talks, a popular mathematics teaching routine in the United States, may offer supports for beginning teachers (BTs) to engage in ambitious instruction. BTs' enactments of number talks, however, are varied, and there are few empirical studies that explore how BTs' enactment of number talks could be more (or less) ambitious. This paper draws on classroom observation data from a large investigation of BTs' enactment of ambitious instruction in elementary mathematics across five teacher preparation programs. We analyzed 19 transcripts of number talks enacted by seven BTs to investigate what makes number talks more or less ambitious. Findings illustrate three patterns among number talks that were categorized as approaching ambitious using the M-Scan (Berry et al., 2013) instrument. Discussions and implications are offered in relation to mathematics teacher education and research.

Friday, 3:10-3:50pm – Research Sessions

058. Teaching and Classroom Practice Research Report C

Teaching and Classroom Practice Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Freedom E

Participant:

- Conventions and Context: Graphing Related Objects onto the Same Set of Axes Steven Jones, Brigham Young University; Douglas Corey, Brigham Young University; Dawn Teuscher, Brigham Young University
 - Several researchers have promoted reimagining functions and graphs more quantitatively. One part of this research has examined graphing "conventions" that can at times conflict with quantitative reasoning

about graphs. In this theoretical paper, we build on this work by considering a widespread convention in mathematics teaching: putting related, derived graphical objects (e.g., the graphs of a function and its inverse or the graphs of a function and its derivative) on the same set of axes. We show problems that arise from this convention in different mathematical content areas when considering contextualized functions and graphs. We discuss teaching implications about introducing such related graphical objects through context on separate axes, and eventually building the convention of placing them on the same axis in a way that this convention and its purposes become more transparent to students.

059. Pre-Service Teacher Education Brief Reports C

Pre-Service Teacher Education Brief Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Freedom F Participants:

- Racial Reckoning in Teacher Education: Using Cases to Get Preservice Teachers Talking About Race Alesia Mickle Moldavan, Fordham University; Monica Lyn Gonzalez, East Carolina University Preservice teachers must have opportunities in teacher education to critically reflect on race and racism in mathematics education. Engaging preservice teachers in such conversations during methods courses can be challenging. This study uses a case specifically designed in a digital context to encourage preservice teachers to talk about race, including their understanding of race and racism in an authentic mathematics classroom situation and how a teacher might respond to the situation. Findings show that preservice teachers talk about race in terms of differing perspectives of discrimination (social versus racial exclusion) and how a teacher might respond (reactive and proactive initiatives). Recommendations and future research considerations are shared to address ways mathematics teacher education can shape preservice teachers' racial reckoning and critical consciousness.
- Using a Critical Framework to Make Teacher Resources Visible Josh Karr, West Virginia University

While practice-based teacher education (PBTE) commonly draws upon multidimensional frameworks for teacher learning, I argue for the expansion of currently utilized frameworks to include dimensions related to justice. I discuss how this expanded framework was developed and draw upon examples from a larger project, focusing on the design and use of practice-based pedagogies centered on discretionary spaces, to illustrate the need for and benefits of this framework. I offer implications for future use of the framework and practice-based pedagogies.

060. PD/In-Service Teacher Education Brief Reports D

Professional Development/In-Service Teacher Education Brief Research Report Session 3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Freedom G

Participants: Teacher S

Teacher Self Report Framework for Making

Teaching Visible Teruni Lamberg, University of Nevada, Reno; Linda Gillette-Koyen, University of Nevada, Reno

The Whole Class Discussion Framework (Author, 2019; Author, 2020) was administered pre and post PD. Specifically, teachers self-reported their teaching practice as it related 1) the design of physical space, 2) classroom routines, 3) lesson planning and 4) the whole class discussions. The meaning of these categories was explicitly addressed in the professional development that teachers participated in. The pre and post data were compared, and the data revealed that there were shifts in every category. The greatest shifts took place on how they facilitated whole class discussions. Implications for using this tool for teachers to professionally notice their practices to refine teaching, and for professional developers to make decisions to adapt PD are discussed.

The Impact of an Immersive Teacher Professional Development Program Based On Exploratory Number Theory Chris Norris-LeBlanc, The Harvard Graduate School of Education; Jon Star, Harvard

In the literature around high quality professional development (PD) opportunities for teachers of mathematics, immersion, duration, collaboration, and a focus on content have emerged as some of the key factors which lead to impactful experiences. Despite knowing which attributes are associated with effective PD, only a small number of programs are rigorously studied or evaluated. This multi-year qualitative study investigated a professional development program - PROMYS For Teachers (PfT) - which immerses teachers in a 7-week intensive summer program in exploratory number theory. Through three case studies with participating teachers, the authors sought to understand the key dimensions of PfT and the impact that it has on participants. Findings show that while PfT can elicit changes in teachers' relationship to mathematics and teaching practice, a lack of clear program goals leads to varied outcomes.

061. Mathematical Processes Research Report C

Mathematical Processes Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Freedom H Participant:

Teacher Feedback and Authority during Instances of Students' Proving *Mitchelle Mbete Wambua*, *University of Missouri-Columbia; Samuel Otten*, *University of Missouri at Columbia; Kimberly Conner, University of Northern Iowa* In this study, we examined the authority dynamics evidenced in a teacher's feedback actions while students proved geometry claims. We discuss who was positioned as authority in various feedback types and provide suggestions for research and practice with respect to teacher feedback and authority in proof instruction.

062. Pre-Service Teacher Education Research Report H

Pre-Service Teacher Education Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Independence A Participant:

Prospective Secondary Mathematics Teacher Responses And The Structure Of Approximations Of Practice Duane Graysay, Syracuse University; Ben Freeburn, Western Michigan University; Fran Arbaugh, The Pennsylvania State University; Nursen Konuk, Metropolitan State University of Denver

To support productive struggle, prospective secondary mathematics teachers (PTs) need to elicit and respond to students' mathematical ideas in ways that focus on those ideas and that position students to build on those ideas. Using the Teacher Response Coding framework from Van Zoest and colleagues (2021) we analyzed PTs' responses in three approximations of practice. We identified significant differences in the natures of responses in one approximation of practice compared to the other two. Using a Levels of Constraint framework based on findings of Kavanagh et al. (2020) we compared structures of the approximations of practice and developed hypotheses regarding which aspects of structure might account for differences in PTs' responses.

063. Virtual RR Mathematical Content Early/Middle Years C

Mathematical Content Early/Middle Years (Grades preK-8)

Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Independence B

Participant:

Interpreting Worked Examples of Integer Subtraction Laura Bofferding, Purdue University; Mahtob Aqazade, Purdue University

Drawing on research around the utility of worked examples, we examine how 29 first- and 27 thirdgrade students made sense of integer subtraction worked examples and used those examples to solve similar problems. Students first chose which of three worked examples correctly represented an integer subtraction problem and used the example to solve a similar problem. Later, we presented only the correct worked example and had them solve another similar problem. Our results highlight how their initial ideas around which worked example was correct supported or constrained their later interpretation and use of the correct worked example. Students were attuned to the number of jumps shown in the examples; however, they sometimes misinterpreted the jumps' direction. Students' visual answers were correct more than their written answers, suggesting further attention to visuals could support students' reasoning

064. Student Learning and Related Factors Research Report A

Student Learning and Related Factors Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Independence C Participant:

A Hypothetical Learning Trajectory For the Understanding of Number Density in High School Students / Una Trayectoria Hipotética de Aprendizaje para la Comprensión de Densidad Numérica con Estudiantes de Bachillerato Mayra Zulay Suárez, Centro de Investigación y de Estudios Avanzados del IPN; Ana Isabel Sacristán, Cinvestav-IPN

During his school life, student learn mathematical topics that can be considered essential for the understanding of the property of density in the set of real numbers. Therefore, we detected a need to design and develop a Hypothetical Learning Path to include topics to help promote the learning of this property. This report shows results of a first stage of an educational experiment as part of an ongoing research. It describes how through the trajectory, high school students are able to recognize ways of finding numbers in an interval using various semiotic representations. We also describe some difficulties that students had to recognize the non-existence of a successor in real numbers are described. Spanish: Durante su vida escolar, el estudiante aprende temas de las matemáticas que podrían considerarse esenciales para la comprensión de la propiedad de densidad en el conjunto de los números reales. Por ello se contempló la necesidad de diseñar y elaborar una Trayectoria Hipotética de Aprendizaje para incluir temas que ayuden a propiciar el aprendizaje de esta propiedad. Este informe muestra los resultados de la primera experimentación educativa de una investigación que aún está en curso. Se expone la delineación de la trayectoria en la que el estudiante, de bachillerato, logra reconocer formas de hallar números en un intervalo usando varias representaciones semióticas. Así mismo, se describen algunas dificultades que tiene el estudiante para reconocer la no existencia de un sucesor en los números reales

065. Mathematical Content Later Years Brief Reports A

Mathematical Content Later Years (Grades 9-12+) Brief Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Independence D

Participants:

The impact of computer simulations on learners' ideas about sampling *Karoline Smucker*, *Ohio State University*

This report presents preliminary results from the initial survey and task within an ongoing design study investigating preservice elementary teachers' approaches to sampling. Nineteen preservice teachers enrolled in an elementary mathematics methods course completed an initial survey involving tasks related to sampling and inference, followed by a series of designed activities using computer simulations as a tool for inquiry of these concepts. Of interest were the preservice teachers' initial ideas, and how exposure to the simulations may have impacted their approaches. Initial analysis of the surveys suggests that participants' ideas about sampling showed similarities to research involving K-12 students. Their work during the first task suggests that computer simulations may help learners make more reasonable predictions within sampling contexts, along with providing a way to quantify the likelihood of those predictions.

Undergraduate Mathematics Students' Self-

Regulation in Routine and Non-Routine Proofs Royce Olarte, University of California Santa Barbara; Sarah A. Roberts, University of California, Santa Barbara; Hannali Pajela, University of California, Santa Barbara; Damaris Hernandez, University of California Santa Barbara

This study examined how undergraduate mathematics students engaged in self-regulatory activities while performing routine and non-routine proofs. We used Zimmerman's model of self-regulated learning (SRL) theory, which emphasized the sequential, cyclic nature of self-regulation feedback loops in learning and task performances to better understand the difficulties students faced with proof-construction. Two student participants participated in think aloud interviews, solving a routine and non-routine number theory proof. Using qualitative data analysis, we found that students engaged in fewer cycles of selfregulation during the routine proofs in comparison to the non-routine proofs. Self-regulation in non-routine proofs involved a broader range of strategies, fewer systematic performances, and more negative selfreactions. Our findings can potentially inform instructors about practices that better support proofconstruction and comprehension.

066. Teaching and Classroom Practice Research Report E

Teaching and Classroom Practice Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Philadelphia North

Participant:

Instructors' Facilitation of Student Participation in Advanced Mathematics Lectures: A Case Study of Two Instructors. Anna Zarkh, UC Berkeley; Sebastian Geisler, Otto-von-Guericke-University Magdeburg

Advanced mathematics lecturing is often portrayed as a uniform teaching style, in which student participation is minimal. We present results from a comparative case study of two instructors' facilitation of student participation in Real Analysis lectures. Analyzing fieldnotes from several observed lectures of each instructor, we found that the two instructors' facilitation of student participation during lectures consistently differed in (1) which participation structures were used, (2) the types of questions asked, and (3) how instruction responded to students' contributions. Our findings show that lecturing in advanced mathematics is not a uniform style and that active student participation in lectures is possible. We interpret the potential impact of observed differences on students' learning and experiences in terms of the Teaching for Robust Understanding (TRU) framework (Schoenfeld, 2018).

067. Technology Research Report C

Technology

Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Philadelphia South Participant:

Examining Preservice Teachers' Professional Noticing of Students' Mathematics through 360 Video and Machine Learning Karl Wesley Kosko, Kent State University; Yuxin Yang, Kent State University; Christine Kathryn Austin, Kent State University; Qiang Guan, Kent State University; Enrico Gandolfi, Kent State University; Zhiqing Gu, Kent State University

Preservice teachers (PSTs) often demonstrate difficulty learning to attend to content-specific student actions in-the-moment. However, machine learning algorithms applied to PSTs' viewing of 360 videos provides a potentially useful tool for teacher educators. In this paper, we describe the initial development of such a tool and the implications for its use.

068. Virtual BRR Pre-Service Teacher Education E

Pre-Service Teacher Education Brief Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Salon 10 Participants:

- Establishing common ground through gestural scaffolding: A first-grade preservice teacher's use of probes Lizhen Chen, Purdue University Many studies have focused on students' gesture use and learning; however, little attention has been paid to preservice teachers' gesture use in their instruction. Therefore, this study aims to expand existing research by investigating a preservice teacher's gestural scaffolding in her mathematics probes. Sources of data included a video of the preservice teacher's teaching, her identification of probes in a stimulated recall interview, and researchers' identification of probes. Results showed that the preservice teacher packaged spatio-motoric information in her iconic and metaphoric gestures to establish common ground with her students. The research findings provide further implications about how teacher educators teach probing practices in preservice teacher education.
- Expanding Connections in Practice: Attention to multiple mathematical knowledge bases in integrated STEAM lessons Tabatha Rainwater, University of Tennessee, Knoxville; Frances K Harper, University of Tennessee, Knoxville; indrani Singh, University of Tennessee, Knoxville; Kay Howell, University of Tennessee, Knoxville As integrated STEM/STEAM education gains prominence in PreK-5 classrooms, elementary prospective teachers face new challenges in learning to focus on children's mathematical thinking and community funds of knowledge (i.e., multiple mathematical knowledge bases) in instruction. We explored prospective teachers' attention to multiple mathematical knowledge bases in integrated STEAM lesson plans, which were co-planned and cofacilitated at an informal STEM event for preschool children and families. Analyzing three lesson plans, we asked how prospective elementary teachers connected children's mathematical thinking, funds of knowledge, and STEAM. We found transitional connections - explicit attempts that were underdeveloped in one or two areas - in two lesson plans and meaningful connections in one. We discuss implications for elementary teacher learning and integrated STEAM practice.

069. Virtual RR Mathematical Content Later Years A

Mathematical Content Later Years (Grades 9-12+) Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Salon 2

Participant:

Isomorphism and Homomorphism as Types of Sameness Rachel Rupnow, Northern Illinois University; Peter Sassman, Northern Illinois University

Isomorphism and homomorphism are topics central to abstract algebra, but research on mathematicians' views of these topics, especially with respect to sameness, remains limited. This study examines 197 mathematicians' views of how sameness could be helpful or harmful when studying isomorphism and homomorphism. Instructors saw benefits to connecting isomorphism and sameness but expressed reservations about homomorphism. Pedagogical considerations and the dual function-structure nature of isomorphism and homomorphism are also explored.

070. Virtual BRR Theory and Research Methods A

Theory and Research Methods Brief Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Salon 3

Participants:

- A Two-Layered APOS Analysis of Inequality Number Line Graphs *Alison Mirin, Arizona State University; Jodi Frost, Indiana State University* Reasoning with inequalities and their solutions is important in mathematics. Research suggests that this reasoning is problematic for many students. We provide a two-layered APOS genetic decomposition of the meaning of number line graphs as representing solution sets. Our two-layered approach addresses the fact that solution sets to inequalities are often infinite. We then discuss instructional implications, which involve the use of a number line as a record-keeping device.
- Structuring and enumeration: A preliminary discussion of spatial-temporal-enactive structuring Joseph Antonides, The Ohio State University; Michael Battista, Ohio State University Prior research has identified spatial structuring-the mental process of constructing an organization or form for an object or set of objects-as critical to students' development of spatial-geometric reasoning and understanding. We propose an alteration to this construct to include aspects of structuring that are especially salient in combinatorial enumeration (though also present in geometric contexts). Specifically, we replace "spatial" with "spatialtemporal-enactive" (or S*) to include temporal and enactive aspects of forming and iterating spatial composites. Further, enumeration involves numerical structuring-the mental process of constructing an organization or form for a set of computations, formulas, or expressions. In meaningful, conceptualizations-based enumeration, students can link numerical structuring to S* structuring, a process we call S*-numerical linked structuring (or S*NLS).
- **071. Virtual RR Pre-Service Teacher Education B** Pre-Service Teacher Education Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Salon 4 Participant:

Enhancing K-12 pre-service teachers' embodied understanding of the geometry knowledge through online collaborative design *Hanall Sung*, University of Wisconsin-Madison; Michael I. Swart, University of Wisconsin - Madison; Mitchell J. Nathan, University of Wisconsin -Madison

In this study, we devised research design that provides pre-service teachers to effectively experience embodied geometric thinking with the goal that it will impact teachers' instruction to students in their classrooms. Using a motion-capture video game and design tool, we offered opportunities for pre-service teachers to experience of performing mathematically related movements as well as creating their own directed actions for given conjectures. We hypothesize that these gameplay and co-design activity will reinforce not only teachers' understanding of the embodied nature of geometric thinking, but also their abilities to transfer their understanding to classrooms and the activities and assessments they design for their students. The results showed that after experiencing the interventions including embodied gameplay and codesign activity, teachers' awareness of students' usage of gestures was changed and they had better ability to understand and interpret students' gestures as a means of teachers' formative assessment practices.

072. Virtual BRR Student Learning and Related Factors A

Student Learning and Related Factors Brief Research Report Session 3:10 to 3:50 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

A Case of Units Coordination Stage Change in Middle School Amy J Hackenberg, Indiana University-Bloomington; Patricia A Walsh, Indiana University; Jonathan Rojas Valero, Indiana University

A case study of a 7th grade student, Emily, was conducted to understand her change from units coordination stage 1 to 2 over the fall semester of 7th grade. Emily participated in a unit-long classroom design experiment conducted that semester by two of the authors, where units coordination stage change was not an explicit goal. Units coordination refers to how students conceive of relationships between discrete units, like 1s, or measurement units, like lengths, as they solve problems. Students at stage 1 can coordinate two different types of units as they solve a problem, such as the number of packages in a crate containing 6 boxes with 8 packages in each box. However, these students are essentially in a "one's world" and do not create structures like six 8s. In this paper we document Emily's stage change. We also consider tasks in the unit that may have supported this change.

Nurturing Students' Understanding of Area Through Variation: A Case Study *Pingping Zhang, Winona State University; Azita Manouchehri, The Ohio*

State University

The theory of variation (Marton & Booth, 1997) has been mostly used as a task/instructional design principle in classroom settings. In other words, studies tend to look at what is made possible to discern rather than how the discernment may happen in the interaction with the students (Kullberg et al., 2017). The purpose of this paper is to shed a light on how a 7th grade student's understanding of area progressed when prompts guided by the theory of variation were provided within a one-on-one interview setting. The concept development framework (Zhang & Manouchehri, 2016) was used to identify the student's understanding for the concept of area. The results suggested that the student's understanding significantly shifted through a series of prompts.

073. Virtual RR PD/In-Service Teacher Education A

Professional Development/In-Service Teacher Education Research Report Session

3:10 to 3:50 pm

Sheraton: Floor Mezzanine - Salon 6 Participant:

A Validation Argument for The Priorities for Mathematics Instruction (PMI) Survey Michele Carney, Boise State University; Joe Champion, Boise State University; Angela R Crawford, Boise State University

Mathematics education needs measures that can be used to research and/or evaluate the impact of professional development for constructs that are broadly relevant to the field. To address this need we developed the Priorities for Mathematics Instruction (PMI) survey consisting of two scales focused on the constructs of Explicit Attention to Concepts (EAC) and Student Opportunities to Struggle (SOS) – which have been linked to increased student understanding and achievement. We identified the most critical assumptions that underlie the proposed interpretation and use of the scale scores and then examined the related validity evidence. We found the evidence for each assumption supports the proposed interpretation and use of the scale scores.

074. Afternoon Break and Snacks

3:50 to 4:20 pm

Sheraton: Floor Ballroom Level - Ballroom Lobby

Friday, 4:20-5:00pm – Research Sessions

075. Teaching and Classroom Practice Research Report D
Teaching and Classroom Practice
Research Report Session
4:20 to 5:00 pm
Sheraton: Floor Mezzanine - Freedom E
Participant:
Establishing Student Mathematical Thinking as an
Object of Class Discussion Keith R. Leatham, Brigham Young University; Laura Van Zoest, Western Michigan University; Ben Freeburn, Western Michigan University; Blake Peterson, Brigham Young University; Shari L Stockero, Michigan Technological University critical yet incompletely understood aspect of effective teaching practice. We have previously conceptualized the teaching practice of building on student mathematical thinking and the four subpractices that comprise it. In this paper we begin to unpack this complex practice by looking closely at its first subpractice, establish. Based an analysis of secondary mathematics teachers' enactments of building, we describe two critical components make precise and make an object—as well as important subtleties of the establish subpractice.

076. Pre-Service Teacher Education Brief Reports D

Pre-Service Teacher Education Brief Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Freedom F

Participants:

- 'My Host Teacher's Math Time': Power Dynamics During Enactments of Student-Centered Routines in Field Placement Brendan Dames, University of Missouri; Corey Webel, University of Missouri In this paper we share data regarding preservice teachers' (PSTs') experiences enacting a number talk routine within a clinical experience, focusing on the ways that the PSTs' described their mentor teachers' influence on the routine. In particular, we describe the case of Ms. Brooks, a PST who lamented several instructional decisions made by her mentor teacher, including interrupting the routine with questions and comments that countered the goals of the number talk routine. The case of Ms. Brooks' challenges can help teacher educators consider the ways they might support PSTs' learning in situations where routines like number talks might come into conflict with status quo practices and instructional norms within clinical experiences.
- Teacher Noticing of students' mathematics as student centered Maryam Zolfaghari, Kent State University; Jennifer Lynn Heisler, Kent State University; Karl Wesley Kosko, Kent State University

Attending to students' actions and mathematical thinking is an important aspect of professional teacher noticing. In this paper, we used 360 videos as a medium to examine the relationship between preservice teachers' (PSTs) observed attending behaviors and their written noticing. Findings suggest that PSTs focusing on students, instead of the teacher, during class discussions provide more specified descriptions of children's mathematical thinking.

077. Teaching and Classroom Practice Brief Reports C

Teaching and Classroom Practice Brief Research Report Session 4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Freedom G Participants:

Revealing the Pedagogy of Discussion in Mathematics Methods Signe Kastberg, Purdue University; Alyson E. Lischka, Middle Tennessee State University; Susan L. Hillman, Saginaw Valley State University

Although characteristics of discussions have been identified in the mathematics education research literature, pedagogy of MTEs' discussion practice is underexplored. Using a self-study methodology, we characterize three MTEs' pedagogy of discussion practice for teaching about teaching mathematics in methods courses. Data sources include recordings and transcripts of MTE facilitated discussions, instructional artifacts (google slides, class overviews, preservice teacher work samples), and recordings/transcripts of weekly critical friends' meetings. We identify commonalities in our pedagogy of discussion practice: anticipating PTs' thinking and layering instructional activities. We argue that scaffolding informs MTEs' discussion practice.

Simulating More Equitable Discussions: Using Teacher Moments and Practice Based Teacher Education in Mathematical Professional Learning Gregory Benoit, Boston University/ MIT TSL; Rachel Slama, M.I.T.; Roya Madoff Moussapour, M.I.T.; Nancy Anderson, MIT; Justin Reich, M.I.T. Teaching System Lab

Digital simulations have become an increasingly popular approach to practice-based teacher education. In this paper we report on a professional learning intervention where we used digital clinical simulations to help mathematics teachers' fluency in facilitating both small group and whole group discussion. Further we discuss implications of digital clinical simulation as a tool that can help mathematics educators develop, practice, and further support their teaching.

078. Theory and Research Methods Brief Reports A

Theory and Research Methods Brief Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Freedom H Participants:

Abstracts for assessments: Describing a summary statement Jonathan David Bostic, Bowling Green State University; Erin E. Krupa, North Carolina State University

Quantitative assessment development is a challenging process. The ways in which an assessment might be used, as well as how its score can be interpreted should be clear to intended users. This manuscript provides a discussion about important and useful elements that should be provided by assessment developers. In turn, this information can foster greater usability and portability of quantitative assessments, which can support scholarship focusing on a specific issue.

Points and Positions: An Intersection of Two Frameworks for Reasoning with Graphs of Functions Erika David Parr, Rhodes College; Benjamin D. Sencindiver, City University of New York; Robert Ely, University of Idaho

In this theoretical report, we examine the intersection of two previously-recognized dimensions of students' reasoning about how symbolic notations represent elements of graphs of functions. One dimension distinguishes location-thinking, where notations refer only to a point's location on a graph, from valuethinking, where such a point is treated as a multiplicative object. The other dimension distinguishes a nominal interpretation of expressions, where expressions refer to positions in the plane, from a magnitude interpretation, where expressions measure a length. Taken together these dimensions provide four distinct ways students reason about expressions, especially those involving function notation, on graphs. Each case reveals new meanings and affordances indicated by the interplay between the two dimensions. We provide both a theoretical account and empirical example of each case.

079. Technology Research Report D

Technology Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Independence A Participant:

Preservice Secondary Teachers' Reasoning about Static and Dynamic Representations of Function Demet Yalman Ozen, Middle Tennessee State University; Nina Gabrielle Bailey, University of North Carolina Charlotte; Samantha Fletcher, Middle Tennessee State University; Hamid Reza Sanei, North Carolina State University; Allison McCulloch, University of North Carolina at Charlotte; Jennifer Lovett, Middle Tennessee State University; Charity Cayton, East Carolina University

This study aims to describe how preservice secondary mathematics teachers (PSMTs) reason about different function representations. The study focuses on two PSMTs' reasonings across static and dynamic representations of functions. Sfard's (2008) Theory of Commognition guided our analysis. Findings indicate that while static representations restrict attention given to covariation, dynamic representations support PSMTs' reasoning about covariation including making connections to how covariation is represented in static graphs.

080. Technology Research Report E

Technology

Research Report Session

4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Independence B Participant:

i articipant.

The Informal Covariational Statistical Reasoning: Focus On The Notion Of Aggregate Using Digital Technology Cindy Nathalia Morgado, CINVESTAV; Ernesto Alonso Sánchez, Departamento de Matemática Educativa, Cinvestav-IPN

We report the results of research on informal covariational statistical reasoning carried out with 22 students between 16 and 18 years old concerned which the design and application of a task using a digital technology environment to introduce the line of best fit. We design the task that is characterized by having elements that foresee the misconceptions reported in the literature, and by focusing on four statistical ideas that are being central to the development of informal reasoning about the line of best fit. After having used the digital technology environment, the students went from seeing a cloud of points as individual points or fragmented into subsets, to seeing it as an aggregate from a mathematical mechanism that unites them with the notion of distance of a cloud to a line. Se reportan resultados de una investigación sobre el razonamiento estadístico covariacional informal

realizada con 22 estudiantes entre 16 y 18 años, en la cual se diseñó e implementó una tarea en un ambiente de tecnología digital para introducir la recta de mejor. El diseño de la tarea se caracteriza por poseer elementos que prevén las malas concepciones reportadas en la literatura, y por enfocarse en cuatro ideas estadísticas que se consideran son centrales para el desarrollo del razonamiento informal acerca de la recta de mejor ajuste. Después de haber utilizado el ambiente de tecnología digital, los estudiantes transitaron de ver a una nube de puntos como puntos individuales, o fragmentado en subconjuntos, a verlo como un agregado a partir de un mecanismo matemático que los une con la noción de distancia de una nube a una recta.

081. Equity and Justice Brief Reports D

Equity and Justice Brief Research Report Session

4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Independence C

Participants:

Perspectives on Rehumanizing Undergraduate Mathematics: Elevating the Voices of Latina and Mixed-Race Women Kelly (she/her) MacArthur, Montana State University; Tracy Elyse Dobie, University of Utah

There are many calls for a sociopolitical turn in math education research (Adiredja & Andrews-Larson, 2017; Aguirre, et al., 2017; Gutiérrez, 2013), as well as calls to rehumanize mathematics classes with a particular focus on Black, Latinx and Indigenous students (Gutiérrez, 2018). This case study explores the experiences and ideas of four Latina and Indigenous Calculus 2 STEM majors to determine what they find rehumanizing in their math courses and what instructional strategies can be used to make university math classes more humane. Using Gutiérrez's eight rehumanizing dimensions (2018), we find that these students' comments fall primarily under the participation/positioning category. We explore the themes arising in this dimension and discuss potential teacher moves that could help create more humane math classes.

Teachers' Remote Instruction Practices That Engage Multilingual Learners *Rue Mansour, UC Santa Barbara; Miriam Burnett, UC Santa Barbara; Sarah A. Roberts, University of California, Santa Barbara; Cameron John Dexter Torti, University of California, Santa Barbara; Julie A Bianchini, University of California, Santa Barbara*

This study investigated teachers' methods for cultivating safe spaces in remote learning environments that enriched language opportunities for Multilingual Learners (MLs) to engage in cognitively demanding work. Researchers utilized qualitative methods to analyze eight teacher interviews from the 2020-2021 academic school year using two complementary theoretical ideas: key principles of reform-based instruction and ML instructional mathematical routines. Findings suggest that teachers perceived more engagement from their students using mathematical language routines, fostered safe spaces that they co-constructed with their students using funds of knowledge, and embedded strategically digital platforms. This research attends to the productive struggle of students and teachers during the COVID-19 pandemic and

how mathematics language routines and technology support this work.

082. Mixed BRR Session D

Brief Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Independence D Participants:

- A Professional Development Model for In-Service Teachers Based on Identification Processes and Teacher Collaboration Veronica Hovos. National Pedagogical University, Mexico; Ruben Garza, National Pedagogical University, Mexico Based on data and results that are part of a larger longitudinal study, we build a Mexican model for the professional development of in-service middle school math teachers. It accounts of information on the general characteristics of the official professional development programs -implemented by the Ministry of Education in Mexico at the epoch. The empirical work started by identifying teachers' personal philosophies or images of mathematics (Ernest, 2007, 2012). It was utilized a blending of theoretical constructs, in particular, the model of professional growth by Clark & Hollingsworth (2002) was useful to understand the role of the context of mathematics school curriculum reform as an important part of the change environment. And, in the end, our diagram for a cyclic model of professional development of inservice mathematics teachers, echoes the schematic representation of documentary genesis by Trouche (2010).
- Characteristics of Two Outstanding Elementary Teachers of Mathematics: Implications for Teacher Education David Feikes, Purdue University Northwest; William Walker, Purdue University; Brandon Sorge, Indiana University Purdue University Indianapolis

This study identifies characteristics of two "outstanding" elementary teachers of mathematics who were very different in style and who taught in different settings. The intent is to determine what characteristics make these two different teachers outstanding in hopes of helping both preservice and practicing teachers improve their teaching of mathematics. Preliminary findings indicate that both teachers were (1) reflective practitioners; (2) focused on children's learning of mathematics; (3) focused on the solution methods used by students when working on mathematics problems; (4) believed that all of their students could learn mathematics; (5) were enthusiastic and dedicated to the profession of teaching; and (6) cared deeply about their students and emphasized the necessity of building relationships with students.

083. Student Learning and Related Factors Research Report B

Student Learning and Related Factors Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Philadelphia North Participant:

Characterizing Opportunities for Mathematical and Social Participation: A Micro-Analysis of Equity in Small-Group Zoom Interactions *Heather Fink*, *UC Berkeley* This study focused on issues of equity related to small-group participation in a distance learning calculus class. Equity is defined as the fair distribution of opportunities for students to participate and learn. I examined how opportunities for mathematical and social participation were constructed through acts of positioning for four students. Findings suggest that creating fair opportunities requires: 1) conceptualizing opportunities for participation as connected to students' positionings and developing identities, 2) acknowledging that what counts as an opportunity for one student does not necessarily count as an opportunity for another student, and 3) leveraging both mathematical and social contributions in creating equitable, supportive, and intellectually rich learning communities.

084. Theory and Research Methods Research Report A

Theory and Research Methods Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Philadelphia South

Participant:

From Theory to Methodology: Guidance for Analyzing Students' Covariational Reasoning Brady A Tyburski, Michigan State University; James Drimalla, University of Georgia; Cameron Byerley, Colorado State University; Steven Boyce, Portland State University; Jeffrey Grabhorn, Portland State University; Kevin Moore, University of Georgia

The fields of quantitative and covariational reasoning boast a wide range of powerful theoretical tools, which are described carefully in the literature. Less frequent and explicit attention, however, has been paid to writing down detailed, practical guidance for operationalizing these theoretical constructs. Some guidance is provided by covariational reasoning frameworks, but much is left unsaid concerning the inherent complexities and ambiguities involved in analyzing students' in-the-moment behaviors and what they convey about their covariational reasoning. In an effort to more clearly link theory to analytic methodology, we share three lessons about analyzing students' covariational reasoning to both make research more accessible to newcomers and better address what is often left unsaid in the covariational reasoning literature.

085. Virtual BRR Pre-Service Teacher Education F

Pre-Service Teacher Education Brief Research Report Session

4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Salon 10

Participants:

Fear of failure or lack of motivation? Understanding the mathematics anxiety of elementary preservice teachers *Amy Olson, Duquesne University; Kathleen Jablon Stoehr, Santa Clara University* Mathematics educators agree that elementary teachers should possess confidence and competence in teaching mathematics. Yet many preservice elementary teachers pursue careers in elementary teaching despite repeated experiences of mathematics anxiety. Previous studies of have defined and documented a range of different experiences of mathematics anxiety related both to learning mathematical content and to pedagogical skill to teach mathematics. This study analyzes the reported experiences of forty-eight preservice elementary in relation to the range of different experiences documented in the literature.

Problem Solving In Teacher Preparation: Two Contexts, One Global Scenario / Retos Matemáticos en la Formación de Maestros: Dos Contextos, un Escenario Global Gladys Krause, William and Mary; ADRIANA INES AVILA ZARATE, Universidad Autónoma de Bucaramanga; ELGAR GUALDRÓN PINTO, UNIVERSIDAD DE PAMPLONA

We describe an investigation on the use of mathematical tasks in mathematics methods courses in teacher preparation programs in two contexts: the United States and Colombia. Specifically we elucidate how mathematical tasks influence teacher training. This research supports a larger project identifying how identities as a teacher and global citizen relate to the contribution of mathematics as a science to the development of nations. Preliminary results indicate that mathematical tasks strengthen a positive attitude towards the teaching of mathematics in both contexts. Likewise, we find differences between the contexts that align with characterizations of individualistic and collectivist societies described by different researchers. Describimos una investigación sobre el empleo de retos matemáticos en cursos de métodos de enseñanza de las matemáticas en la formación de maestros de preescolar y primaria en dos contextos: Estados Unidos y Colombia. Nuestro enfoque principal es describir cómo los retos matemáticos influyen en la formación de maestros. Esta investigación es parte de un provecto más grande donde buscamos identificar qué implica ser un maestro y ciudadano global en relación con la incidencia que tiene la matemática como ciencia que aporta al desarrollo de las naciones. Resultados preliminares indican que los retos matemáticos inciden en el fortalecimiento de una actitud positiva hacia la enseñanza de las matemáticas en los dos contextos. Así mismo encontramos diferencias en cada contexto alineadas con caracterizaciones de sociedades individualistas y colectivistas descritas por diferentes investigadores.

086. Virtual RR Mathematical Processes A

Mathematical Processes

Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Salon 2 Participant:

Participant:

Quantitative and Covariational Reasoning as the Basis for Mathematical Structure For Real-World Situations Sindura Subanemy Kandasamy, Texas State University; Jennifer A Czocher, Texas State University

In this paper we address the question, how do quantitative reasoning and covariational reasoning present as students build structural conceptions of real-wrold situations. We use data from an exploratory teaching experiment with an undergraduate STEM major to illustrate the explanatory roles quantitative reasoning and covariational reasoning play in, (a) coordinating more than two interdependent quantities, (b) conceiving of real-world situations in more than one way, (c) constructing networks of quantitative relationships, and (d) creating a mathematical expression. We conclude that quantitative and covariational reasoning influences a modeler's structuring for a real-world situation as he conceives quantities, operates on them, reasons about how they vary with one another and construct a mathematical representation.

087. Virtual BRR Technology A

Technology

Brief Research Report Session 4:20 to 5:00 pm

4.2010 5:00 pm Sheraton: Floor Mezzanine - Salon 3

Participants:

How Middle School Students with Mathematics Learning Disabilities Bootstrap Their Use of Technology *Alayne Armstrong, University of Regina*

Grounded in a learner's perspective, this case study investigates the bootstrapping resources that middle years students with mathematics learning disabilities draw on to use their personal electronic devices to support their mathematical learning. Semi-structured interviews were conducted with 14 participants in two provinces in Western Canada. Using Beretier's categories of bootstrapping resources, the participants' reported uses of technology are discussed. Early findings suggest that participants' bootstrapping behaviors are influenced by the practices and attitudes of those around them, including teachers, family, peers, and even people they observe online.

Sustaining Cognitive Demand with Desmos Technology Victoria Delaney, Stanford University; GIna Kinsey, Stanford University Teachers today are encouraged to incorporate digital technologies into mathematics instruction to build students' technological fluency and deepen mathematical understanding. However, the degree to which students' technology use sustains cognitive demand remains unclear. This study will contribute to the understanding of the complex relationship between technology and cognitive demand by providing a video analysis of an eighth grade mathematics teacher's task launch and the ensuing enactment by students. Findings indicate that technology may raise cognitive demand in potentially transformative ways, although teacher actions and student familiarity with technology also play a role throughout enactment.

088. Virtual BRR PD/In-Service Teacher Education B Professional Development/In-Service Teacher Education Brief Research Report Session

4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Salon 4

Participants:

Building "Small Worlds" in Online Professional Development with Evidence-Based Noticing and Wondering Anthony Matranga, California State University San Marcos; Jason Silverman, Drexel University

Understanding how to design online professional development environments that support mathematics

teachers in developing mathematical and pedagogical knowledge is more important than ever. We argue that productive social and sociomathematical (SM) norms have benefits for teachers' mathematics learning in online asynchronous collaboration and that particular patterns in interactions can create context for the emergence of such norms. We employed social network analysis to compare the emerging social networks of two iterations of an online asynchronous professional development course focused on functions to understand whether particular scaffolds can support the emergence of particular patterns of interactions. Results suggest that evidence-based noticing and wondering can impact the "small world" properties of a social network and associated potential for the emergence of social and SM norms.

Productive Disruption in an Online Professional Development Environment Valerie Klein, Drexel University; Wesley Shumar, Drexel University; Carol Brandt, Temple University; Jason Silverman, Drexel University

The EnCoMPASS project (Emerging Communities for Mathematical Practices and Assessment) at Drexel University has produced a web-based software tool for the assessment of student work. This paper discusses research on the impact of this tool on teachers' attitudes toward work with students in the software environment. The tool supports teacher to take a more dialogic approach to working with students and to engage in the dialectic of problem solving, discussion and mathematical thinking. It is suggested that the tool aids teacher to transition toward this more interactive approach to teaching mathematics while also acknowledging and addressing concerns about the time it takes to engage in more detailed dialogue and thinking about mathematics with their students.

089. Virtual BRR Curriculum, Assessment, and Related Topics A

Curriculum, Assessment, and Related Topics Brief Research Report Session 4:20 to 5:00 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

"I failed to remember what I should have learnt." Resolution of misconceptions during comparative judgement Jennifer Palisse, The University of Melbourne; Deborah King, The University of Melbourne; Mark MacLean, The University of British Columbia

Comparative judgment is a relatively new assessment approach. It involves assessing students' work in pairs from which assessors judge which of the two solutions is 'better'. We explore the use of comparative judgement as a pedagogical tool where students evaluate other students' work. We are interested in whether comparative judgement leads to improvements in either the quality of students' written work, or improvements in students' mathematical understanding. We report on pilot study results where undergraduate students compared solutions to a rational inequalities problem.

Validating an Assessment of Students' Covariational Reasoning Heather Lynn Johnson, University of Colorado Denver; Gary Olson, University of Colorado Denver; Amy Smith, CU Denver; Amber Gardner, University of Colorado Denver; Xin Wang, RMC Research; Courtney Donovan, University of Colorado Denver In this mixed methods study, we validated a fully

In this mixed methods study, we validated a fully online assessment of students' covariational reasoning. We combined qualitative and quantitative methods to analyze 30 responses from undergraduate college algebra students during individual task based interviews. Our findings were statistically significant; students' total number of items correct could be explained by their evidence of covariational reasoning. We conclude with discussion of our work moving forward.

090. Virtual RR Pre-Service Teacher Education A

Pre-Service Teacher Education

Research Report Session

4:20 to 5:00 pm

Sheraton: Floor Mezzanine - Salon 6

Participant:

Exploring Connections Between Prospective Teachers' Views of Authority and Experiences in Justification Brenda Rosencrans, Portland State University; David Brown, Portland State University; Diana G Salter, Portland State University; Eva Thanheiser, Portland State University

The purpose of this project was to understand how implicit views of authority support or limit prospective elementary teachers' (PTs) mathematical activity of justifying and to understand how the experience of justifying might support a development of an internal source of authority. In this case study of 18 PTs, we coordinate an analysis of 1) their responses to two justification tasks and 2) interview transcripts in which they discuss their experiences in learning to justify. Preliminary results indicate ways in which their views of authority limited their reasoning about mathematics by not recognizing their own sense-making and supported a sense-making exploration of mathematics that was freeing and empowering. These results provide mathematics teacher educators with insight to help them identify and address limiting views of authority and leverage productive views of authority.

Friday, 5:00-6:00pm – Poster Session See Appendix 2 for Poster Titles, Abstracts, and Locations

091. Friday Poster Session

Poster Session 5:00 to 6:00 pm Sheraton: Floor Ballroom Level - Liberty Ballroom A

092. Student Reception

6:00 to 8:00 pm

Con Murphy's Irish Pub: Upstairs Reception Room Join us for happy hour and appetizers at Con Murphy's Irish Pub (1700 Benjamin Franklin Parkway) in the upstairs reception room! This event is included in conference registration for all students (graduate and undergraduate).

SATURDAY, OCTOBER, 16

093. Morning Coffee/Tea & Snacks

8:40 to 9:00 am

Sheraton: Floor Ballroom Level - Ballroom Lobby

094. Virtual Poster Session

Visit <u>https://cvent.me/9Kn5NL</u> to participate in the asynchronous virtual poster session. Virtual poster pdfs and videos will be available for viewing throughout the whole conference, and you can ask questions through the conference hub.

Saturday, 9:00-9:40am - Research Sessions

095. Pre-Service Teacher Education Brief Reports I

Pre-Service Teacher Education Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom E

Participants:

Pre-Service Mathematics Teachers Identify Critical Events: What Changes in Their Attention? Sigal Hava Rotem, University of Haifa; Michal Ayalon, University of Haifa

This study explores the changes in pre-service mathematics teachers' attention to critical events within the context of a year-long teachers' preparation program in which noticing critical events was a key preparation tool. We asked 20 pre-service teachers to identify and describe critical events they witnessed during school observations/teaching. We then used an empirical and theoretical-based model developed to explore the ways in which pre-service teachers changed their attention to these critical events. Our findings reveal that the pre-service teachers' foci of attention were broadened; they were attentive to more details, especially to students' affect. We demonstrate these findings using the case of Nasim.

Teacher Candidates' Construction of Characters in Scripts Matthew P Campbell, West Virginia University; Erin E. Baldinger, University of Minnesota; Josh Karr, West Virginia University; Sean P. Freeland, West Virginia University Scripting tasks are a commonly used pedagogy in which teacher candidates (TCs) are presented with a scenario and asked to write a dialogue continuing the discussion. Little attention has been paid to the students that TCs imagine as part of the script. We describe our initial efforts to attend to the students constructed in scripts in which we observed multiple character traits and ways such traits can coalesce into recognizable characters. This work suggests the importance of intentionally considering various aspects of the scripts as part of efforts to reveal TCs' perceptions of students and the resources TCs bring to the work of teaching.

096. Mathematical Processes Research Report D Mathematical Processes Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom F

Participant:

Theo's reinvention of the logic of conditional statements' proofs rooted in set-based reasoning Paul Christian Dawkins, Texas State University; Kyeong Hah Roh, Arizona State University; Derek Eckman, Arizona State University; YOUNGKEE CHO, Texas State University

This report documents how one undergraduate student used set-based reasoning to reinvent logical principles related to conditional statements and their proofs. This learning occurred in a teaching experiment intended to foster abstraction of these logical relationships by comparing the predicate and inference structures among various proofs (in number theory and geometry). We document the progression of Theo's emergent set-based model from a model-of the truth of statements to a model-for logical relationships. This constitutes some of the first evidence for how such logical concepts can be abstracted in this way and provides evidence for the viability of the learning progression that guided the instructional design.

097. Mathematical Content Later Years Research Report A

Mathematical Content Later Years (Grades 9-12+) Research Report Session

9:00 to 9:40 am Sheraton: Floor Mezzanine - Freedom G

Participant:

Analytic Equation Sense: a Conceptual Model to Investigate Students' Algebraic Manipulation Yufeng Ying, University of Georgia; Kevin Moore, University of Georgia

In this paper, we propose a new construct named analytic equation sense to conceptually model a desired way of reasoning behind students' algebraic manipulations and use of equivalent expressions. Building from the analysis of two existing models in the field, we argue for the need for a new model and use empirical evidence to explain the new model.

098. Pre-Service Teacher Education Research Report F

Pre-Service Teacher Education

Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Freedom H

Participant:

Opportunities to Learn in Cycles of Enactment and Investigation Fran Arbaugh, The Pennsylvania State University; Duane Graysay, Syracuse University; Ben Freeburn, Western Michigan University; Nursen Konuk, Metropolitan State University of Denver

Using an opportunity to learn (OTL) lens, this study investigated one Cycle of Enactment and Investigation (CEI) enacted in a secondary mathematics methods course. Analyzing course artifacts and final interviews, we found that the PTs had OTL in all six nodes of the CEI, that OTL differed across the nodes, and that OTL in later nodes depended on knowledge built in previous nodes. Implications include the importance of PTs engaging in all nodes of a CEI to maximize OTL about mathematics teaching practices, mathematics, students, and learning.

099. Pre-Service Teacher Education Research Report G

Pre-Service Teacher Education Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Independence A Participant:

Prospective Mathematics Teachers' Designed Manipulatives As Anchors For Their Pedagogical and Conceptual Knowledge Denish Ogweno Akuom, Montclair State University; Steven Greenstein, Montclair State University Positioning teachers as designers of curricular resources invites opportunities for exploration at the intersection of content, pedagogy, and design. As researchers accepting greater responsibility for preparing teachers to maintain a commitment to their pedagogical vision in practice, this work seeks to cultivate the imagination of humanistic forms of mathematics teaching and learning by supporting these explorations. Toward that end, this paper reports on research that examines connections between the pedagogical/conceptual knowledge that prospective teachers embed in the designs of original manipulatives and how those designs mediate the pedagogical moves they make in teaching situations. The promise of this work is that these connections may reveal a viable means to support bolder connections between teacher preparation and practice. Implications of our findings for teacher preparation are considered.

100. Equity and Justice Research Report B

Equity and Justice Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Independence B Participant:

Participant:

Narratives of Raza in Mathematics Education Research Literature/Narrativas De La Raza En La Literatura De Investigación De Educación Matemática Stacy R Jones, The University of Texas at Austin; Carlos Nicolas Gomez Marchant, The University of Texas at Austin We present a finding from a literature analysis of Raza populations published in top-tiered peer reviewed mathematics education journals. We look at how narratives are perpetuated and resisted at the intersections of Raza, mathematics education, and research. Our findings reveal the field of mathematics education research is perpetuating deficit narratives of Raza through 1) simplistic descriptions of Raza which perpetuate a racial hierarchy; 2) white institutional spaces group, order, and Americanize Raza populations; and 3) counter-stories of La Raza. We will only concentrate on the first finding for this presentation. The examined literature continues to center Anglos' narratives and values while maintaining a social hierarchy and assimilate and Americanization of La Raza. Finally, we provide implications for disseminating research to go beyond simplistic demographics of social constructs.

101. Student Learning and Related Factors Research Report J

Student Learning and Related Factors Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Independence C Participant:

The Evolution from Linear to Exponential Models when Solving a Model Development Sequence *Luis Emmanuel Montero-Moguel, University of Texas at San Antonio; Veronica Vargas-Alejo, University of Guadalajara; Guadalupe Carmona, University of Texas at San Antonio*

This article describes the results of an investigation based on Models and Modeling Perspectives [MMP]. The evolution of the models built by undergraduate students is presented when solving a model development sequence designed to elicit their conceptualization of exponential functions. As a result, it was observed that students' thinking was modified, expanded and refined, as their models evolved during their participation in the model development sequence. First, the students created linear function models that required redirection, later, they began to dissociate linear and exponential variation, then they began eliciting ideas on exponential variation that were more situated, and finally, students' solutions evolved towards shareable and reusable exponential models.

102. Mathematical Content Early/Middle Years Brief Reports D

Mathematical Content Early/Middle Years (Grades preK-8)

Brief Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Independence D

Participants:

"El modelo de línea numérica como espacio de representación homogénea" Sharon Samantha Membreño Estrada, CINVESTAV-IPN; Claudia Margarita Acuña, Centro de Investigación y Estudios Avanzados del IPN

En este trabajo se investiga el tránsito de los signos utilizados desde índices hasta símbolos en tareas de desigualdades numéricas e inecuaciones lineales, con apoyo del modelo de la recta numérica. En el estudio de caso, observamos que la estudiante tenia buen manejo de la numerabilidad, sin embargo, no fue suficiente para determinar el conjunto solución dadas dos inecuaciones simultáneas. Lo que fue resuelto producto de una práctica reflexiva que permitió usar los segmentos con propiedades matemáticas a través de una mediación semiótica, de manera que este modelo funcione como un espacio de representación homogéneo.

Positive Outcomes of a Student's Struggle with Negatives Zarina Gearty, University of Massachusetts- Dartmouth

Operations with negative numbers are taught to students several years after only dealing with positive numbers. However, only one unit of one year is devoted to learning and becoming proficient in operating with both negative and positive numbers. This particular study reports on a student who has been taught the concept of negative numbers but not formally introduced to strategies or rules for operations. During clinical interviews, the student was given open number sentences and asked to explain how she would solve for missing values. Her explanations reveal that working with adding and subtracting negative numbers was a form of productive struggle that had potential to build connections and illuminate mental inconsistencies. These type experiences could be beneficial for both students and teachers.

103. Technology Research Report B

Technology Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Philadelphia North Participant:

Participant

Dynamic spatial diagrams and solid geometric figures Camden Glenn Bock, The University of Maine: Justin Dimmel. University of Maine This paper reports on a study of learners' use of immersive spatial diagrams to make arguments about three-dimensional geometric figures. Immersive spatial diagrams allow learners to use the movement of their bodies to control their point of view, while immersed in three-dimensional digital renderings. We present analysis of two pairs of pre-service elementary teachers' argumentation about the shearing of pyramids, using the ck¢-Enriched Toulmin Model of Argumentation (Pedemonte & Balacheff, 2016) to link the affordances of immersive spatial diagrams to the learners' mathematical reasoning. We share how one pair of learners took points of view bending beside and standing within the pyramid to describe how the space inside is transformed without reference to one- or twodimensional components of the representation.

104. Theory and Research Methods Research Report D Theory and Research Methods

Theory and Research Method

Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Philadelphia South Participant:

Revealing Mathematical Activity in Non-Formal Learning Spaces Caro Williams-Pierce, University of Maryland; Nihal Katirci, University of Maryland; Amber Simpson, Binghamton University; Ekta Shokeen, University of Maryland; Janet Bih, University of Maryland We offer this synthesized framework as a tool to reveal mathematical activity in a non-formal makerspace. In particular, we connected research at different grain sizes to illustrate and explain how mathematics plays a crucial, if often implicit, role in this activity. We begin with describing the Approximate Number System and the Ratio-Processing System, explain how those systems connect to both embodied cognition and Thompson's (1994) conceptualization of quantities. We then examined how prediction and anticipation relate, with a particular emphasis on how social feedback guided the emergent mathematical activity. Finally, we synthesize across the two frameworks, in order to better reveal mathematical activity in low-notation environments, as the first step towards a framework for understanding mathematical learning in nonformal and low-notation contexts.

105. Virtual BRR Teaching and Classroom Practice C Teaching and Classroom Practice Brief Research Report Session 9:00 to 9:40 am

Sheraton: Floor Mezzanine - Salon 10 Participants:

- Analysis of Teacher Actions to Promote Generalizing Allyson Hallman-Thrasher, Ohio University; Susanne Strachota, University of Wisconsin-Madison; Jennifer Thompson, Ohio University This study analyzes the instruction of one teacher in two classroom episodes. We analyzed the teacher's instruction using a framework for whole-class discourse and a framework for identifying activity that supports generalizing. Across both episodes when priming and particularly generalizingpromoting activity increased, students' generalizing activity also increased. We observed an increase in the number and quality of questions and student contributions in the episode with more student generalizations. Similarly, the responsibility for questioning and thinking shifted from teacher to student as more students responded to requests for justification. Avenues of future research include identifying productive small group practices that support generalization. Implications discuss focal points for inservice teachers and teacher educators aiming to bolster their understanding of how to support students' generalizing.
- Supporting Improvement Efforts in Tertiary Instruction: The Case of Charles as a Bricoleur Amy Been Bennett, University of Nebraska-Lincoln

The French anthropological notion of bricolage has been used as a research framework to describe various phenomena, but rarely to describe teaching mathematics. In this study, one college mathematics instructor, Charles, positions himself as an expert when lecturing, but acts as a bricoleur, or do-ityourself craftsperson, when teaching via active learning. The case of Charles illustrates the obstacles that many experienced lecturers encounter as they attempt to transition to evidence-based instructional practices and reframes the efforts of teachers as bricoleurs with an anti-deficit perspective. This paper provides implications for tertiary institutions wanting to support instructors who wish to improve their pedagogy.

106. Virtual RR Theory and Research Methods B

Theory and Research Methods Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 2

Participant:

A Conceptual Synthesis on Approximations of Practice *Bima Kumari Sapkota, Purdue University; Brooke Max, Purdue University* Approximations of practice create valuable opportunities for preservice teachers (PSTs) by engaging them in components of teaching. By reviewing the literature, this study explored PSTs' learning through approximations and the extent approximated practices preserve the complexity – or authenticity – of teaching. A review of 25 empirical studies related to approximations of mathematics teaching indicated that mathematics teacher educators are currently exploring an expansion of opportunities through approximations wherein PSTs could experience a higher degree of authenticity. The existing conceptualization of authenticity emphasizes the complexity of practices but overlooks how approximated practices prepare PSTs for their future teaching. An alternative definition is proposed for the emerging conceptualization of authenticity to highlight how PSTs' learning through approximations prepares them for their future teaching.

107. Virtual RR Theory and Research Methods A

Theory and Research Methods Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 3

Participant:

Identifying graphical forms used by students in creating and interpreting graphs Jon-Marc Gregory Rodriguez, University of Iowa; Steven Jones, Brigham Young University In this paper, we describe a framework for characterizing students' graphical reasoning, focusing on providing an empirically-based list of students' graphical resources. The graphical forms framework builds on the knowledge-in-pieces perspective of cognitive structure to describe the intuitive ideas, called "graphical forms", that are activated and used to interpret and construct graphs. In this study, we expand on the current knowledge base related to the specific graphical forms used by students. Based on data involving pairs of students interpreting and constructing graphs we present a list of empirically documented graphical forms and organize them according to similarity. We end with implications regarding graphical forms' utility in understanding how students construct graphical meanings and how instructors can support students in graphical reasoning.

108. Virtual RR Mathematical Knowledge for Teaching A

Mathematical Knowledge for Teaching Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 4

Participant:

Teachers' Representational and Contextual Justifications for Selecting Pedagogical Representations *Erik Jacobson, Indiana* University; Jinqing Liu, Indiana University; Pavneet Kaur Bharaj, Indiana University Bloomington; Theodore Michael Savich, Indiana University

There have been many efforts to measure pedagogical content knowledge with multiple-choice survey instruments, but little is known about how different types of items contribute. In this study, we examined interviews with 9 Grade 4 teachers to develop a deeper understanding of how teachers select pedagogical representations in the context of a survey assessment. Our analysis revealed two broad themes: representational justification (focused on how teachers interpreted features of the representation) and contextual justification (focused on how teachers considered their students and their own perspectives and experiences). These results indicated that content and pedagogical knowledge were highly intertwined in teachers' work on these tasks. However, the results also identify limitations for using this item type to measure teachers' pedagogical content knowledge in mathematics. Implications are discussed.

109. Virtual BRR PD/In-Service Teacher Education A

Professional Development/In-Service Teacher Education Brief Research Report Session

9:00 to 9:40 am

Sheraton: Floor Mezzanine - Salon 5

Participants:

An Exploration of Coach-teacher Interactions During Modeling Evthokia Stephanie Saclarides, University of Cincinnati; Jen Munson, Northwestern University

Drawing on six coach-teacher dyads' interactions (n=295) across 25 lessons, this study examines the foci and depth of coach-teacher modeling interactions. Qualitative analyses revealed six types of coach-teacher interactions, and two levels of depth that take into account the extent to which reasoning about content, pedagogy, and students was made evident during coach-teacher interactions. Implications for future research as well as practice are provided.

The Influence of Positionality on Coaches' Opportunities for Professional Learning Britnie Delinger Kane, The Citadel; Evthokia Stephanie Saclarides, University of Cincinnati Content-focused coaching is highly complex work, yet little is known about how such coaches develop the expertise needed to successfully support teaching and learning in schools. This discourse analysis explored one group of elementary mathematics coaches' learning opportunities while collaboratively engaging in mathematics. Drawing on video and interview data from coaches and their district leader. our analysis highlights that coaches' discursive positioning influenced the types of coaching expertise they were able to develop while engaging collaboratively in mathematics. Implications for future research and practice are discussed.

110. Virtual BRR Teaching and Classroom Practice B

Teaching and Classroom Practice Brief Research Report Session 9:00 to 9:40 am Sheraton: Floor Mezzanine - Salon 6 Participants:

Factors Influencing the Instructional Planning of Secondary Statistics Teachers *Taylor Ray Harrison, Northwest Missouri State University* An examination of the decision-making process of secondary statistics teachers and the beliefs these teachers draw on when planning statistics instruction. Particular attention is paid to contextual factors that result in instruction that is not consistent with teachers' beliefs.

Impact of Lesson Design on Mathematical Questions Rashmi Singh, Boston University; Hector Ivan Nieves, Boston University; Erin Barno, Boston University; Leslie Dietiker, Boston University How does the design of lessons impact the types of questions teachers and students ask during enacted high school mathematics lessons? In this study, we present data that suggests that lessons designed with the mathematical story framework to elicit a specific aesthetic response ("MCLEs") having a positive influence on the types of teacher and student questions they ask during the lesson. Our findings suggest that when teachers plan and enact lessons with the mathematical story framework, teachers and students are more likely to ask questions that explore mathematical relationships and focus on meaningmaking. In addition, teachers are less likely to ask short recall or procedural questions in MCLEs. These findings point to the role of lesson design in the quality of questions asked by teachers and students.

111. Morning Break and Snacks

9:40 to 10:05 am Sheraton: Floor Ballroom Level - Ballroom Lobby

Saturday, 10:05-11:35am

Working Groups (See Appendix 1 for Abstracts)

112. Group Discussions Discussion Group Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom E

113. Coaching the Coaches and Other Efforts to Develop Mathematics Teacher Educators for Inservice Teachers Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom F

114. Complex Connections: Reimagining Units Construction and Coordination Working Group

10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom G

115. Gender and Sexuality in Mathematics Education: Emerging Conceptual and Methodological Frameworks Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Freedom H

116. Authenticity in Mathematics Education Assessment Working Group 10:05 to 11:35 am Online Working Group – Join through conference hub

Online Working Group – Join through conference hub at <u>https://cvent.me/9Kn5NL</u>

117. Conceptions and Consequences of What We Call Argumentation, Justification, and Proof Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence B

118. Using Self-Based Methodologies to Unpack Mathematics Teacher Educators' Work Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence C

119. Creating space for productive struggle toward a more equitable future: Persevering through challenges from within Working Group

10:05 to 11:35 am Sheraton: Floor Mezzanine - Independence D

120. Mathematics Curriculum Recommendations for Elementary Teacher Preparation Working Group 10:05 to 11:35 am

Sheraton: Floor Mezzanine - Philadelphia North

- 121. Mathematical Play: Across Ages, Context, and Content Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Philadelphia South
- 122. Continuous Improvement Lesson Study Working Group/Grupo de Trabajo en La Mejoramiento Continua del Estudio de Lecciones Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 10

123. Preservice Teacher Learning of Practice Through Simulated Teaching Experiences Before, During & After COVID Working Group 10:05 to 11:35 am Online Working Group – Join through conference hub at <u>https://cvent.me/9Kn5NL</u>

124. Statistics Education: New Connections and Future Directions / EDUCACIÓN ESTADÍSTICA: NUEVAS CONEXIONES Y FUTURAS DIRECCIONES Working Group 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 3

125. Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium Research Colloquium 10:05 to 11:35 am Sheraton: Floor Mezzanine - Salon 5

126. Models and Modeling Perspectives Research Colloquium Research Colloquium 10:05 to 11:35 am Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

Saturday, 11:45am-12:25pm – Research Sessions

128. Mixed BRR Session E Two or More Strands Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Freedom E Participants: Challenging an Affective Binary in Mathematics Education Abhinav Ghosh, Harvard University A long-standing focus on quantitatively measuring affective responses in mathematics education research has created a binary perspective of seeing affect as either positive or negative. In this paper, I examine this through a preliminary analysis of research on affective responses in the latter half of
the 20th century in the United States. Subsequently, I problematize this affective binary, not just for its limited theorization of affect, but also for the exclusionary mechanisms it enables in the form of comparison, surveillance, and intervention.

Three Steps Forward: Validity Evidence For The PSM3 Jonathan David Bostic, Bowling Green State University; Toni Ann Sondergeld, Drexel University; Gabriel Matney, Bowling Green State University; Gregory Ethan Stone, MetriKs Amerique LLC

An purpose of this submission is to discuss validity evidence related to a third-grade problem-solving measure (PSM3). The PSM3 is connected to a series of tests designed to measure students' problemsolving performance aligned with the Common Core State Standards for Mathematics. Multiple validity sources are drawn together to support the PSM3's interpretations and uses.

129. Pre-Service Teacher Education Research Report E

Pre-Service Teacher Education Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Freedom F

Participant:

Impact of Mediated Field Experiences On Teacher Candidates' Self-Reported Learning: A Multi-Institutional Descriptive Pilot Study Barbara Swartz, West Chester University; Esther M Billings, Grand Valley State University; Melinda Knapp, Oregon State University - Cascades Campus; Holly Henderson Pinter, Western Carolina University; Sararose Lynch, Westminster College

Mediated Field Experiences (MFEs) provide teacher candidates (TCs) structured opportunities to unpack and enact core teaching practices, gain mathematics content and pedagogical knowledge, and reflect critically on mathematics teaching and learning. In this paper we present findings from a multiinstitutional descriptive pilot study that investigates the impact of MFEs on TC learning. TCs reported that they (1) deepened their understanding of the targeted core teaching practice(s), (2) developed a vision of ambitious mathematics teaching, (3) recognized the importance of cultivating a positive classroom learning community, and (4) increased their confidence when teaching after their completion of a one-term course implementing MFEs.

130. Teaching and Classroom Practice Brief Reports A

Teaching and Classroom Practice Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Freedom G Participanta

Participants:

An Exploration of Teachers' Why-Questions in the Mathematics Classroom Kathleen Melhuish, Texas State University; Simon Byeonguk Han, Portland State University; M. Alejandra Sorto, Texas State University; Sharon Strickland, Texas State University

Teacher's why-question can press students toward justification, make sense of mathematical structure, and make students' thinking visible to others.

However, the productivity of why-questions hinges on their underlying purpose. In this presentation, we illustrate our framework of underlying purpose of why-question by examining 153 why-questions from 49 classroom videos (grade 4th-8th). While a particular question can appear similar in content, the expected student responses ranged significantly and thus we argue for two implications. First, as researchers, coarsely defining question types by categories such as "why" may be insufficient to tie a teacher move to a particular functional purpose. Second, if we want why-questions to cue students to provide mathematical domain explanations (justifications), there is a need to better understand what classroom/discourse factors lead to productive why-question use.

Development of Teachers' Press for Contextualization to Ground Students' Understanding Luke Reinke, UNC Charlotte; Michelle Stephan, UNC Charlotte We investigate the development of a teaching practice called pressing for contextualized operating, which is teacher questioning aimed at grounding students' mathematical activity to their understanding of the problem context. We found significant differences in two teachers' facilitation of class discussions after making the teachers aware of the learning opportunities that pressing for contextualized operating provides. The teachers demonstrated similar patterns in their development of their practice, both exhibiting a phase where contextual backing for mathematical activities were elicited through leading questions. We also provide descriptions of more student-centered approaches to contextual press that the teachers developed, as they experimented with the practice.

131. Curriculum, Assessment, and Related Topics Brief Reports C

Curriculum, Assessment, and Related Topics Brief Research Report Session

11:45 to 12:25 pm Sheraton: Floor Mezzanine - Freedom H Participants:

Productive Mathematical Meanings as a Guide to Analyzing Algebra Textbooks Lori Burch, Indiana University; Erik S Tillema, Indiana University; Jennifer Lynn Cox, Indiana University; Iwan Andi Jonri Sianturi, Indiana University; Selim Yavuz, Indiana University; Matthew Hardee, Indiana University

Thompson (2015) has proposed that a productive mathematical meaning is a meaning that prepares students for future learning and lends coherence to extant meanings. We use this definition to propose that a productive mathematical meaning in the area of expanding algebraic expressions and factoring polynomials revolves around developing an understanding of structural relationships between (binomial) factors and polynomials. We then give a brief outline of a combinatorial and quantitative approach to support the development of such relationships that can grow from such an approach. Once we have elaborated on a productive mathematical meaning for expanding and factoring, we analyze four Algebra 1 and Algebra 2 textbooks to investigate their approach to these topics. Our findings suggest that significant curricular

development work is needed to support productive mathematical meanings in this domain.

Use of Teacher-Created Curricular Resources by Elementary Mathematics Teachers: Before and During the Covid-19 Pandemic Marcy B Wood, University of Arizona; Mona Baniahmadi, Duquesne University; Kristin Giorgio-Doherty, Michigan State University; Kaitlyn B Sammons, Purdue University; Corey Drake, Michigan State University; Jill Newton, Purdue University; Amy Olson, Duquesne University; Kristen E. Ferguson, Purdue University

This study explores the use of third through fifth grade mathematics curricular resources before and during the COVID-19 pandemic. Before the pandemic, researchers reported on a shift from boxed curricular materials made by major educational publishing houses toward online resources including teacher-created resources such as Teachers Pav Teachers and Pinterest. In order to learn more about this trend and others developing during the pandemic, we administered a survey to a national sample of elementary teachers. The survey shows the prevalence and increase of teacher-created materials during the pandemic. This has implications for researchers and administrators as they consider to how to best support teachers in selecting, designing, and adapting their own curricular materials, especially for diverse learning contexts.

132. Teaching and Classroom Practice Brief Reports F

Teaching and Classroom Practice Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Independence A

Participants:

Examining Productive Struggle in Math 1 Classrooms using Mathematical Language Routines Cameron John Dexter Torti, University of California, Santa Barbara; Tomy Nguyen, University of California Santa Barbara; Royce Olarte, University of California Santa Barbara; Sarah A. Roberts, University of California, Santa Barbara; Julie A Bianchini, University of California, Santa Barbara

- This study examines how implementing mathematical language routines affected multilingual learners in Math 1 classrooms engaged in productive struggle. We used three complementary theoretical frameworks - productive struggle, mathematical language routines, and reform-based instruction for multilingual learners to examine two co-taught special education Math 1 classes, investigating video data qualitatively from one student in each class. We found a noted difference in productive struggle between lessons taught prior to the introduction of the mathematical language routines and the lessons in which teachers implemented the mathematical language routines. This study shows how researchers and teachers participating in professional development improved instructional practices and student learning outcomes.
- Examining the Relationship Between Ambitious Instruction and Culturally Responsive Teaching in Elementary Mathematics Casedy Ann Thomas, The University of Alabama

Mathematics education research has yet to reach a consensus on what ambitious instruction looks like in practice with historically marginalized learners. This mixed methods study examines the relationship between ambitious instruction and culturally responsive teaching (CRT) in elementary mathematics classrooms. The first phase of this study incorporated a multi-case study to understand how three teachers who have been certified in CRT by professional development opportunities within their district are implementing CRT. In the second phase of the study, a quantitative observation measure was used to examine the standards-based mathematics teaching practices of the three teachers. The findings suggest that effective mathematics teaching practices are foundational to implementation of CRT and examine dimensions of ambitious instruction that support CRT in practice.

133. Equity and Justice Research Report C

Equity and Justice

Research Report Session 11:45 to 12:25 pm

Sheraton: Floor Mezzanine - Independence B Participant:

Storylines in news media texts: A focus on mathematics education and minoritized groups Annica Andersson, University of Southeastern Norway; Beth Herbel-Eisenmann, Michigan State University; Hilja Lisa Huru, UiT The Arctic University of Norway; Ulrika Ryan, USN; David Wagner, University of New Brunswick We identify storylines about youth from minoritized cultures and/or languages in Norwegian news media to identify positionings made available to migrated and Indigenous mathematics students in this public discourse. Our search from 2003-2020 in a Norwegian media database including newspapers, journals, tabloids, etc, identified 1896 articles, reduced to 96 for relevancy. These storylines were identified: 'The majority language and culture are keys to learning and knowing mathematics', 'Mathematics is language- and culture-neutral', 'Minoritized mathematics students are motivated by gratitude', 'Extraordinary measures are needed to teach students from minoritized groups mathematics', 'Students from minoritized groups must put in extraordinary effort to learn mathematics', 'Students from minoritized groups' mathematics achievements are linked to culture and gender', and 'Students from minoritized groups underachieve'

134. Pre-Service Teacher Education Research Report J Pre-Service Teacher Education

Research Report Session

11:45 to 12:25 pm Sheraton: Floor Mezzanine - Independence C

Participant:

Task Development to Address Error Patterns in Prospective Teachers' Posing of Multi-Step Word Problems Alexandra Lair Foran, Texas A&M University; Rachael Mae Welder, Texas A&M University; Ashley Marrie Williams, Texas A&M University

National and state standards in the US have emphasized the importance of solving and posing word problems in students' mathematics learning for decades. Therefore, it is essential for prospective teachers (PTs) to have the mathematical knowledge necessary to teach these skills to their future students. Unfortunately, little research has investigated how PTs develop problem-posing skills. By employing thematic qualitative text analysis, the researchers identified nine distinct patterns in errors identified in K-8 PTs' posing of two-step addition and subtraction word problems, in the context of a collegiate teacher education course. These results were used to inform the initial design of an interventional task to bring awareness of common errors to PTs.

135. Virtual BRR Mixed Session G

Two or More Strands Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Independence D

Participants:

How Preservice Teachers (PSTs) Grapple with the Concept of Mathematical Modeling *Reuben* Asempapa, Penn State Harrisburg; Derek Sturgill, University of Wisconsin-Stout; Yasemin Gunpinar, St. Catherine University

Mathematical modeling is an important skill and process to solve real-life problems but a source of concern for the preparation of preservice teachers (PSTs) in teacher education programs. In this session, participants will learn about an empirical research designed to investigate how preservice teachers (PSTs) grapple with the concept of mathematical modeling. The audience will be engaged in the research process, the experiences of collecting and analyzing data, and the interesting results or outcomes of the study. The results of this study have implications for mathematics education researchers and teacher education programs.

Mathematical Modeling Competency in Upper-Elementary: Validity Evidence at the Item Level James Smith, University of Arizona; Erin Turner, University of Arizona; Amy Roth McDuffie, Washington State University

Mathematical modeling is a high-leverage topic that involves connecting real-world situations, phenomenon, and/or data with mathematical models. Despite broad consensus of its importance in K-12 mathematics curriculum, instruments measuring mathematical modeling in elementary grades have remained scarce. We addressed this need by designing the Mathematical Modeling Student Assessment (MMSA) for students in grades 3 through 5. In this brief report, we investigate evidence supporting the use of the MMSA for these targeted grades by performing differential item functioning (DIF; Penfield & Camilli, 2006) to investigate potential bias which may impact score interpretations. We describe results and discuss implications for the use of the MMSA, as well as future measurement of elementary mathematical modeling.

136. Mathematical Processes Brief Reports A Mathematical Processes Brief Research Report Session *11:45 to 12:25 pm Sheraton: Floor Mezzanine - Philadelphia North* Participants: From Number Lines to Graphs: A Middle School Student's Re-Organization of the Space *Halil Ibrahim Tasova, California State University San Bernardino; Kevin Moore, University of Georgia* In this paper, we report on developmental shifts of a middle school student's (Ella) graphing activity as we implement an instructional sequence that emphasizes quantitative and covariational reasoning. Our results suggest that representing quantities' magnitudes as varying length of directed bars on number lines supported Ella re-organizing the space consistent with a Cartesian plane.

Middle Schoolers' Use of Representations in Problem-Solving around Slope Allison L. Gantt, University of Delaware

In this study, I examine how the construction and use of representations might relate to the learning process in a problem-solving task about slope. I conducted two task-based interviews with eighth-grade students who had not yet engaged in formal study of slope to explore this relationship. I highlight one case for each student during which construction of a new representation (specifically a table or graph) coincided with a shift in their problem-solving approach, which I operationalize as student use of a representation. I discuss the implications of these moments in generating opportunities to learn.

137. Policy, Leadership, and Misc Research Report A Policy, Leadership, and Miscellaneous Topics Research Report Session *11:45 to 12:25 pm*

11:45 to 12:25 pm Sheraton: Floor Mezzanine - Philadelphia South

Participant:

Mathematical Mothers: Investigating Shifts in Perspective Around What Counts as Mathematics Sam Prough, University of Wisconsin-Madison Bridging the gap between mathematical learning at home and school has been an issue for education research for decades (Galindo & Sheldon, 2012). Expectations for mathematics do not often align for teachers and parents (Posey-Maddox & Hayley-Lock, 2016) and a limited view of what counts as mathematics persists. What needs more attention is the meaningful mathematical learning that happens at home but is rarely seen as mathematics. Parents frequently struggle in supporting their children's mathematical learning, but that struggle becomes productive when parents are recognized as mathematically capable. This paper shows how two mothers shift their perspectives of what counts as mathematics and recognize the rich content in their current interactions with young children. Making such connections between mathematics and parent action can strengthen the relationship between athome and school learning.

138. Virtual BRR PD/In-Service Teacher Education D

Professional Development/In-Service Teacher Education Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Salon 10 Participants: High school teachers' thinking about the limit concept Beste Gucler, University of Massachusetts Dartmouth

Facilitating meaningful discourse is a component of

supporting productive struggle. To facilitate meaningful discourse in their classrooms, teachers need to be aware of and reflect on their own mathematical discourses and communication. This study examines one pre-service and seven in-service high school teachers' thinking about the limit concept in a calculus content course they took as part of their professional development. The course focused on eliciting teachers' discourses on limits and make them explicit topics of discussion and reflection to support teacher thinking and communication. The results indicate that the approach has the potential to support teacher thinking and increase awareness of their mathematical discourses and communication. The study concludes that it is important for teachers to engage in productive struggle to use it as a practice in their own classrooms.

How Adjunct Instructors' Perceptions about Implementing Research-based Mathematics Curriculum may Influence their Professional Development Needs Zareen Gul Rahman, James Madison University

When planning professional development (PD) for adjunct instructors the PD developers should be mindful of the diverse experiences and needs of adjunct instructors. Developing PD that is one-sizefits-all may not work for all adjunct instructors. In this study the diversity of 3 adjunct instructors' experiences is highlighted prior to and in the initial stages of implementing a new research-based Precalculus curriculum. This work draws from a larger study (Author, 2018) about adjunct instructors' experiences navigating a new mathematics curriculum.

139. Virtual RR Teaching and Classroom Practice B

Teaching and Classroom Practice Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Salon 2

Participant:

Exploring Teachers' Responsiveness to Children's Fraction Thinking and Relationships to Fraction Achievement Susan B Empson, University of Missouri; Victoria R. Jacobs, University of North Carolina at Greensboro

Identifying components of teaching that make a difference in children's learning is an ongoing challenge in our field. Focusing on teaching that is responsive to children's fraction thinking, we decomposed responsiveness into the instructional practices of questioning to support and extend children's thinking, noticing children's thinking, and anticipating children's thinking. We worked with 49 teachers in grades 3-5 in multiyear professional development and assessed their expertise in each of the practices. We also assessed their students' fraction achievement at the beginning and end of the school year. Correlational analyses revealed significant moderate relationships among teachers' expertise in the three practices, and a multilevel regression analysis revealed significant positive relationships for both expertise in teacher questioning and years of professional development with children's fraction achievement.

140. Virtual RR Teaching and Classroom Practice C Teaching and Classroom Practice Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Salon 3

Participant:

Noticing for Equity in Written Work: Exploring One Teacher's Student Work Analysis Practices Miriam S Leshin, Stanford University Attending to students' thinking and using it to inform instruction has been shown to be an effective teaching practice. Although research on teacher noticing has explored how teachers attend to and interpret thinking in the moment and through video, less is known about the ways in which teachers notice students' thinking in written work, as well as the cultural dimensions that shape noticing. While work on "noticing for equity" has begun to explore the latter, it focuses on noticing of participation. This qualitative case study asks if equitable noticing extends to students' work. Analysis of one equityoriented math teacher's student work analysis practices revealed that she a.) attended to the details of students' strategies with a learner stance, b.) contextualized their understandings, c.) interpreted their understandings through a strengths-based lens, and d.) planned to respond by identifying aspects of work to share with the class.

141. Virtual RR Student Learning and Related Factors D

Student Learning and Related Factors Research Report Session

11:45 to 12:25 pm

Sheraton: Floor Mezzanine - Salon 4

Participant:

Gesture Indicates Productive Struggle in Proof Writing: Case Studies from a Basic Topology Course Keith Gallagher, Simon Fraser University Many students struggle with proof writing. However, struggle is not universally bad: researchers have distinguished between productive and unproductive forms of struggle and have identified productive struggle as essential for learning mathematics. Yet, in practice, recognizing when learners are engaged in productive struggle or unproductive struggle can be challenging. In this report, I argue that students' gesture production may indicate engagement in productive struggle. I observed three undergraduate students from an introductory point-set topology course, collaborating in pairs to complete proof tasks. I present evidence from the students' work on two proof tasks that undergraduate students' gesture frequently when they are engaged in productive struggle and that gesture is rare during engagement in unproductive struggle.

142. Virtual BRR Mathematical Content Later Years A

Mathematical Content Later Years (Grades 9-12+) Brief Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

The Productivity of Transformational Reasoning: Students' Ways of Understanding Congruence Based on Their Learning Experience Anastasia M Geotas, Arizona State University; Kyeong Hah Roh, Arizona State University; Alan O'Bryan,

Arizona State University

This study explores how students reason about congruence based on their high school learning experience. We developed an online survey to characterize how students understand congruence and gather their recollections about high school geometry coursework. We distributed the survey to thirty-three undergraduate students at a public university. Three ways students understood congruence emerged from data analysis: pictorial, measurement-based, and transformational. The results indicate that transformational reasoning was the most productive among students' meanings. However, less than onefifth of participants exhibited transformational reasoning in the activities. The results also suggest that diverse contexts encourage critical thinking about congruence. In this paper, we discuss the implications of our findings to research and teaching of congruence.

Thinking about Constant Rate of Change: A Case Study of Alexi Ishtesa Khan, Arizona State University

The study presents a student's thinking about the idea of constant rate of change and her thinking about the foundational ideas for understanding the constant rate of change. The idea of constant rate of change involves students' quantitative reasoning, covariational reasoning, and proportional reasoning. The result of the exploratory teaching interviews also discusses how the participant thinks about quantities, the relationship between quantities, representation of quantities, changes in quantities, rate, ratio, and proportionality in relation to the idea of constant rate of change.

143. Virtual RR Student Learning and Related Factors B

Student Learning and Related Factors Research Report Session 11:45 to 12:25 pm Sheraton: Floor Mezzanine - Salon 6 Porticipant

Participant:

Circular Reasoning: Shifting Epistemological Frames across Mathematics and Coding Activities Corey Brady, Vanderbilt University; Lauren Vogelstein, Vanderbilt University; Melissa Gresalfi, Vanderbilt University; Madison Knowe, Vanderbilt University

STEM integration holds significant promise for supporting students in making connections among ideas and ways of thinking that might otherwise remain "siloed." Nevertheless, activities that integrate disciplines can present challenges to learners. In particular, they can require students to shift epistemological framing, demands that can be overlooked by designers and facilitators. We analyze how students in an 8th grade mathematics classroom reasoned about circles, across math and coding activities. One student showed evidence of shifting fluently between different frames as facilitators had expected. The dramatic change in his contributions gauge the demands of the activities, as do the contributions of other students, who appeared to work within different frames. Our findings have relevance for the design and facilitation of integrated STEM learning environments to support students in navigating such frame-shifts.

144. Saturday Lunch (Included)

12:30 to 1:30 pm Sheraton: Floor Ballroom Level - Liberty Ballroom BCD

Saturday, 1:30-2:30pm – Plenary Session

145. Saturday Plenary - Critical Race Theory and Mathematics Education
Plenary Session

1:30 to 2:30 pm

Sheraton: Floor Ballroom Level - Liberty Ballroom

BCD

Panelists:

Cathery Yeh, Chapman University

Robert Berry, University of Virginia

Christopher Jett, University of West Georgia

Maria Zavala, San Francisco State University

Moderator: Imani Goffney, University of Maryland

Saturday, 2:45-3:25pm – Research Sessions

146. Teaching and Classroom Practice Brief Reports D Teaching and Classroom Practice Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Freedom E Participants:

Comparing Motivations for Flipped Instruction to Data on Flipped Implementations in Algebra Samuel Otten. University of Missouri at Columbia; Ruby Ellis, University of Missouri; Ze Wang, University of Missouri at Columbia; Zandra de Araujo, University of Missouri Flipped instruction, where videos are assigned for students to watch as homework in lieu of problem sets, has been implemented by an increasing number of mathematics teachers. Their reasons for flipping range from a desire to have less time spent in class on lectures and more time on collaboration (and greater engagement) to a hope that videos increase completion rates for homework compared to problem sets. This study examines the extent to which those reasons for flipping instruction are reflected in observation data from 22 flipped and 25 non-flipped Algebra 1 classes. Flipped classes were found to have less lecture time in class but the increased student work time was not necessarily collaborative. During student work time engagement levels were higher in flipped classes than non-flipped classes but the reverse was true during whole-class discourse. Homework completion rates were not significantly different.

Teachers' Instructional Responses to the COVID-19 Pandemic Courtney Vahle, University of Missouri - Columbia; Jaepil Han, University of Missouri; Zandra de Araujo, University of Missouri In March 2020, the COVID-19 pandemic drastically impacted schooling across the United States. Many schools closed rapidly giving teachers little time to prepare. In May 2020, as part of an ongoing study on Algebra instruction, we interviewed teachers to understand how their instruction changed as a result of the switch to emergency remote teaching. Using a framework of practical rationality, we consider the breach of norms due to the COVID-19 pandemic, a natural breaching experiment, in examining three teachers' instructional responses during that time. Our findings suggest that while teachers often cited similar norms being breached, their responses to those breaches and the reasons behind those responses varied.

147. Equity and Justice Brief Reports F

Equity and Justice

Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Freedom F Participants:

Mathematical Activity as a Site for Teachers to Develop a Critical Mathematical Consciousness Sandra Zuniga Ruiz, University of California, Berkeley; Mallika H Scott, Cal State Fullerton

In this paper, we argue that teachers need opportunities to make sense of ideologies at the interactional level, in mathematical activity. We propose the conception of critical mathematical consciousness, as a framework to support teachers to investigate the ways individual math learning is nested within specific math contexts, ideologies about mathematics, and the larger sociopolitical context. We propose principles to support the development of critical mathematical consciousness, which we illustrate through our respective projects which center mathematical activity as a site to challenge, disrupt and rearticulate existing mathematical ideologies.

"Very Bright but Quiet": Racial, Gender, and Competence Narratives in Mathematics Teacher Professional Development Lee Melvin Madayag Peralta, Michigan State University; Kathryn R. Westby, Michigan State University; Beth Herbel-Eisenmann, National Science Foundation

This study explores how mathematics teacherresearchers (TR) talked about students while involved in equity work in a partnership with university-researchers. Equity work by teachers is complexified by the always-present influence of race, gender, and competence ideologies. Studies, however, have mostly investigated implicit bias in lab-based settings. This paper examines interviews from the partnership to understand how ideologies became instantiated in an authentic professional development setting. Our findings highlight how TRs drew on race and gender narratives in complex, uneven ways when characterizing certain students as "shy", "quiet", or "confident". Further, we explore how TRs' characterizations of students may have been shaped by a mathematics educational narrative that privileges discourse-oriented classrooms and by the research environment itself.

148. Mixed BRR Session F

Pre-Service Teacher Education Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Freedom G Participants:

Elementary Teacher Candidates' Connections Between Mathematics and Literacy Teaching *Lisa* Hawley, Michigan State University

One persistent challenge in elementary teacher education is supporting teachers in developing confidence in teaching mathematics in ways that develop children's conceptual understanding. This challenge is intensified by the math anxiety that many elementary teachers experience. I argue that elementary teachers' position as subject area generalists could allow them to draw on their strengths in teaching other subject areas. This paper explores the connections that elementary teacher candidates (TCs) make between mathematics and literacy teaching during focus group interviews. Findings indicate that TCs noted similarities in content and in instructional practices. Creating spaces for TCs to reflect on similarities and differences between subject areas could allow them to draw on their strengths in teaching other subject areas to increase their confidence in mathematics teaching.

Transfer Undergraduate Mathematics Students Creating Online Community During COVID-19 Hannali Pajela, University of California, Santa Barbara; Damaris Hernandez, University of California Santa Barbara; Royce Olarte, University of California Santa Barbara; Sarah A. Roberts, University of California, Santa Barbara This study examined how transfer mathematics students reflected on their experiences with remote, online-instruction caused by the COVID-19 pandemic. Using a model of knowledge-sharing communities, we sought to better understand any challenges they faced and adjustments they made to support their learning. Through qualitative data analysis of semi-structured individual interviews with two transfer mathematics undergraduates, we found that students were aware of the difficulties they faced with a new class structure and with building community. To attend to these challenges, students exhibited a high level of agency in generating virtual communities to simulate the level of connectivity that in-person instruction affords; they perceived these communities as salient to their learning. Our findings can potentially inform instructors on practices that better support community building.

149. Mathematical Content Later Years Research Report B

Mathematical Content Later Years (Grades 9-12+) Research Report Session 2:45 to 3:25 pm

Sheraton: Floor Mezzanine - Freedom H Participant:

Operationalizing authentic and disciplinary activity for the undergraduate context Kathleen Melhuish, Texas State University; Kristen Vroom, Oregon State University; Kristen Lew, Texas State University, Department of Mathematics; Brittney Ellis, Portland State University Many educators and researchers advocate for student engagement in disciplinary activity. This is especially

the case in advanced undergraduate courses taken by mathematics majors. In our respective design-based research projects, we found a need to better operationalize the activity of mathematicians in order to both plan for and document student engagement in disciplinary activity. In this presentation, we share our literature-based efforts to identify the tools and objects used by pure mathematicians in their work. We share the overarching framework we developed: Authentic Mathematical Proof Activities (AMPA) and illustrate the ways we have used this framework to analyze teacher-student activity using an activity theory lens. We conclude with reflections on how tensions between authenticity-to-the-discipline and authenticity-to-the-students shape the teacher-student activity system.

150. Mathematical Knowledge for Teaching Brief Reports A

Mathematical Knowledge for Teaching Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Independence A

Participants:

Exploring the pedagogical content knowledge for teaching fractions between two Iranian experienced teachers *Maryam Zolfaghari, Kent State University*

Teachers' knowledge of teaching fractions and their ability to teach such a challenging topic plays an essential role in children's learning fractions. While some scholars have investigated teachers' pedagogical content knowledge for teaching (PCK) fractions, there is less attention on how PCK for fractions is operationalized by teachers of different nationalities. This study reports on initial efforts to understand how PCK for fractions operates between two expert teachers from Iran. Findings from interviewing these teachers suggests that the pedagogical reasoning of both teachers in confronting PCK-Fractions scenarios is similar. The implications of the commonalities in teachers' PCK-Fractions reasoning are discussed in the paper.

Theoretical Framing for Preservice Teachers' Virtual Cuisenaire Rod Use When Exploring Fraction Tasks Beth L. MacDonald, Utah State University; Steven Boyce, Portland State University; Claudia Marie Bertolone-Smith, California State University Chico; Diana L. Moss, University of Nevada, Reno; Jeffrey Grabhorn, Portland State University; Christopher Orlando Roman, Portland State University

Given the most recent need for virtual teaching, many mathematics teacher educators have taught preservice teachers with virtual manipulatives, which often stood in for physical manipulatives. This brief considers the theoretical framing for pre-service teachers' actions with physical Cuisenaire rods before considering benefits and limitations virtual Cuisenaire rod features afford when making such a transition to virtual Cuisenaire rods. In particular, we seek to consider the theoretical question: what is gained and lost when trying to replicate preservice teachers' use of physical Cuisenaire rods with virtual Cuisenaire rods?

151. Mathematical Content Early/Middle Years Brief Reports E

Mathematical Content Early/Middle Years (Grades preK-8) Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Independence B Participant: When is a Guess More than Just a Guess? Middle-Grades Students' Guess and Check Strategies Karen Zwanch, Oklahoma State University The appropriateness of guess and check as a problem-solving strategy has been debated. This qualitative study examines the use of guess and check by middle-grades students to solve linear systems of equations. Students' reasoning is examined within the number sequences framework, which is based in part on students' units coordination. Only students at the fourth and fifth stages (out of five) correctly solved systems of equations algebraically; this is attributed to their operations on two- and three-level unit structures, and to a disembedding operation. Students at the third stage applied strategic guess and check methods, which is attributed to assimilating with composite units (i.e., units of units), but these students could not correctly use an algebraic method. For students at the second stage, guess and check was non-strategic, which is attributed to their construction of composite units in activity. Implications for instruction are discussed.

152. Virtual BRR Mixed Session J

Student Learning and Related Factors Brief Research Report Session 2:45 to 3:25 pm

Sheraton: Floor Mezzanine - Independence C Participants:

- Interpretation of Graphics in Context by Undergraduate Students Veronica Vargas-Alejo, University of Guadalajara; Carlos Enrique Flores Gasca, University of Guadalajara This article presents the results of an investigation related to the interpretation of graphs of piecewise functions associated with situations. A sequence of activities based on NetLogo was designed. This was implemented in an online environment, using the Zoom platform. The theoretical framework used to analyze the results was Carlson's theory of covariational reasoning. The participants in this research was 15 college-level fourth-quarter students. As a result, it was established that the students were able to exhibit Level 3 of covariational reasoning
- Applying Systemic Functional Linguistics to Unpack the Language of Additive Word Problems Rachael Mae Welder, Texas A&M University; Ashley Marrie Williams, Texas A&M University; Michelle Mai Kwok, Texas A&M University; Jason Moore, Oakland University

Research has not yet examined the linguistic patterns of additive problem types nor explored how linguistic analysis might be applied to support preservice elementary teachers in making sense of the semantic and structural differences amongst them. Using a corpus of 150 word problems, the authors conducted an ideation analysis, drawing from systemic functional linguistics theory. The findings resulted in a distillation of language features key to the mathematical processes in the three types of additive problems (i.e. change, part-part-whole, and compare). Preservice elementary teachers (n=97) were introduced to metalanguage as a tool for analyzing structural differences in additive word problems. Analysis of their work demonstrated their ability to employ the functional metalanguage to identify challenges and describe specific linguistic

characteristics associated with each type of additive problem.

153. Virtual BRR Technology B

Technology Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Independence D

Participants:

- Estimating Climate Change Numbers: How Tolerance for Error Can Support Science Learning Ian Thacker, University of Texas at San Antonio; Rachel Broadway, University of Texas, San Antonio; Shon Feder, Informal Systems Texts presenting novel statistics can shift learners' attitudes and conceptions about controversial science topics. Recent research suggests that such science learning can be supported by bolstering targeted mathematical reasoning skills, though the learning is concentrated among people with higher prior knowledge. Our project aimed to build on this research by exploring why learning was greatest among the most skilled. We conducted ten thinkaloud interviews with undergraduate and graduate students as they estimated climate change data before being shown the scientifically accepted value. The findings highlight that students with higher prior knowledge tended to have a higher tolerance for error in their calculations, a willingness to make casual "back-of-the-envelope" calculations, and often interpreted quantitative feedback in terms of its scientific meaning rather than in terms of a measure of performance.
- Positive Change in Mathematics Teacher Educators' Migration to Emergency Remote Teaching During the Pandemic Shannon O. S. Driskell, University of Dayton; Rachel Harrington, Western Oregon University; Ann Wheeler, Texas Women's University; Steve Rhine, Pacific University Our consortium of four universities conducted survey research with mathematics teacher educators (MTEs) regarding their transition to online teaching during COVID-19. This research report focuses on some of the positive change in instruction that was identified by respondents in Spring 2020. Results shared in this report focus on formative assessment strategies, general technological tools, and mathematically focused technological tools that were initiated by MTEs during the migration to online teaching.

154. Mathematical Processes Brief Reports D

Mathematical Processes Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Philadelphia North

Participants:

Persistence of playing school: Examining an immersive semester-program for shaping students' mathematical perceptions and practices Amanda Milewski, University of Michigan; Justin Dimmel, University of Maine; Carolyn Hetrick, University of Michigan; Ed Silver, University of Michigan; Chandler Brown, Novi High School In this paper, we report on a study in which we investigated the outcomes of a 90-day immersive

semester-program located on an island in the western

Atlantic Ocean that utilizes a place-based curriculum for shaping students' learning. Using interviews and surveys, we investigated how students describe their mathematical experiences in the program, changes in students' attitudes towards mathematics, and students' tendencies to engage in sense-making (drawing on realistic considerations) in the context of story problems administered during their time in the program. Our findings suggest that while students' experiences in an immersive mathematical experience outside of school may support them in gaining more productive dispositions towards mathematics, it may not be enough to support students in unlearning the norms regarding the suspension of sense-making associated with doing story problems in school.

The Emergence of Students' Collective Proving Activity Tenchita Alzaga Elizondo, Portland State University

While working with peers is seen as valuable for mathematical learning, this practice is understudied with undergraduate students in proof-based courses. This study investigates how collective activity emerged among three students working on a proving task. Results show that as part of their collective activity, the group had to collectively create and coordinate multiple aspects of proof. I argue that this coordination was a critical component of their ability to move forward in their collective proving activity.

155. Teaching and Classroom Practice Brief Reports G

Teaching and Classroom Practice Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Philadelphia South

Participants: Elementary Mathematics Teachers' Feedback Practices: A Multiple Case Study Kristin Sue Hartland, University of Alabama Huntsville Feedback is essential for helping students move forward in their learning, and the beliefs teachers hold could potentially affect the way they provide information to their students. However, the ways in which teachers provide feedback during mathematics instruction and their own implicit beliefs are often overlooked as contributors to the various types of feedback they provide. The purpose of this study was to examine the ways in which elementary teachers provide feedback during mathematics instruction. The results of this study revealed that (1) although both participants ascribed to an incremental theory. they demonstrated varying commitments to providing self-level feedback, (2) one participant provided all three types of feedback within one classroom observation on multiple days, and (3) both participants provided little to no feedback directed at the process and self-regulation levels overall.

Spin-Ups: How Teachers Scaffold Group Work with Whole Class Prompts and the Messages They Contain Erika David Parr, Rhodes College; Elizabeth B Dyer, Middle Tennessee State University

Teachers often employ group work to actively engage students in mathematical activity. While groups work, teachers may support groups in a number of ways. We extend the metaphor of a "launch" to define a "spin-up" as an instance in which teachers scaffold group work with whole class prompting. We examined an AP Calculus AB classroom in which the teacher often used spin-ups for a variety of purposes to support group work. We describe our findings from analyzing the occurrence of each spin-up during the lesson, the content of each spin-up instance, and the messaging around each spin-up. These findings help highlight the complex decision-making involved in supporting students' more autonomous work in the classroom.

156. Virtual BRR Pre-Service Teacher Education D

Pre-Service Teacher Education Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Salon 10

Participants:

A Critical Participatory Action Research of Social Justice Mathematics Michael Lolkus, Purdue University; Alexis Grimes, Purdue University; Camryn Adkison, Purdue University; Isabelle Miller, Purdue University

Current events have underscored the need for mathematics teachers to facilitate and engage in critical conversations of social justice in their secondary classrooms. After completing a social justice mathematics course, three prospective mathematics teachers (PMTs) and one prospective mathematics teacher educator engaged in a critical participatory action research study to explore: (a) how to support PMTs as they engage in social justice mathematics; and (b) how PMTs engage secondary students with social justice mathematics. This study informs ongoing efforts to support PMTs' development of critical mathematics literacy. Furthermore, this study provides an example of the possibilities of engaging PMTs in collaborative research that serves to (a) reemphasize and amplify teachers' voices; (b) support PMTs to engage their students in social justice mathematics; and (c) encourage PMTs to connect education research into practice.

Developing Preservice Teachers' Noticing of Equitable Practices to Empower Students Engaging in Productive Struggle Shawnda Smith, Texas Woman's University; Christine Alyssa Herrera, California State University, Chico; Hiroko Kawaguchi Warshauer, Texas State University; Christina Starkey, Kentucky Wesleyan College

In our study, we used video analysis to examine how preservice elementary teachers (PSTs) noticed and described the equitable teaching practices that leverage students' multiple mathematical knowledge bases (MMKB) including prior mathematics knowledge, cultural, community, family, and linguistic knowledge and experiences; student interests; and peers, to support productive struggle. The PSTs (n=40) in their final mathematics content course analyzed a video episode of a classroom with a teacher and students engaged in productive struggle about a task. Frameworks of teacher noticing and productive struggle were incorporated in their assignment to guide the PSTs in their analysis. We report on the levels of connections PSTs made of the MMKB to the support and resolution of productive struggle.

157. Virtual RR PD/In-Service Teacher Education C

Professional Development/In-Service Teacher Education Research Report Session

2:45 to 3:25 pm

Sheraton: Floor Mezzanine - Salon 2

Participant:

Profiles of Teachers' Expertise in Professional Noticing of Children's Mathematical Thinking Victoria R. Jacobs, University of North Carolina at Greensboro; Susan B Empson, University of Missouri

Noticing children's mathematical thinking is foundational to teaching that is responsive to children's thinking. To better understand the range of noticing expertise for teachers engaged in multiyear professional development, we assessed the noticing of 72 upper elementary school teachers using three instructional scenarios involving fraction problem solving. Through a latent class analysis, we identified three subgroups of teachers that reflected different profiles of noticing expertise. Consideration was given to the noticing component skills of attending to children's strategy details, interpreting children's understandings, and deciding how to respond on the basis of children's understandings. We share theoretical and practical implications for not only the three profiles but also our choice to explore separately two versions of deciding how to respond (deciding on follow-up questions and deciding on next problems).

158. Virtual RR Student Learning and Related Factors A

Student Learning and Related Factors Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Salon 3 Participant:

Productive Struggle Leading to Collective Mathematical Creativity *Ayman Aljarrah, Acadia University; Jo Towers, University of Calgary* In this article we show how students' productive struggle on a mathematical task can lead to collective mathematical creativity. We use observable (co)actions and interactions from a video record that features three Grade 6 students in a problem-solving session to document the emergence of collective creativity leading to a solution. We discuss some key features of the task and the learning environment and present implications for classroom practices aimed at helping students to capitalize on their mathematical struggles.

159. Virtual RR Student Learning and Related Factors E

Student Learning and Related Factors
Research Report Session
2:45 to 3:25 pm
Sheraton: Floor Mezzanine - Salon 4
Participant:
Image of Mathematics in and Out-Of-School: A Case
Study of Two Original Participants in an
Afterschool STEM Club lili zhou, Purdue
university; Elizabeth Suazo-Flores, Purdue
University; Rose Mbewe, PURDUE

UNIVERSITY; Jill Newton, Purdue University

In this case study, we investigated the mathematics learning experiences of two adult women who participated in an afterschool girls STEM club 26 years ago. We explored their experiences in and out of school and how such experiences informed their images of mathematics. Data were collected from a survey, focus group interviews, and individual interviews. Using qualitative analysis, we learned that their school mathematics experiences influenced the participants' images of mathematics. The findings also revealed the participants' continuities and discontinuities among learning experiences between school and out-of-school mathematics. This study suggests creating spaces to develop curricula that bridge school and out-of-school learning experiences.

160. Virtual BRR Mixed Session A

Mathematical Content Later Years (Grades 9-12+) Brief Research Report Session 2:45 to 3:25 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

- Complexity of word problems through its reading in students and future teachers Maria Teresa Sanz, Cepartamento Didáctica de la Matemática. Universidad de Valencia; Emilia López-Iñesta, Departamento Didáctica de la Matemátia. Universidad de Valencia; Daniel Garcia-Costa, Departamento Informática. Universidad de Valencia; Francisco Grimaldo, Departamento Informática. Universidad de Valencia The objective of this study was to investigate, in future teachers and secondary school students, the evolutionary pattern of the relationships between the reading ability of the participants according to the population to which they belonged and the average reading time per word as a determinant of complexity of a word problem statement, as well as the relationship with performance in word problems where the fraction acts as an operator and the reconstruction of the whole is calculated. The results showed that the proposal to scale reading ability, adapted to the distribution of the studied population through quartiles and interquartile range, is consistent with the results obtained in the existing literature. In addition, the reading ability of future teachers is greater than that of secondary-level students and corresponds to greater success in solving the problems studied.
- Disciplinary content knowledge about solving problems where the fraction acts as operator *DIANA HERREROS TORRES, Departamento Didáctica de la Matemática. Universidad de Valencia; Maria Teresa Sanz, Cepartamento Didáctica de la Matemática. Universidad de Valencia; Carlos Bernardo Gómez Ferragud, Departamento Didáctica de las Ciencias Experimentales y Sociales. Universidad de Valencia*

La presente investigación busca indagar acerca del conocimiento disciplinar y didáctico, de docentes recién titulados en Magisterio de educación Primaria, en sus distintas menciones, acerca de la fracción cuando actúa como operador. Para ello se realiza una prueba donde se deben resolver dos problemas, tanto de forma aritmética como gráfica. La característica común de los problemas es la fracción en su sentido como operador, sobre un número natural y sobre un número fraccionario. En segundo lugar, se efectúa un análisis sobre el conocimiento didáctico del contenido sobre fracciones, a partir de un instrumento diseñado y validado para ello. Los resultados reflejan mayores niveles de éxito cuando la fracción operaba sobre un número natural, además, en términos generales, la resolución gráfica resultó más compleja que la aritmética. En cuanto al conocimiento didáctico, aparecieron niveles bajos en lo relacionado con las dificultades de enseñanza y aprendizaje.

161. Virtual RR Student Learning and Related Factors C

Student Learning and Related Factors Research Report Session

2:45 to 3:25 pm

Sheraton: Floor Mezzanine - Salon 6

Participant:

Student Struggle During Collaborative Problem-Solving in One Mathematics Classroom Michael Jarry-Shore, Stanford University; Madhuvanti Anantharajan, Stanford University In solving mathematics problems in collaboration, students encounter a range of mathematical and social struggles. As teachers cannot possibly respond to every such struggle, they may need to respond to those with which students require most support. Yet, little is known about students' success in overcoming the various types of struggle they encounter. In this study, we examined the types of struggle students experienced as they worked together in solving a cognitively-demanding problem. We analyzed the relative proportions of the various types of struggle they encountered, their success in overcoming each type, and the resources they leveraged in doing so. While students overcame many mathematical struggles, they had less success overcoming struggles related to reaching consensus or having their questions answered by peers. We argue that teachers may merit from support in learning to attend to these latter, more social struggles.

162. Afternoon Break and Snacks

3:25 to 3:50 pm

Sheraton: Floor Ballroom Level - Ballroom Lobby

Saturday, 3:50-4:30pm - Research Sessions

163. Mathematical Processes Brief Reports C Mathematical Processes Brief Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Freedom E Participants: A Case of a Student Using Diagrams while Reading a Proof Kristen Vroom, Oregon State University; Tenchita Alzaga Elizondo, Portland State University Reading proofs is a significant part of mathematicians' and undergraduate mathematics students' work and is often viewed as challenging for students. Viewing the act of reading proof as a form of problem-solving, we investigated the different

ways that a student analyzed and refined his diagram

as he made sense of a proof. We found that (a) the student analyzed his diagrams in different and important ways and (b) that his diagrams could be viewed as a series of refinements in which the diagram evolved into a more descriptive representation of the formal proof. We argue that his diagram usage supported his proof comprehension.

Conjecture of Theorem Statements and Their Proofs by Analogy: The Case of Andrew *Michael Duane Hicks, Texas State University*

Construction of proofs by analogy with previously constructed proofs is a ubiquitous strategy in abstract algebra due to the existence of several structural similarities between algebraic structures. Examples found in textbooks suggest that such proofs by analogy are straightforward. However, it is unclear how students make sense of these proofs by analogy. This preliminary report explores one student's process of producing conjectures for theorem statements and their respective proofs in ring theory by analogy with what they knew from group theory. In particular, I analyze the student's analogical reasoning with the use of the Analogical Reasoning in Mathematics framework to make inferences about their analogical proof activity. Results indicate that Andrew reasoned more productively when spontaneously reasoning by analogy, while he lacked confidence in analogous statements and proofs that were prompted by the interviewer.

164. PD/In-Service Teacher Education Brief Reports B Professional Development/In-Service Teacher Education

Brief Research Report Session

3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Freedom F Participants:

Comparing Elementary Mathematics Specialists' Beliefs with their Peers Maria Elizabeth Nielsen Stewart, University of Missouri - Columbia; Corey Webel, University of Missouri

The study's purpose is to explore how Elementary Math Specialists (EMS) teachers' practice-based beliefs differ from their peers, especially regarding situation-specific self-reported practices. Likert-scale survey data was compared to teacher responses to situation-specific questions where teachers were asked to explain how they would respond to various mathematics classroom situations. This approach allowed the researchers to compare self-reported beliefs with practice-based beliefs, building on prior research. Two findings from this study are: (1) EMS teachers were more likely to believe that conceptual understanding should come before instruction and (2) teachers who exhibit more confidence about doing mathematics and more security in their teaching of mathematics are more likely to engage in practices like having students share and discuss multiple strategies and to delay teaching of standard algorithms.

(Mis)alignment between teachers' in-the-moment noticing and post-instruction noticing Jinqing Liu, Indiana University; Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Ayfer Eker, Giresun University; Kemol Robert Lloyd, co-author; Pavneet Kaur Bharaj, Indiana University Bloomington Being able to notice students' mathematical thinking during teaching (enacted noticing) impacts the quality of instruction. Also, noticing students' mathematical thinking and reflecting on the activities of teaching while watching the classroom videos (reflected noticing) is important for teachers' longterm professional development. We explored the relationships between enacted and reflected noticing by examining the data from seven elementary inservice teachers engaged in a professional development program. By analyzing 33 coaching videos and post-coaching conversations, we found that teachers' enacted noticing did not align with their reflected noticing, and reflective noticing tended to be of lower quality than enacted noticing. Professional identity and teacher efficacy seemed to influential factors. We discuss implications for future research and professional development.

165. Policy, Leadership, and Misc Research Report B

Policy, Leadership, and Miscellaneous Topics Research Report Session 3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Freedom G Participant:

Opportunities to Develop Statistical Literacy: A Comparison of State Standards to GAISE II Anita Sundrani, University of Houston; Travis Weiland, University of Houston

In today's polarizing political climate, there is a need to build citizens' statistical literacy to combat misinformation and support data-based arguments. To that aim, we investigate K-12 standards documents for their alignment with the American Statistical Association's Guidelines for the Assessment and Instruction in Statistics Education (GAISE II). We found that the states that explicitly reference GAISE or had standards that explicitly addressed the statistical investigative process did not offer consistent opportunities for students to engage in each element of the investigative process and at each developmental level. We discuss the implications of the findings and provide recommendations for policy makers and standards writers.

166. Pre-Service Teacher Education Research Report B

Pre-Service Teacher Education

Research Report Session

3:50 to 4:30 pm Sheraton: Floor Mezzanine - Freedom H

Participant:

Eliciting Dispositions for Teaching in the Context of a Video-Based Intervention for Secondary Teacher Candidates Laurie Overman Cavey, Boise State University; Nirmala Naresh, University of North Texas; KANITA DUCLOUX, Western Kentucky University; Tatia Baum Totorica, Boise State University

For years, teacher education programs have focused considerable effort on teacher knowledge and how to develop the types of knowledge that matter in teacher education candidates. Meanwhile, candidate dispositions for teaching have received little attention, particularly in mathematics courses for candidates. As developers and practitioners of a curriculum intervention designed to support candidates' mathematical knowledge, we are beginning to see how much disposition towards teaching mathematics matters in a candidate's ability to attend to students' ideas. In this paper we share results from a pilot study investigating the dispositional characteristics elicited in an online video-based curriculum focused on students' ideas on a figural pattern task. Results indicate that efforts to cultivate secondary candidates' disposition for teaching may have payoffs with respect to both dispositions and knowledge.

167. Student Learning and Related Factors Brief Reports A

Student Learning and Related Factors Brief Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Independence A

Participants:

Calculus Instruction and Female Sense of Belonging Casey Griffin, University of Delaware

Women continue to be underrepresented in undergraduate science, technology, engineering, and mathematics (STEM) majors. Low sense of belonging and poor instruction in introductory STEM courses, especially Calculus, have been identified as key contributors to women leaving STEM. Incorporating active learning has potential to support female students in developing a stronger sense of belonging and persisting in STEM. This study investigates the instructional experiences and sense of belonging of female students enrolled in two versions of introductory Calculus - a standard course and a non-standard course infused with active learning. Females in the active learning course reported significantly higher sense of belonging and greater impact of instruction on their sense of belonging than female students in the standard course.

Developing Students' Understanding of Proof through Revising Proofs Based on Peer Critiques Brooke Krejci, Winona State University; Kimberly Conner, University of Northern Iowa

We present the results of a research study focused on the peer critiquing process in a high school geometry course. Our objective relates to the development of proof writing by engaging geometry students with all aspects of the third Common Core Standard for Mathematical Practice (SMP3): construct viable arguments and critique the reasoning of others. In alignment with these goals, students were asked to make a conjecture, draft an argument, provide written critiques, and revise their final arguments based on provided peer critiques. Specifically, we will present the types of critiques students provided one another and the extent to which students addressed each type of critique when revising their arguments. Although students' revisions in final arguments did not always progress the overall proof, we will discuss how the broader instructional sequence can provide an opportunity to discuss key components of proof by drawing on students' ideas.

168. Teaching and Classroom Practice Research Report A

Teaching and Classroom Practice Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Independence B

Participant:

An Analysis of Patterns of Productive and Powerful Discourse in Multilingual Secondary Mathematics Classrooms William Zahner, San Diego State University; Lynda Wynn, California State University Stanislaus; Ernesto D Calleros, San Diego State University & University of California San Diego; Kevin Pelaez, San Diego State University and University of California San Diego We present an analysis of three 9th grade integrated mathematics lessons in which a group of teachers and researchers redesigned a sequence of lessons with the goal of engaging a linguistically diverse group of students in productive and powerful discussions (Herbel-Eisenmann et al. 2013). The three lessons were part of a design experiment. Two lessons were observed during regular school day instruction, and the other lesson was part of an after-school teaching experiment. Drawing on a sociocultural framework and methods of classroom discourse analysis (Cazden, 2001; Pierson, 2008), we analyze how the teachers in the three settings structured whole-class discourse to create opportunities for a multilingual group of students to participate in the discussion and to appropriate mathematical tools for thinking.

169. Technology Brief Reports C

Technology

Brief Research Report Session

3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Independence C

Participants:

Fostering Virtual Collaboration in Geometry: Analyzing Task Design and Technology Zareen Gul Rahman, James Madison University; V. Rani Satyam, Virginia Commonwealth University; Younggon Bae, University of Texas Rio Grande Valley

We investigated preservice mathematics teachers' engagement in virtual collaboration on geometry tasks. In online synchronous classroom environments, PSTs collectively explored four different transformations on Desmos applets and created written descriptions and exemplary figures to describe the mathematics behind each transformation. We analyzed video recordings of the online group discussion and identified emerging group actions mediated by technology, which demonstrated social and mathematical aspects of collaboration. The design features of the task (e.g., setting group norms, co-constructing deliverables) and the technological features of the virtual workspace (e.g., dynamic geometry, shared screen, shared presentation) fostered students exchanging ideas and engaging in sense-making. Limitations of the task design and the virtual environment will be discussed for future improvement.

The Effects of Instructors and Student Activity in Learning from Instructional Calculus Videos Aaron Weinberg, Ithaca College; Jason Martin, University of Central Arkansas; Michael Tallman, Oklahoma State University

We report the results of an investigation into the factors that affect students' learning from calculus instructional videos. We designed 32 sets of instructional and assessed students' learning with

pre- and post-video questions. We examined how students' engagement with the videos, their prior experience, self-identified ways of interacting with the videos, and ways they experienced confusion connected to their learning. Our results indicate that there is a complicated relationship between the student, curriculum, instructional practices, and the video content, and that the effectiveness of instructional videos may be contextualized by both instructional practices and the extent to which the understandings supported in the videos are compatible with the meanings promoted during instruction.

170. Technology Brief Reports A

Technology

Brief Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Independence D Participants:

A Framework for Analysis of Variance and Invariance in a Dynamic Geometry Environment Gal Gili Nagar, UMass Dartmouth; Stephen Hegedus, Southern Connecticut State University; Chandra Hawley Orrill, UMass Dartmouth Variance and Invariance are essential to the development of advanced spatial perception and understanding of geometric objects. In this paper, we present an initial framework for analysis of teachers' experiences in a dynamic geometry environment from two perspectives - continuous variation and set of examples. We synthesized relevant literature followed by an empirical study of 122 descriptions of six teachers' experiences with variance and invariance tasks. As a result, we developed an analytic framework to describe how generating examples versus experiencing continuous variation might look like in a dynamic environment. We also found cases when we struggled to characterize an experience under a specific perspective and concluded that these perspectives might not be as far apart as the literature seems to suggest. Possible implications for designing opportunities to teacher education and future research directions are discussed.

The Bessie Coleman Project: Broadening Historically-Excluded Students' Participation in Computer Science Jacqueline Leonard, University of Wyoming; Roni Ellington, Morgan State University; Daniel Blustein, Rhodes College; Will Jordan, Temple University

This research report presents the results of The Bessie Coleman Project (BCP), which was named for the first African-American and Native woman to receive a pilot's license. Urban and rural students from historically-excluded backgrounds (i.e., Black, Latinx, Indigenous, and female) were recruited to participate in the BCP. Computer modeling, 3D printing, flight simulation, and drones were used as interventions to enhance students' computational thinking (CT) skills and STEM efficacy. Project staff and facilitators implemented the project in Pennsylvania, Colorado, and Wyoming in Year 2. This research report describes the results of the Year 2 BCP study before the COVID-19 pause, specifically as they relate to student identity and to broadening underrepresented students' participation in STEM.

171. Teaching and Classroom Practice Research Report B

Teaching and Classroom Practice Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Philadelphia North Participant:

Classroom Supports for Generalizing Amy Ellis, University of Georgia; Yufeng Ying, University of Georgia; Anne Wawsa, University of Georgia; Kevin Moore, University of Georgia; Michael Hamilton, University of Georgia; Halil Ibrahim Tasova, California State University San Bernardino; Aytug Ozaltun Celik, Pamukkale Unversity

Generalization is a critical component of mathematics learning, but it can be challenging to foster generalization in classroom settings. Teachers need access to better tools and resources to teach for generalization, including an understanding of what tasks and pedagogical moves are most effective. This study identifies the types of instruction, student engagement, and enacted tasks that support generalizing in the classroom. We identified three categories of Classroom Supports for Generalizing (CSGs): Interactional Moves, Structuring Actions, and Instructional Routines. The three categories operate at different levels to show how teachers, students, tasks, and artifacts work in interaction to mutually support classroom generalizing.

172. Theory and Research Methods Research Report C Theory and Research Methods

Research Report Session

3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Philadelphia South Participant:

Opportunities for Mathematics Engagement in Secondary Teachers' Practice: Validating an Observation Tool Amanda Jansen, University of Delaware; Ethan Smith, University of Delaware; James A Middleton, Arizona State University; Catherine E. Cullicott, Arizona State University The purpose of this report is to present our process and results for establishing validity and reliability of an observation tool used to investigate teaching practices that high school mathematics teachers use to engage students. We developed our tool using established practices, such as reviewing literature to develop a framework for instruction and piloting the tool to design descriptive levels for rubrics. After validating externally by consulting experts, additional rubrics regarding teaching mathematics for equity were added to the tool. We conducted a reliability study of 149 episodes of classroom instruction (equivalent to 447 10-minute segments of instruction in all), two raters per episode, to investigate the nature of coding disagreements. Most disagreements occurred due to raters noticing different evidence rather than different interpretations of rubrics, which suggested the value of two raters and resolution meetings.

173. Virtual BRR PD/In-Service Teacher Education C Professional Development/In-Service Teacher Education Brief Research Report Session 3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Salon 10 Participants:

Making Sense of Multilingual Learner Principles and Mathematics Language Routines Through Studio Day Professional Learning Sarah A. Roberts, University of California, Santa Barbara; Cameron John Dexter Torti, University of California, Santa Barbara; Julie A Bianchini, University of California, Santa Barbara

We studied 11 teachers' reflections of their experiences in a professional learning experience organized around mathematics language routines (MLRs) and five principles of effective mathematics instruction of multilingual learners. We examined how teachers' ideas around these principles developed using the MLRs across a studio day professional learning cycle. Using open-coding, we analyzed pre-studio day and studio day reflection responses to understand how teachers' understanding of the MLRs and principles developed, looking for patterns in individual teachers, individual routines, and across all routines and teachers. We found that teachers mentioned sentence frames less often as a method for attending to their multilingual learners; teachers identified that the MLRs were an organizational method their students could use; and, finally, teachers noted they could use multiple modes of communication.

Teachers' Routine and Adaptive Expertise through Mathematical Modelling Instruction in Remote Learning Megan Brunner, Oregon State University; Rebekah Elliott, Dr.; Elyssa Stoddard, Oregon State University

As part of an ongoing study, this paper reports on teachers' use of instructional routines for modelling prior to and during remote teaching. We problematize the use of instructional routines through notions of adaptive and routine expertise and pose questions to explore how routines can be adapted to attend to instructional responsibilities in remote learning environments. This study contributes to modelling instruction literature and extends research on use of instructional routines in innovative teaching.

174. Virtual RR Technology B

Technology Research Report Session

3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Salon 2 Participant:

Participant:

The Relationship between Confidence, Accuracy, and Decision Making in a Calculus Skills Review Program Carla van de Sande, Arizona State University; Jana Elle Vandenberg, Arizona State University

Just like physical skills, cognitive skills grow rusty over time unless they are regularly used and practiced. Thus academic breaks, or other interruptions in formal instruction, can cause students to lose valuable ground, even at the university level. The Keeping in School Shape (KiSS) program is an intervention that uses technology to provide regular retrieval practice to help students maintain proficiency over academic breaks by delivering a daily review problem via text message or email. In addition to supporting the review of requisite skills, the program promotes a growth mindset through feedback messages that encourage students to try again if they get a problem wrong and to do a related challenge problem if they get a problem correct. This paper reports on the relationship between confidence, accuracy, and decision making during an implementation of the KiSS Program at a large university with students enrolled in an introductory Calculus course sequence.

175. Virtual BRR Mathematical Knowledge for Teaching A

Mathematical Knowledge for Teaching Brief Research Report Session 3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Salon 3

Participants:

Articulating the Unarticulated: Prospective Secondary Mathematics Teachers' Narratives of Proof Without Words *Xiaoheng Yan, Simon Fraser University*

This paper reports a preliminary analysis of prospective secondary mathematics teachers' diagrammatic reasoning and understanding of visual proofs. The data comprises responses to a task in which participants were asked to articulate how a given claim was proven through diagrams and to compose a dialogue between two students and a teacher about the proofs. The findings show that the participants' approaches to articulate "the unspoken" of the diagrams greatly differed; their pedagogical preferences to teach the same mathematical content were also distinct. The unspoken and unarticulated, from prospective teachers' perspective, were different from what was anticipated.

The parameter in textbooks, a documental analysis / El parámetro en los libros de texto, un análisis documental *Luis Enrique Hernández, CINVESTAV-IPN; Claudia Margarita Acuña, Centro de Investigación y Estudios Avanzados del IPN*

The following documentary research investigates in textbooks the background for the introduction of parameters as control variables. In a sample of texts ranging from high school to undergraduate level, we observed the structure and expectations of textbook contents on the subject of Systems of Linear Equations (SEL), infinite solutions and the parameters needed to solve them. We found that the books almost always propose SEL squares with unique and numerical solutions, few mention the infinite solutions that are posed up to the undergraduate level, the parameters are used in an ambiguous way, in no case is their dual character noticed. We conclude that, although there is neither an adequate treatment of the parameter, it is possible to addres the case of infinite solutions by using it as a control variable that takes advantage of the available knowledge.

176. Virtual BRR Equity and Justice A

Equity and Justice Brief Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Salon 4 Participants: Conceptualizing Mathematics Modules that Integrate Professional Noticing and Equity Cindy Jong, University of Kentucky; Molly Fisher, University of Kentucky; Jonathan Norris Thomas, University of Kentucky; Edna O'Brien Schack, Morehead State University; Walker Mask, University of Kentucky

In this paper, we describe the theory that guides the development of microlearning modules connecting noticing and equity in mathematics. Gutiérrez's (2009) four dimensions of equity framework which includes access, achievement, identity, and power, is used to inform the modules. The professional noticing of children's mathematical thinking to include attending, interpreting, and deciding (Jacobs, Lamb, & Philipp, 2010) is also woven into the module development. We analyze data from preservice elementary teachers' ideas about equity and responses to a video to inform our project and discuss the critical importance of making equity explicit in mathematics methods courses. Results indicate that preservice elementary teachers' ideas of equity primarily fall into the dominant axes by focusing on access and achievement, but also show evidence of the critical axes of identity and power in responses to the classroom video.

Theorizing Complex Embodiment in Mathematics Rachel Lambert, University of California Santa Barbara; David Hernandez-Seca, University of Northern Iowa; Rebeca Mireles-Rios, University of California Santa Barbara

Cognizant of educational debts (Ladson-Billings 2006) for Latinas in math, as well as for students with Learning Disabilities (LD), we seek to develop understanding of the experiences of Latinas with LD in math classrooms. To do so, we need theoretical and methodological tools to analyze the emotional, embodied experience of learning mathematics within figured worlds of mathematics classrooms. Scholarship on identity in math currently lacks a systematic theoretical and methodological grounding that would allow for critical analysis of both intersectionality, relationships and emotion. Using analysis of how a Latina with LD was positioned by her teachers, this paper describes a collaborative, interdisciplinary theoretical and methodological project to develop these theoretical tools.

177. Virtual BRR Mathematical Content Later Years B

Mathematical Content Later Years (Grades 9-12+) Brief Research Report Session 3:50 to 4:30 pm Sheraton: Floor Mezzanine - Salon 5

Participants:

Extractive and Inferential Discourses for Equation Solving Cody L Patterson, Texas State University; Elizabeth Wrightsman, Texas State University; Mehmet Kirmizi, Texas State University; Rebecca McGraw, University of Arizona

We investigate the algebraic discourse of secondary mathematics teachers with respect to the topic of equation solving by analyzing five teachers' responses to open-ended items on a questionnaire that asks respondents to analyze hypothetical student work related to equation solving and explain related concepts. We use tools from commognitive analysis to describe features of teachers' explanations, focusing on ways in which participants depict equation solving as a process of extracting solutions using prescribed routines for acting on mathematical symbols or as a process of making successive inferences about possible values of a hypothesized solution. We use these survey responses as examples to illustrate a distinction in discourses about equation solving that has implications for students' learning of common procedures for finding solution sets of equations and systems.

Fraction's representation, fractions' arithmetic and word problems solving as skills to solve task involving fractions Maria Teresa Sanz, Cepartamento Didáctica de la Matemática. Universidad de Valencia; Carlos Valenzuela, Universidad de Guadalajara; Olimpia Figueras, Centro de Investigación y de Estudios Avanzados del IPN; BERNARDO GOMEZ ALFONSO, Facultad de Magisterio. Departamento: Didáctica de la Matemática. Universitat de València The students' fractions knowledge is considered a determining factor for success in their school years. Thus, the interest arises to evaluate the understanding high school students have about this concept. To achieve this goal, three skills are evaluated in this work: graphic representation, arithmetic and word problem solving; as well as the effect of the first two on the third. A test was applied on two different students' groups (198: first grade, 112: second grade) from public schools in Mexico City. After a quantitative analysis, the results show that students from the second-grade group had greater ability in word problem solving and representation, but not in the case of arithmetic, with which the first-grade students were more successful; in that group, a high association between representation and arithmetic with word problem solving is shown.

178. Virtual RR Curriculum, Assessment, and Related Topics A

Curriculum, Assessment, and Related Topics Research Report Session

3:50 to 4:30 pm

Sheraton: Floor Mezzanine - Salon 6

Participant:

Tracing Beginning Teachers' Mathematics Curriculum Use in Their First Three Years of Teaching Byungeun Pak, Dixie State University; Corey Drake, Michigan State University This study explores how five beginning elementary teachers used their mathematics curriculum materials in their first three years of teaching. Prior research suggests that teachers' curriculum material use in their earlier careers may not change significantly from year to year (e.g., Valencia, Place, Martin, & Grossman, 2006). Our investigation builds on this prior research with a focus on elementary mathematics curriculum use. We analyzed interview transcripts from five teachers' first three years drawing on a framework developed by Forbes and Davis (2010). Our analysis indicates that these five teachers used their mathematics curriculum in different ways from Year1 through Year 3. They followed their mathematics curriculum with few adaptations in their first year, and then began to modify their curriculum more extensively in their second and third years.

Saturday, 4:30-5:30pm – Poster Session See Appendix 2 for Poster Titles, Abstracts, and Locations

179. Saturday Poster Session

Poster Session 4:30 to 5:30 pm Sheraton: Floor Ballroom Level - Liberty Ballroom A

Saturday, 5:10-5:50pm - Hosted Sessions

180. NSF Funding Opportunities in the Directorate for Education and Human Resources

Special Event

5:10 to 5:50 pm

Sheraton: Floor Mezzanine - Independence D The National Science Foundation (NSF) offers multiple grant programs that promote research, innovations in learning and teaching and/or infrastructural support in mathematics education. Program Officer(s) from the NSF Division of Research on Learning in Formal and Informal Settings (EHR/DRL) will provide information about programs that welcome submissions from the mathematics education community, discuss the NSF review process, and provide tips on effective proposal preparation.

Participant:

NSF Funding Opportunities in the Directorate for Education and Human Resources *Toya Jones Frank, George Mason University* The National Science Foundation (NSF) offers multiple grant programs that promote research, innovations in learning and teaching and/or infrastructural support in mathematics education. Program Officer(s) from the NSF Division of Research on Learning in Formal and Informal Settings (EHR/DRL) will provide information about programs that welcome submissions from the mathematics education community, discuss the NSF review process, and provide tips on effective proposal preparation.

181. 2022 PME-NA Conference Open Forum

Special Event

5:10 to 5:50 pm Sheraton: Floor Mezzanine - Independence C

Come chat with the local organizing committee for the 2022 PME-NA Conference. We would love to hear your questions and ideas for creating a welcoming, inclusive, and meaningful conference experience.

Participant:

2022 PME-NA Conference Open Forum Alyson E. Lischka, Middle Tennessee State University; Jeremy F Strayer, Middle Tennessee State University; Elizabeth B Dyer, Middle Tennessee State University

Come chat with the local organizing committee for the 2022 PME-NA Conference. We would love to hear your questions and ideas for creating a welcoming, inclusive, and meaningful conference experience.

181. Saturday Banquet and Entertainment (Included in registration)

Special Event 6:00 to 9:00 pm Sheraton: Floor Ballroom Level - Liberty Ballroom BCD

SUNDAY, OCTOBER, 17

Sunday, 8:15-8:55am – Research Sessions

182. Curriculum, Assessment, and Related Topics **Research Report A** Curriculum, Assessment, and Related Topics Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Freedom E Participant: Slope Across the Curriculum: A Textbook Case Analysis Thomas Fisher, Penn State Behrend; Courtney Nagle, Penn State Behrend; Deborah Moore-Russo, University of Oklahoma This study reviews how slope is developed in expository materials across a seven-textbook series. Slope development is analyzed using a framework of five slope components to describe which components are used and connected, and by investigating accompanying levels of covariational reasoning. Findings suggest that the series describes slope from multiple components, and this development is grounded in various levels of covariational reasoning. While many connections were found between components, occurrences of both visual and nonvisual approaches within components were not prevalent. Suggestions include building connections between Behavior Indicator and Determining Property components through descriptions of covariation as well as more connections to the Steepness component. 183. Mathematical Content Early/Middle Years Brief

183. Mathematical Content Early/Middle Years Brief Reports A

Mathematical Content Early/Middle Years (Grades preK-8)

Brief Research Report Session

8:15 to 8:55 am

Sheraton: Floor Mezzanine - Freedom F

Participants:

Students' Early Constructing and Interpreting Their Data Displays of Categorical Data Leslie Nabors Olah, Educational Testing Service; Eun Mi Kim, University of Kansas

Constructing and interpreting data displays are crucial for statistical learning as well as college and career readiness. The findings presented in this paper are part of a larger study of the development of statistical concepts and skills. Our research question is: how do students in grades 4 to 6 construct and interpret statistical graphs for categorical data? Thirty students organized data, constructed their own graphs, and interpreted values and patterns in their graphs. Preliminary findings indicate that organizing data by groups may relate to understanding that data can be aggregated in the data display. In addition, choosing which type of data display to construct appears to impact interpretation of data shape or patterns, even in this simple case. Implications for educators and researchers are discussed.

Students' Reorganizations of Variational,

Covariational, and Multivariational Reasoning Toni York, Montclair State University; Erell Germia, Montclair State University; Youngjun Kim, Montclair State University; Nicole Panorkou, Montclair State University In this paper we examine sixth grade students'

In this paper we examine sixth grade students constructions and reorganizations of variational, covariational, and multivariational reasoning as they engaged in dynamic digital tasks exploring various science phenomena. We present case studies of two pairs of students from a larger whole-class design experiment to illustrate students' forms of reasoning and the type of design that supported those constructions and reorganizations. We argue that students constructed multivariational relationships by bridging, transforming, and reforming their reasoning and that the nature of the multivariational relationship being constructed affected this process.

184. Mathematical Knowledge for Teaching Research Report D

Mathematical Knowledge for Teaching Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Freedom G

Participant:

Using Proportional Tasks to Explore Teachers' Ability to Make Sense of Student Thinking Rachael Eriksen Brown, Penn State Abington; Chandra Hawley Orrill, UMass Dartmouth In this paper, we extend our previous work on challenges teachers face when engaging with proportional reasoning contexts to investigate two contexts that included four problems for middle grades teachers to solve as well as eight student solutions. Analysis included coding for correct solving of the problem as well as making sense of and determining reasonableness of the associated student work. Results indicate that making sense of student work was not dependent on correctly solving the problem. Determining reasonableness of student work was more challenging for our 32 participants. The think aloud interview, we argue, mimics responding to student thinking in a live setting. Implications for teacher knowledge as well as professional development and teaching will be discussed.

185. Mathematical Processes Research Report B

Mathematical Processes Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Freedom H

Participant:

Supporting Middle-School Students' Development of Emergent Graphical Shape Thinking *Teo Paoletti*, University of Delaware; Julien Corven, University of Delaware; Allison L. Gantt, University of Delaware

Emergent graphical shape thinking (Moore & Thompson, 2015) is a way of reasoning that is critical across numerous STEM fields. However, evidence indicates that the underlying component ideas for emergent thinking are underdeveloped in school mathematics education (e.g., Thompson & Carlson, 2017), and few studies directly report on students' development of this way of thinking. We present the results of a teaching experiment conducted with eighth-grade students to support stable meanings for emergent graphical shape thinking. We focus on the in-the-moment meanings expressed by a pair of students as they engaged in a sequence of tasks that we conjecture could support stable meanings for constructing and interpreting graphs.

186. Mixed BRR Session B

Two or More Strands Brief Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Independence A

Participants:

Retrospective Study of Teachers' Experiences that Contribute to Their Development as Modelers and Teachers of Modeling *Rose Mary Zbiek*, *Pennsylvania State University; Susan Peters*, University of Louisville; Benjamin Galluzzo, Clarkson University; Stephanie White, University of Louisville

Mathematical modeling is new to many teachers, especially in the United States. To complement studies of the effectiveness of professional development programs, we use retrospective methods to elicit modeling teachers' perceptions of experiences that contributed to their capacities to understand mathematical modeling and to facilitate students' mathematical modeling experiences. Empirical evidence suggests a trajectory along which teacher understanding of mathematical modeling and the teaching of it might develop. Results inform the design of teacher professional learning activities as well as advance inquiry in mathematical modeling teaching and learning.

Mathematics Doctoral Students' Priorities: What They Look For When Choosing a Ph.D. Program Katrina Piatek-Jimenez, Central Michigan University; Christine M Phelps-Gregory, Central Michigan University

Mathematics doctoral programs have high attrition rates, however, the research examining students' experiences in doctoral programs is limited. The work presented in this paper examines the priorities doctoral students describe when transferring to a new Ph.D. program in mathematics. Although our participants provide both climate and programmatic desires for a program, the two most influential reasons for choosing a new program were wanting a good fit mathematically and professionally between the program and their career goals and wanting more opportunities to do research. These results have implications for the design of mathematics doctoral programs.

187. PD/In-Service Teacher Education Brief Reports A

Professional Development/In-Service Teacher Education Brief Research Report Session

8:15 to 8:55 am

Sheraton: Floor Mezzanine - Independence B Participants:

Shaping the Professional Growth of Mathematics Faculty Who Teach Prospective Secondary Teachers Lindsay Nicole Czap, Middle Tennessee State University; Sally Ahrens, University of Nebraska - Lincoln; Alyson E. Lischka, Middle Tennessee State University; Yvonne Lai, University of Nebraska-Lincoln

Professional development (PD) that supports faculty in teaching courses for prospective secondary teachers, especially courses focused on mathematical knowledge for teaching, are largely absent from higher education, despite the need to improve instruction in these courses. This study examines a novel PD program inspired by a rehearsal pedagogy. We analyzed videos of PD discussions for attention to instructional relationships throughout the year using an instructional triad framework, and we interpreted the PD structure using Clarke and Hollingsworth's (2002) Interconnected Model for Professional Growth. We suggest that a rehearsalinspired pedagogy offered opportunities for faculty growth in the use of student-centered instructional practices.

Lesson Study: Supporting Secondary Teachers' Perseverance to Engage with Student Thinking Jenifer Hummer, West Chester University of Pennsylvania

This report includes results from a qualitative study in which secondary teachers were supported, through lesson study, to engage with student thinking in the context of teaching mathematical modeling.

188. Policy, Leadership, and Misc Brief Reports B Two or More Strands

Brief Research Report Session 8:15 to 8:55 am

Sheraton: Floor Mezzanine - Independence C

Participants:

Caregiver-Child Interactions: Informal Ways of Doing Mathematics during Engineering Tasks Amber Simpson, Binghamton University; Jing Yang, Indiana University; Jungsung Kim, Indiana University

The purpose of this study is to understand how applications of math concepts and practices unfolded between children and caregivers during makingengineering activities in their home environments. In this presentation, we present how informal measurement unfolded differently among two childcaregiver dyads within one making-engineering activity – creating a rain gauge. We demonstrate how physical objects and caregiver guidance afforded children a way to externalize their mathematical thinking.

Conceptualizing Practices in Interdisciplinary Groups From a Mathematics Education Researcher's Perspective Elizabeth Suazo-Flores, Purdue University; William Walker, Purdue University; Hanan Alyami, Purdue University; Mahtob Aqazade, Purdue University; Signe Kastberg, Purdue University

Mathematics Education Researchers (MERs) contribute to the growth of mathematics education when joining interdisciplinary groups. However, little is known about the ways of work within such groups (i.e., practices). We aimed to enhance our definition of practices by exploring practices reported by an MER in her interdisciplinary group. A transcript from a semi-structured interview comprised the data. Our grounded theory analysis resulted in an enhanced definition of practices informed by the participant's descriptions of interdisciplinary work. We argue that practices in interdisciplinary groups involve ways of being, operating, and interacting.

189. Pre-Service Teacher Education Research Report A

Pre-Service Teacher Education

Research Report Session 8:15 to 8:55 am

Sheraton: Floor Mezzanine - Independence D

Participant:

Elementary Preservice Teachers' Views and Enactments on Fostering Perseverance *Christina Koehne, SUNY New Paltz*

The purpose of this study is to investigate three elementary preservice teachers' (ePSTs') conceptions of and reflections on the role of perseverance in mathematics. This study presents findings regarding the ePSTs' perseverance conceptions, student interactions, and the ePSTs reflections from a twoweek summer math camp in which they assisted in teaching elementary student campers. Additionally, this study used an analytic framework based on a corpus of literature to capture how the preservice teachers' conceptions, interactions, and reflections aligned with each other and with current and relevant research recommendations.

190. Student Learning and Related Factors Research Report D

Student Learning and Related Factors

Research Report Session

8:15 to 8:55 am

Sheraton: Floor Mezzanine - Philadelphia North Participant:

Differential Backward Transfer Effects for Students with Different Levels of Linear Function Reasoning Abilities Charles Hohensee, University of Delaware; Matthew M Melville, University of Delaware; Crystal Collier, University of Delaware; Yue Ma, University of Delaware Backward transfer is when learning about a new topic influences an individual's prior ways of reasoning about a topic they previously learned about. This study looked at how quadratic functions instruction influenced different students' prior ways of reasoning about linear functions differently. Specifically, we compared students at three levels reasoning about linear functions, low-, mid-, and high-level. We used a pre/posttest design that bracketed a two-week summer math program. Results showed that students at different reasoning levels experienced different backward transfer effects, that particular mathematical reasoning processes were most involved in the effects, and that the effects spanned two dimensions of productiveness of mathematical reasoning. Results from this study are significant for better understanding the construct of backward transfer, and have implications for teaching quadratic functions.

191. Teaching and Classroom Practice Brief Reports B

Teaching and Classroom Practice Brief Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Philadelphia South Participants: Patterns of Reasoning: Warrants in Elementary Mathematics and Coding Arguments Claire Miller, University of Georgia; Jenna Menke, University of Georgia; AnnaMarie Conner, University of Georgia

Argumentation is widely used in teaching mathematics, but little research has been done on argumentation in teaching integrated mathematics and coding. As part of a larger study investigating collective argumentation in teaching mathematics, science, and coding, we classified the warrants given by elementary age students who were engaged in argumentation in mathematics and coding. Three major categories - calculation, visual, and unformalized knowledge - accounted for the majority of warrants given. Further analysis revealed differences in types of warrants when the primary focus of the argument was coding versus when the primary focus of the argument was mathematics. Our results suggest that expecting students to provide reasons for modifying their code, similar to what is expected in mathematics arguments, helps move them away from a trial-and-error to a more structured approach to coding.

Supporting Generalizing In The Classroom: One Teacher's Beliefs and Instructional Practice Michael Hamilton, University of Georgia; Kevin Moore, University of Georgia; Amy Ellis, University of Georgia; Yufeng Ying, University of Georgia; Halil Ibrahim Tasova, California State University San Bernardino; Aytug Ozaltun Celik, Pamukkale Unversity; Anne Nyarotso Waswa, University of Georgia

Generalization and generalizing are crucial aspects of learning mathematics. Different types of generalizations, mental activities required for generalizing, and activities that support generalizing have all been studied in various contexts. The purpose of this study is to extend this body of research by investigating how one teacher supported generalizing in her classroom. Specifically, we examined her beliefs about generalization and how to support generalizing in classrooms. We found that the teacher held numerous beliefs about generalization and these beliefs influenced her beliefs about how to support generalizing in classrooms. Moreover, we found that her beliefs formed a system of beliefs and were consistently evidenced in her classroom instruction. In this paper, we describe the teacher's beliefs, how they were related in a system of beliefs, and provide examples of how her beliefs were enacted in the classroom. We conclude with practical implications for mathematics teacher educators.

192. Teaching and Classroom Practice Research Report H

Teaching and Classroom Practice Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Salon 10 Participant: Semantically Linked Syntactic Literacy Affordances in Secondary Mathematics Ethan Smith,

University of Delaware

This report details a literacy affordance framework for describing and connecting the ways in which teachers focus their students on the syntactic structures of reading, writing, speaking, and listening in mathematics. This framework is intended to serve as a critical starting point for connecting and moving broader research in secondary mathematics teaching towards a sociolinguistic perspective. The framework is applied to a sample of teachers from two U.S. states to indicate ways in which these secondary mathematics teachers currently attend to such literacies in otherwise dialogically orientated lessons. Findings indicate the applicability of the framework as well as the opportunities and shortfalls in how such teachers currently attend to language in secondary mathematics.

193. Virtual RR Curriculum, Assessment, and Related Topics C

Curriculum, Assessment, and Related Topics Research Report Session 8:15 to 8:55 am

:15 to 8:55 am

Sheraton: Floor Mezzanine - Salon 2

Participant:

Assessing the Quality of Mathematics in Cameroon Primary School Textbooks and its Implications to Learning NAPTHALIN ACHUBANG ATANGA, UNIVERSITY OF BAMENDA, CAMEROON/CBC EDUCATION DEPARTMENT, BAMENDA, CAMEROON

Mathematics textbooks for upper primary classes in the English Subsystem of Education in Cameroon were examined to determine the quality of mathematics in them and possible teacher knowledge fostered. The quality of mathematics in these textbooks is classified as medium and the dominant teacher knowledge fostered is common content knowledge. These textbooks are full of accurate standard algorithms and mathematical definitions, significantly void of multiple strategies and representations; contain high proportion of mathematical explanations that are either partially accurate or accurate but incomplete. Textbooks with medium mathematical quality have high potentials of causing learners and teachers to be mathematically malnourished.

194. Virtual BRR Mixed Session D

Two or More Strands Brief Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Salon 3

Participants:

A Theoretical Analysis of Tangram Puzzles Laura Bofferding, Purdue University; Alexandra Foster, Purdue University

Although Tangram puzzles are an important tool used in early education to promote students' spatial visualization and composing and decomposing abilities, classification of the puzzles' difficulty is lacking. Current classifications rely on the extent to which particular shapes are distinct within the puzzles. Using a theoretical framework that highlights characteristics of puzzles along two continua (integrating to decomposing and elements to structures), we analyzed 114 Tangram puzzles. This framework can help researchers and educators identify puzzles that target specific spatial visualization strategies. Embedding Expert Knowledge: A case study on developing an accessible diagrammatic interface Stacy Doore, Colby College; Justin Dimmel, University of Maine; Rose Xi, Bowdoin College; Nicholas Giudice, University of Maine When students with blindness and visual impairment (BVI) are confronted with visual graphics in the geometry classroom, additional instructional supports are often provided through verbal descriptions of images, tactile and haptic representations, and/or kinetic movement. This preliminary study examines the language used by instructional experts to describe geometry images to students with and without access to a visual instructional image. Specifically, we investigated expert descriptions of geometry diagrams for 1) spatial information, 2) instructional concept information, and 3) overall description structure (e.g., length, vocabulary, image part/whole order/relationships). We found that experts used nearly twice as many words to describe diagrams in the no visual access condition. We consider the double-edged nature of this result for supporting BVI learners in classrooms and chart possibilities for future research

195. Teaching and Classroom Practice Research Report G

Teaching and Classroom Practice Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Salon 4 Participant

Participant:

Moves Teachers Use to Respond to Students' Non-Canonical Approaches for Solving Equations Amanda Milewski, University of Michigan; Sharon Strickland, Texas State University: Orly Buchbinder. UNIVERSITY OF NEW HAMPSHIRE; Pat G Herbst, University of Michigan; Daniel Chazan, University of Maryland A historical review of mathematics textbooks suggests a canonical method to solving equations that teachers often see as "the" way to solve equations. In this paper, we examine data from a nationallydistributed sample of 524 secondary mathematics teachers who responded to scenario-based survey items that represent the instructional situation of solving equations. The items featured scenarios in which students presented non-canonical solution methods and asked participants to share how they would respond. Using a framework that draws on systemic functional linguistics, we describe the linguistic resources teachers used. While closed moves are frequently used to avoid discussion of non-canonical solutions, our results suggest that teachers find ways to make regular use of: (1) closed moves for accommodating non-canonical solutions and (2) open moves when steering the conversation back to the canonical method.

196. Virtual BRR Pre-Service Teacher Education A

Pre-Service Teacher Education Brief Research Report Session 8:15 to 8:55 am Sheraton: Floor Mezzanine - Salon 5

Participants:

PST Learning to Facilitate Argumentation via Simulation: Exploring the Role of Understanding

and Emotion Heather Howell, Educational Testing Service; Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Pavneet Kaur Bharaj, Indiana University Bloomington; Calli Shekell, ETS; Meredith Thompson, MIT We share research focused on examining transitions in elementary pre-service teachers' understanding of, and skills in, leading argumentation-focused discussions in mathematics during participation in a sequence of three different digital practice-based activities, collectively referred to as the Online Practice Suite (OPS). We examined 14 PSTs responses to post-activity surveys targeting their emotional states and understanding of argumentationfocused discussions at multiple timepoints over the course of a single semester. From this initial coding, we selected three cases that represent a range of understandings and emotional experiences and conducted in-depth analyses on the patterns of engagement in the OPS, drawing on recorded/transcribed records of practice for each PST to describe how their emergent understandings of argumentation and discussion and their emotional state are intertwined with their learning of the practices. We discuss ways that teacher educators can scaffold PSTs' experiences as they develop the skills to facilitate argumentation-focused discussions.

The Development of Preservice Teachers' Thinking About Engaging Children in Mathematical Argument Kate Kline, Western Michigan University; Gina Kling, Western Michigan University

This study examined the development of 41 preservice elementary teachers' understanding of what it takes to engage children in mathematical argument. Findings indicate that when preservice teachers are provided opportunities to struggle with generating and justifying claims themselves, they more effectively recognize the value in having children discuss the same ideas. In addition, their characterization of argumentation becomes more honed when they are provided multiple opportunities to analyze teaching (their own and others') to discern when children's productive struggle is being undermined or utilized to enhance understanding.

197. NSF Funding Opportunities in the Directorate for Education and Human Resources

Special Session

8:15 to 8:55 am

Sheraton: Floor Mezzanine - Salon 6 The National Science Foundation (NSF) offers multiple grant programs that promote research, innovations in learning and teaching and/or infrastructural support in mathematics education. Program Officer(s) from the NSF Division of Research on Learning in Formal and Informal Settings (EHR/DRL) will provide information about programs that welcome submissions from the mathematics education community, discuss the NSF review process, and provide tips on effective proposal preparation.

Participant:

NSF Funding Opportunities in the Directorate for Education and Human Resources *Toya Jones Frank, George Mason University* The National Science Foundation (NSF) offers multiple grant programs that promote research, innovations in learning and teaching and/or infrastructural support in mathematics education. Program Officer(s) from the NSF Division of Research on Learning in Formal and Informal Settings (EHR/DRL) will provide information about programs that welcome submissions from the mathematics education community, discuss the NSF review process, and provide tips on effective proposal preparation.

199. Virtual RR Mathematical Content Early/Middle Years A

Mathematical Content Early/Middle Years (Grades preK-8) Research Report Session

8:55 to 9:00 am

Sheraton: Floor Mezzanine - Salon 6

Participant:

Integration of Mathematics History into Model-Eliciting Activities for Making Sense of Negative Integers Serife Sevinc, Middle East Technical University; Busra Ay, Middle East Technical University

This study aims to explore seventh-grade students' understanding of negative integers as they engaged in mathematics history integrated model-eliciting activities in small groups. For this educational case study, we designed model-eliciting activities based on six design principles of the models-and-modeling perspective that incorporated history of negative integers. Both written data and video records of students were analyzed to elicit the facets of their models of negative integers. We found that students' thought that either daily life contexts or people's need drove the invention of negative integers. The findings also indicated students' reasoning on the evolvement of mathematics ideas by contribution of different culture, revealing the role of math history integration into the modeling process. In this sense, our study presents a unique approach in modeling literature.

Sunday, 9:10-9:50am - Research Sessions

200. Mathematical Knowledge for Teaching Research Report B

Mathematical Knowledge for Teaching Research Report Session 9:10 to 9:50 am

Sheraton: Floor Mezzanine - Freedom E Participant:

Mathematical Knowledge for Teaching Proof: Comparing Secondary Teachers, Pre-service Teachers and Undergraduate STEM majors Orly Buchbinder, UNIVERSITY OF NEW HAMPSHIRE; Sharon M McCrone, University of New Hampshire; Michelle Capozzoli, University of New HAmpshire; Rebecca Butler, University of New Hampshire

It has been suggested that integrating reasoning and proof in mathematics teaching requires a special type of teacher knowledge - Mathematical Knowledge for Teaching Proof (MKT-P). Yet, several important questions about the nature of MKT-P remain open, specifically, whether MKT-P is a type of knowledge specific to teachers, and whether MKT-P can be improved through intervention. We explored these questions by comparing performance on an MKT-P questionnaire of in-service secondary mathematics teachers, undergraduate STEM majors, and preservice secondary mathematics teachers. The latter group completed the questionnaire twice- before and after participating in a capstone course, Mathematical Reasoning and Proving for Secondary Teachers. Our data suggest that MKT-P is indeed a special kind of knowledge specific to teachers and it can be improved through interventions.

201. Mathematical Content Early/Middle Years Brief Reports B

Mathematical Content Early/Middle Years (Grades preK-8)

Brief Research Report Session

9:10 to 9:50 am

Sheraton: Floor Mezzanine - Freedom F

Participants:

- Exhibiting Integers' Conflict and Resolution Using a Mathematics Storybook: The Case of Four Fifth Graders Mahtob Aqazade, Purdue University Students often struggle to make sense of integer concepts because they contradict their whole number understanding. In this paper, I unfold how four fifth graders interpret a story conflict and its resolution within different interactive versions of a mathematics storybook (i.e., control, interactive question, interactive visual, and interactive mixed), which was designed to highlight the contradictory ideas between the absolute and linear values of integers in the context of temperature. Over three sessions of reading and retelling, students paid more attention to the differences between positive and negative numbers' order and value and more often referred to the mathematical conflict and its resolution. This study informs the effectiveness of introducing the concept of integers by presenting conflict and illuminates ways that students can be supported through the resolution process.
- Identifying and Fixing Double Counting Errors in Mathematics and Programming Sezai Kocabas, Purdue University; Lizhen Chen, Purdue University; Laura Bofferding, Purdue University; Mahtob Aqazade, Purdue University; Ana-Maria Haiduc, Purdue University

For elementary students, counting is a foundation skill that plays a role in both mathematics and programming. We investigated how 28 first- and 27 third graders, who analyzed worked examples as part of a programming intervention, debugged (identified and fixed bugs) and reasoned about double-counting errors in mathematics and programming tasks. Students completed the tasks on a pretest, a midtest (after three playing sessions), and a posttest (after a programming presentation and three additional playing sessions). Results showed that identifying double-counting errors positively correlated with fixing those errors in both programming and mathematics tasks and that students made more gains if they had analyzed worked examples during their game playing sessions prior to the test. The results suggest the importance of two-dimensional coordination in programming and mathematics debugging.

202. Mathematical Processes Research Report A

Mathematical Processes Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Freedom G Participant:

Harmony and Dissonance: An Enactivist Analysis of the Struggle for Sense Making in Problem Solving Steven Greenstein, Montclair State University; Erin Pomponio, Montclair State University; Denish Ogweno Akuom, Montclair State University

This work seeks to understand the emergent nature of mathematical activity mediated by learners' engagement with multiple artifacts. We explored the problem solving of two learners as they aimed to make sense of fraction division by coordinating meanings across two artifacts, one being a physical manipulative and the other a written expression of the standard algorithm. In addressing the question, "How do learners make sense of and coordinate meanings across multiple representations of mathematical ideas?" we took an enactivist perspective and used tools of semiotics to analyze the ways they navigated the dissonance that arose as they sought to achieve harmony in meanings across multiple representations of ideas. Our findings reveal the value of such toolmediated engagement as well as the complexity of problem solving more broadly. Implications for learning mathematics with multiple artifacts are discussed.

203. Reviewing for and Publishing in the Journal for **Research in Mathematics Education**

Special Session 9:10 to 9:50 am

Sheraton: Floor Mezzanine - Freedom H Participant:

Reviewing for and Publishing in the Journal for Research in Mathematics Education Pat G Herbst, University of Michigan The editor will describe the journal's purpose and processes, what our reviewers look for in

submissions, and what the editorial team looks for in reviews. The editor will answer questions from prospective submitters and reviewers and receive feedback from previous authors and reviewers

204. PD/In-Service Teacher Education Research **Report D**

Professional Development/In-Service Teacher Education Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Independence A Participant:

Tracing Take-Up Across Practice-Based Professional Development and Collaborative Lesson Design Jennifer Lynn Valerio, University of Pennsylvania This study explored how two professional development approaches to reforming math instruction with different mechanisms for fostering change might have valuable synergies when used in tandem to support take-up, i.e., teachers' acceptance, adoption, and incorporation of ideas into practice. This investigation of Practice-Based Professional Development and Collaborative Lesson Design found that take-up was a recursive process that occurred

across both PD types as teachers iteratively moved between building and deploying knowledge. Both overarching and practice-specific struggles occurred during enactment, triggering shifts back to knowledge building. Struggles associated with learning to facilitate productive struggle included making sense of student thinking, identifying and providing appropriate scaffolds without lowering the cognitive demand, and helping students move from intuitive to mathematical arguments.

205. Teaching and Classroom Practice Brief Reports J

Teaching and Classroom Practice Brief Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Independence B

Participants: A Serendipitous Mistake: How One Teacher's

- Beliefs and Knowledge Mediated Her In-The-Moment Instruction Halil Ibrahim Tasova, California State University San Bernardino; Amy Ellis, University of Georgia; Michael Hamilton, University of Georgia; Kevin Moore, University of Georgia; Anne Nyarotso Waswa, University of Georgia; Aytug Ozaltun Celik, Pamukkale Unversity; Yufeng Ying, University of Georgia In this case study, we report how a ninth-grade mathematics teacher's beliefs about her students and knowledge influenced her decisions and actions. We first illustrate how the teacher retrospectively interpreted her response to an unexpected incident in the classroom as a mistake mediated by her beliefs about the students' abilities (i.e., "let's just focus on the basics"). Then, we illustrate how the teacher's response to that moment played a role in enabling her to leverage meaningful mathematical discussion. Results showed that, although the teacher was aware of different conceptualizations of slope, she wanted to promote a particular meaning of slope (i.e., slope as a formula) in the moment guided by her mathematical knowledge for teaching slope and beliefs about her students' mathematical knowledge.
- Mathematical Authority in Authoring, Animating, and Assessing Mathematical Ideas Jessica Pierson Bishop, Texas State University; Michael Duane Hicks, Texas State University; Christina Koehne, SUNY New Paltz

In this paper, we describe how mathematical authority is enacted in middle-grades mathematics classrooms where authority, for us, is dynamic, negotiated, and discursively enacted. To operationalize authority, we considered (a) the mathematical activity for which one was claiming authority, and (b) the holder of authority (who deferred to whom for a given activity). We accounted for three broad categories of mathematical activity: Authorship, Animation (oral and written communication), and Assessment of mathematical ideas. In general, we found when students had authority for authorship they were more likely to have authority for animation and assessment, but not always. We also found that teachers were more likely to share authority for authorship of ideas, but maintain authority for scribing and assessing. The results shared here provide an overall characterization of mathematical authority for the classrooms in our study

206. Pre-Service Teacher Education Research Report I Pre-Service Teacher Education

Research Report Session 9:10 to 9:50 am

 $9.10\,10\,9.30\,am$

Sheraton: Floor Mezzanine - Independence C Participant:

Rethinking How Units Coordination is Assessed in Preservice Teacher Populations Alexis Stevens, James Madison University; Rich Busi, James Madison University; Jennifer Gibson, James Madison University; LouAnn Lovin, James Madison University

Fraction proficiency continues to be a challenge for many learners of mathematics. Valid and reliable methods for assessing fraction understanding are critical tools in the pursuit of meeting this challenge. Written assessments have been widely used with K-12 students to assess fraction understanding, including units coordination. However, using these types of assessments with a preservice PreK-8 teacher population has proved difficult and inconclusive. Preservice PreK-8 teachers have a variety of algorithmic techniques at their disposal, which has resulted in the need to reexamine how units coordination is assessed in this population. This paper shares the subsequent reconceptualization of assessing preservice PreK-8 teachers' units coordination.

207. Teaching and Classroom Practice Research Report I

Teaching and Classroom Practice Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Independence D

Participant:

Using Teacher and Student Noticing to Understand Engagement During Secondary Mathematics Lessons Amanda Mohammad Mirzaei, University of Delaware; Amanda Jansen, University of Delaware; Lorna Headrick, Arizona State University; James A Middleton, Arizona State University

The purpose of this paper is to present a framework that illustrates teachers' and students' ways of noticing of mathematical engagement. This framework offers clarity about the complexity of engagement, and it includes three elements: evaluations of the presence of engagement, descriptions of the nature of engagement, and features of the classroom that support or constrain engagement. We interviewed 30 sets of high school math teachers and focus groups of their students and asked them to reflect on students' engagement during a videotaped lesson from their classrooms. Results illustrate cases of how noticing of engagement between teachers and students can be shared. Cases of partially and minimally shared noticing of engagement suggest opportunities for teachers to learn about students' perspectives or how to communicate with students about their intentions in engaging them.

208. Technology Research Report A Technology

Research Report Session

9:10 to 9:50 am

Sheraton: Floor Mezzanine - Philadelphia North Participant:

Doing Math in the Digital Age: An Analysis of Online Mathematics Platfoms Rowan Machalow, University of Pennsylvania; Lara Condon, University of Pennsylvania; Janine Remillard, University of Pennsylvania We present an analysis of 9 commonly used mathematics online student-facing platforms and propose a typology for characterizing the nature of the learning opportunities they offer elementary students. We identify three types of student learning experiences: instruction and practice, practice-based, and conceptual games and activities, and describe each one in terms of the relationships among the nature of interactions, student agency, and the types and progressions of tasks. We find that within and across categories, there is substantial variation in cognitive demand and student agency.

209. Student Learning and Related Factors Research Report E

Student Learning and Related Factors Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Philadelphia South

Participant:

Enacted Task Characteristics: Setting an Infrastructure for Students' Quantitative Reasoning Nigar Altindis, Syracuse University; Waleed Ashraf Raja, Syracuse University In this study, we explored enacted task characteristics that supported students' quantitative reasoning. We employed a design-based methodology; we conducted a teaching experiment with eight secondary school students. Through ongoing and retrospective analyses, we identified ETCs which supported students' quantitative reasoning. The ETCs can set the infrastructure for students' QR when students are: (a) identifying changing attributes of the tasks or situations, (b) coordinating the change among quantities, and (c) making generalizations about quantitative relationships. ETCs play an important role in development of students' meaningful understanding when tasks are designed with focus on quantitative reasoning and representational fluency.

210. Technology Research Report F

Technology Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Salon 10

Participant:

Word Problem Solving with Geogebra: a Source of Possibilities in the Study of Relationships / Resolución de Problemas Verbales con Geogebra: una Fuente de Posibilidades en el Estudio de Relaciones Adrián Gómez-Arciga, Centro de Investigación y de Estudios Avanzados del IPN The purpose of this study was to analyze how the systematic use of GeoGebra influences the ways of reasoning of high school students when they incorporate it in the resolution of word problems. The study was carried out with a group of 20 students who were studying Mathematics I. The results show that the students appropriated resources from the dynamic geometry system (GeoGebra) which, when used systematically, allowed them to implement strategies to represent geometrically the concepts involved in the problems, explore and analyze relationships between the elements of the dynamic models built and find the solutions. Thus, thanks to the exploration and analysis of relationships, it was possible to discuss with the students concepts such as: ratio, domain, locus, variation.

211. Virtual RR Curriculum, Assessment, and Related Topics B

Curriculum, Assessment, and Related Topics Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Salon 2

Participant:

Impact of Teachers' Identification of Written Mathematical Points on Students' Learning NAPTHALIN ACHUBANG ATANGA, UNIVERSITY OF BAMENDA, CAMEROON/CBC EDUCATION DEPARTMENT, BAMENDA, CAMEROON

I examined the relationship between teachers' identification of mathematical points (MPs) in written lessons and students' mathematical learning opportunities. Lessons in teachers' guides and classroom instruction were analyzed for written MPs and those articulated by teachers during instruction. Appropriately identifying written MPs and suggested curricular resources to realize them positively impacted students' mathematical learning opportunities. Positive impact was influenced by the teacher's ability to appropriately identify the role of available curricular resources in supporting the achievements of written MPs, recognize relationships between suggested activities and curricular resources toward written MPs, and develop a productive mathematical storyline

212. Virtual BRR Mixed Session C

Two or More Strands Brief Research Report Session 9:10 to 9:50 am

Sheraton: Floor Mezzanine - Salon 3

Participants:

Confidence And Participation In A Calculus Review Program: A Case Study Jana Elle Vandenberg, Arizona State University; Carla van de Sande, Arizona State University

The Keeping in School Shape (KiSS) program aims to prepare students for Calculus 2 using retrieval practice and push technology. By providing a variety of resources such as hints and solutions the program allows for each student to have a unique experience within the program. The goal over time is to create more resources and options that are known to support students with specific backgrounds and challenges. This can be informed by performing case studies of students who have participated in the program and analyzing how their experience could have been further enriched. This paper discusses such a case study.

FEEDBACK PRACTICE for an ABSTRACT ALGEBRA PROFESSOR and STUDENTS'

SUCCESSFUL PROOF REVISIONS Sarah

Hanusch, SUNY Oswego; David Allan Miller, West Virginia University; Matthew Schraeder, West Virginia University; Nurul Wahyuni Schraeder, West Virginia University; Jeffrey Slye, SUNY-Oswego

This paper reports a case study of the feedback practice of one professor (Dr. X) in an abstract algebra course and the utilization of the feedback by four students from the class. The students and Dr. X were interviewed regarding three proofs per student that were graded by Dr. X. The professor provided rationale for each piece of feedback she provided and was interviewed about her general feedback practices. The students provided their interpretations of the feedback and were also given a chance to revise the proofs to gauge whether they learned from the feedback. We found that Dr. X leaves comments on her students' proofs to make students think, to correct notational or logical errors, or to address misinterpretations. The instructor's provision of feedback was not dependent upon the deduction of points. We also found that students were generally able to revise their proofs by addressing Dr. X's comments

213. Virtual BRR Pre-Service Teacher Education G

Pre-Service Teacher Education Brief Research Report Session

9:10 to 9:50 am

9.10 10 9.30 am

Sheraton: Floor Mezzanine - Salon 4

Participants:

Middle Grades Pre-service Teachers' Struggle to Create Productive Struggle Monica Anthony, University of Maryland

Task selection is a critical element of mathematics teaching because mathematical tasks differ in the learning opportunities made available to students. This study examines the tasks selected by pre-service teachers (PSTs) in a field based middle grades mathematics methods course. In this brief research report, I examine how PSTs' understanding of productive struggle informs their selection and implementation of tasks. Overall, PSTs sought to avoid unproductive struggle but were unsure how to create and sustain productive struggle. Implications for teacher education include supporting PSTs in developing a robust understanding of productive struggle and the types of tasks and instruction to support it.

Video Analysis of Preservice Elementary Teachers: Supporting Productive Struggle in a Mathematics Method Course Yalcin Udun, University of Arizona; Jason Celal Aydar, University at Buffalo-SUNY; Emel Cevik, Texas A&M University; Ayse Sunbul, American Collage of Education; Ozgul Kartal, University of Wisconsin-Whitewater

In this study, we explored how elementary preservice teachers (PTs) demonstrate supporting productive struggle in a peer teaching activity, after they were engaged in supporting productive struggle practice through a series of activities in a math methods course. While PTs demonstrated strategies that support productive struggle in giving time, asking questions, task, and discussion/feedback in several different ways; the results indicated that they were not able to support productive struggle in use of tools, scaffolding, praising, and mistakes categories. Implications for teacher educators are discussed through connections between and among the strategies.

214. Virtual BRR Mixed Session B

Two or More Strands Brief Research Report Session 9:10 to 9:50 am Sheraton: Floor Mezzanine - Salon 5

Participants:

Becoming Aware: An Equity Noticing Framework Christa Jackson, Saint Louis University; Kelley Buchheister, University of Nebraska-Lincoln; Cynthia E. Taylor, Millersville University of Pennsylvania

To develop an equity-centered orientation in teacher education programs, it is essential teacher educators recognize what prospective teachers attend to in classroom events and how they relate these events to mathematics instruction. In this study, we examine what prospective teachers attend to in a classroom vignette focused on cultural, racial, and economic biases. Using the Equity Noticing Framework, we identify what prospective teachers attend to, how they critically examine hidden biases, and what actions they would take to be change agents. The results indicate the importance of providing opportunities for prospective teachers to become aware of systems of oppression and ways to foster change in the mathematics classroom.

Confronting Colorblindness: The Impact of Critical Math Modules on Preservice Teachers' Conception of Race and Racism Luke B Carman, North Carolina State University; Robin Keturah Anderson, North Carolina State University

How do undergraduate preservice teachers (PSTs) incorporate conceptions of race and racism into their understanding of math methods and philosophies of teaching? This paper reports on an intervention conducted in an introductory math methods course. PSTs experienced course content that was explicitly reframed around issues of critical mathematics, social justice, and systemic racism. Data from final assignments was analyzed to determine students' conceptions of race. While the majority of students' conceptions remained colorblind, students more critically analyzed race and racism when course topics explicitly presented and supported their importance.

215. Virtual RR Equity and Justice A

Equity and Justice Research Report Session 9:10 to 9:50 am

Sheraton: Floor Mezzanine - Salon 6 Participant:

Participant:

Community Math Stories: Informal Adult Educators Exploring Mathematics Identity through Digital Mathematics Storytelling *Theodore Chao, The Ohio State University; Melissa Adams Corral, The Ohio State University; Ayse Ozturk, The Ohio State University; Ho-Chieh Lin, The Ohio State University; Yuhang Li, OSU* During the COVID-19 pandemic, many urban schools relied on community centers with existing computer labs and high-speed internet that could provide in-person support for a small number of children engaging in online learning. Using a digital storytelling approach, this research report analyzes the mathematics identities of 15 informal adult educators at community centers during the pandemic. Situating the stories shared though Critical Race Theory counternarratives, this study enables participants to ground their narratives within their own spaces of power. Because informal adult educators are not family members nor school-based educators, they often are invisible variables in conceptualizing a child's mathematics learning. This research seeks to elicit their mathematics stories and understand how to enact digital mathematics storytelling through listening to how community members positions math.

216. Morning Break and Snacks

Special Event 9:50 to 10:40 am Sheraton: Floor Ballroom Level - Ballroom Lobby

Sunday, 10:45am-12:00pm

Working Groups (See Appendix 1 for Working Group Abstracts)

- **218.** Group Discussions Discussion Group Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Freedom E
- 219. Coaching the Coaches and Other Efforts to Develop Mathematics Teacher Educators for Inservice Teachers Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Freedom F

220. Complex Connections: Reimagining Units Construction and Coordination Working Group 10:45 to 12:00 pm

Sheraton: Floor Mezzanine - Freedom G

221. Gender and Sexuality in Mathematics Education: Emerging Conceptual and Methodological Frameworks Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Freedom H

222. Authenticity in Mathematics Education Assessment

Working Group 10:45 to 12:00 pm Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

223. Conceptions and Consequences of What We Call Argumentation, Justification, and Proof Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Independence B

224. Using Self-Based Methodologies to Unpack

Mathematics Teacher Educators' Work Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Independence C

225. Creating space for productive struggle toward a more equitable future: Persevering through challenges from within Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Independence D

226. Mathematics Curriculum Recommendations for Elementary Teacher Preparation Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Philadelphia North

227. Mathematical Play: Across Ages, Context, and Content Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Philadelphia South

228. Continuous Improvement Lesson Study Working Group/Grupo de Trabajo en La Mejoramiento Continua del Estudio de Lecciones Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Salon 10

229. Preservice Teacher Learning of Practice Through Simulated Teaching Experiences Before, During & After COVID Working Group 10:45 to 12:00 pm Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

- 230. Statistics Education: New Connections and Future Directions / EDUCACIÓN ESTADÍSTICA: NUEVAS CONEXIONES Y FUTURAS DIRECCIONES Working Group 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Salon 3
- 231. Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium Research Colloquium 10:45 to 12:00 pm Sheraton: Floor Mezzanine - Salon 5

232. Models and Modeling Perspectives Research Colloquium Research Colloquium 10:45 to 12:00 pm Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

Appendix 1: Working Group Abstracts

Group Discussions Discussion Group

Sheraton: Floor Mezzanine - Freedom E

Participant:

Group Discussions Discussion Group William Zahner, San Diego State University; Jessica Pierson Bishop, Texas State University; Jennifer Langer-Osuna, Stanford University; Anna Fricano DeJarnette, University of Cincinnati This inaugural meeting of the Group Discussions Discussion Group will convene to consider current research on group discussions in mathematics. In this series of meetings, the goal of the discussion group will be to share work (both in progress and completed), engage in collaborative analysis of data, jointly identify areas for future research, and establish connections within the PMENA community for future collaborations.

Coaching the Coaches and Other Efforts to Develop Mathematics Teacher Educators for Inservice Teachers

Sheraton: Floor Mezzanine - Freedom F

Participant:

Coaching the Coaches and Other Efforts to Develop Mathematics Teacher Educators for Inservice Teachers Cynthia H Callard, University of Rochester; Jennifer Kruger, University of Rochester; Ryan Gillespie, University of Idaho; Stephanie Martin, University of Rochester; Julie Amador, University of Idaho; Jeffrey Choppin, University of Rochester; Cynthia Carson, Warner School of Education - University of Rochester; Genie Foster, University of Rochester

This working group will engage educators who conduct professional development for, and research on, mathematics teacher educators in the context of inservice mathematics teacher education. One project that will be discussed is a professional development model designed to support mathematics coaches from rural districts. We encourage others who focus on developing teacher educators or designing professional development for teacher educators to join us. Goals for this working group are to share insights from the work of preparing teacher educators, to discuss the challenges of extrapolating understanding of teacher development to the development of teacher educators, and to develop potential collaborations for future work. We intend for this working group to continue into future PME-NA conferences as we build on this initial collaboration to influence our individual work and the field at large.

Complex Connections: Reimagining Units Construction and Coordination

Sheraton: Floor Mezzanine - Freedom G

Participant:

Complex Connections: Reimagining Units Construction and Coordination Beth L. MacDonald, Utah State University; Steven Boyce, Portland State University; Cameron Byerley, Colorado State University; Claudia Marie Bertolone-Smith, California State University Chico; Jeffrey Grabhorn, Portland State University; Diana L. Moss, University of Nevada, Reno; Christopher Orlando Roman, Portland State University

Students' construction, coordination, and abstraction of units underlie success across multiple mathematics domains. This working group aims to facilitate collaboration between researchers and educators with the particular aim of extending research on units coordination and construction across age groups, learning differences, and mathematical contexts.

Gender and Sexuality in Mathematics Education: Emerging Conceptual and Methodological Frameworks

Sheraton: Floor Mezzanine - Freedom H

Participant:

Working Group on Gender and Sexuality in Mathematics Education: Emerging Conceptual and Methodological Frameworks *Brent Jackson, Michigan State University; Julia Przybyla-Kuchek, University of Georgia; Katrina Piatek-Jimenez, Central Michigan University; Ana DIas, Central Michigan University; Jennifer Hall, Monash University; Elizabeth Kersey, University of Northern Colorado; Alexander Moore, Virginia Polytechnic Institute and State University; Weverton Ataide Pinheiro, Indiana University Bloomington; Lynda Wiest, University of Nevada - Reno The Working Group on Gender and Sexuality in Mathematics Education has convened during the three previous PME-NA conferences. These meetings have resulted in a shared foundational knowledge of the research area and has helped us to develop understandings related to how language choices in gender and sexuality research influences research methods, results, and interpretations. At the June 2021 PME-NA we aimed to expand our communal knowledge to more fully utilize theories of gender and sexuality within our work in mathematics education, attending to and problematizing the concept of identity. The October 2021 working group is organized to continue these discussions, while also focusing on emerging conceptual and methodological frameworks. Members of the working group will continue to develop partnerships in order to respond to theoretical and methodological dilemmas.*

Authenticity in Mathematics Education Assessment

Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

Participant:

Authenticity in Mathematics Education Assessment Priscila D Correa, University of Windsor; Richelle Marynowski, University of Lethbridge; P. Janelle McFeetors, University of Alberta

We propose the establishment of a new working group that critiques a means-end view of assessment in K-12 mathematics education and recognizes the human endeavor of learning through authenticity in assessment. Through engagement in assessment tasks and discussions, we aim to develop a shared understanding of authentic assessment that leads to the creation of guiding

principles and example tasks.

Conceptions and Consequences of What We Call Argumentation, Justification, and Proof

Sheraton: Floor Mezzanine - Independence B

Participant:

Conceptions and Consequences of What We Call Argumentation, Justification, and Proof Michelle Cirillo, University of Delaware; Megan Staples, University of Connecticut; Karl Wesley Kosko, Kent State University; Jill Newton, Purdue University; AnnaMarie Conner, University of Georgia; Carlos Nicolas Gomez Marchant, The University of Texas at Austin

Argumentation, justification, and proof are conceptualized in many ways in extant mathematics education literature. At times, the descriptions of these objects and processes are compatible or complementary; at other times, they are inconsistent and even contradictory. Regardless of the descriptions of these processes, however, given the importance of argumentation, justification, and proof to the discipline of mathematics, as well as their valued roles as learning practices, it is critical to query the relationship between engaging students in such processes and the promotion of equitable learning spaces and outcomes. This year, working group leaders aim to facilitate discussions and collaborations among researchers to advance our collective understanding of argumentation, justification and proof through an equity and inclusion lens.

Using Self-Based Methodologies to Unpack Mathematics Teacher Educators' Work

Sheraton: Floor Mezzanine - Independence C

Participant:

Using Self-Based Methodologies to Unpack Mathematics Teacher Educators' Work Elizabeth Suazo-Flores, Purdue University; Signe Kastberg, Purdue University; Melva R Grant, Old Dominion University; Jennifer Ward, Kennesaw State University; Sue Ellen Ellen Richardson, Purdue University; Olive Chapman, University of Calgary
Narrative inquiry, self-study, and autoethnography (i.e., self-based methodologies) are methodologies used by mathematics teacher educators (MTEs). These methodologies have opened up the field by unpacking and unearthing MTEs' work communicating findings from their practices. Building from our previous working groups at PME-NA 2018-2020, we sustain a community where MTEs can feel supported in their study design, implementation, representation of findings, and publication using self-based methodologies to develop perspectives on philosophical underpinnings of self-based methodologies and addressing trustworthiness and authenticity in our reports.

Creating space for productive struggle toward a more equitable future: Persevering through challenges from within

Sheraton: Floor Mezzanine - Independence D

Participant:

Creating space for productive struggle toward a more equitable future: Persevering through challenges from within *Ricardo* Martinez, University of Nebraska - Lincoln; Melissa Adams Corral, The Ohio State University; Luz Angelica Maldonado Rodriguez, Texas State University; Gladys Krause, William and Mary; Joel Amidon, University of Mississippi

This working group is a consistent space for equipping, informing, and challenging mathematics education researchers to "frame equity as a continually evolving process of growth". Since its inception this working group has continued to productively orient, inspire, and organize mathematics education researchers to move toward outcomes in our field that prioritize anti-racist mathematics education as a mechanism for change. The challenge of this working group remains one of moving from collective reflections around issues of equity and diversity in mathematics education to actions that become catalysts for change. We acknowledge that this year's call for "productive struggle" is necessary, however it needs people and community to support such efforts.

Mathematics Curriculum Recommendations for Elementary Teacher Preparation

Sheraton: Floor Mezzanine - Philadelphia North

Participant:

New Working Group: Mathematics Curriculum Recommendations for Elementary Teacher Preparation Julien Corven, University of Delaware; Joseph DiNapoli, Montclair State University; Lynsey Gibbons, University of Delaware; Valerie Long, Indiana University of Pennsylvania; Rachel N Starks, Boston University

This new working group seeks to provide research-based recommendations that support teacher preparation programs in providing an effective curriculum for the mathematics instruction pre-service elementary teachers receive.

Mathematical Play: Across Ages, Context, and Content

Sheraton: Floor Mezzanine - Philadelphia South

Participant:

Mathematical Play: Across Ages, Context, and Content David Plaxco, Clayton State University; Paul N. Reimer, AIMS Center for Math and Science Education; Caro Williams-Pierce, University of Maryland; Amy Ellis, University of Georgia; Susanna Molitoris Miller, Kennesaw State University; Amber Simpson, Binghamton University; Michelle Zandieh, Arizona State University; Matthew MAUNTEL, Florida State University; Muhammed Fatih Dogan, Adiyaman University

In the proposed working group, we will build from the foundation of the past two years' working groups as well as our members' continuing collaborations with researchers outside of this group. Specifically, we propose three days of activity, each advancing different aspects of developing the body of mathematical play research. We have planned the three following foci: adapting existing mathematical tasks and curricula to increase opportunities for play (Day 1); adapting voluntary play activity to support

mathematical learning (Day 2); and collaborating with members of the EMIC research community through an intra-working-group discussion session to explore play as an embodied approach to mathematics learning (Day 3).

Continuous Improvement Lesson Study Working Group/Grupo de Trabajo en La Mejoramiento Continua del Estudio de Lecciones

Sheraton: Floor Mezzanine - Salon 10

Participant:

Continuous Improvement Lesson Study Working Group/Grupo de Trabajo en La Mejoramiento Continua del Estudio de Lecciones Dittika Gupta, Midwestern State University; Lara Dick, Bucknell University; Melissa M. Soto, San Diego State University; Mollie Appelgate, Iowa State University

This working group is a new initiative aimed at providing a structure for Mathematics Teacher Educators (MTEs) to engage in Continuous Improvement Lesson Study (CILS), a process of MTE professional development that involves working collaboratively to design a lesson, improve preservice teacher (PST) learning, and MTE practice. The goals this year are to share the CILS process and experiences, and form sub-groups of MTEs with common interests to engage in the CILS process to develop an educative lesson. The eventual goal is to collaborate with sub-groups to share lessons and experiences in an edited book or a special issue of a journal.

Preservice Teacher Learning of Practice Through Simulated Teaching Experiences Before, During & After COVID

Online Working Group – Join through conference hub at https://cvent.me/9Kn5NL

Participant:

Preservice Teacher Learning of Practice Through Simulated Teaching Experiences Before, During & After COVID *Liza Bondurant, Delta State University; Heather Howell, Educational Testing Service; Minsung Kwon, California State University Northridge; Carrie W Lee, East Carolina University; Yvonne Lai, University of Nebraska-Lincoln* This working group is a continuation of a 2019 PME-NA working group focused on the challenges and opportunities of using simulations of teaching practice as an educative tool for preservice teachers focusing on simulation use in the context of the COVID-19 pandemic. Initially, we will share the takeaways from the 2019 working group. Next, we will discuss our experiences implementing simulated teaching within mathematics methods courses that experienced challenges due to COVID-19 conditions. Finally, we aim to identify the pieces of this work that are worth preserving after the pandemic.

Statistics Education: New Connections and Future Directions / EDUCACIÓN ESTADÍSTICA: NUEVAS CONEXIONES Y FUTURAS DIRECCIONES

Sheraton: Floor Mezzanine - Salon 3

Participant:

Statistics Education: New Connections and Future Directions / EDUCACIÓN ESTADÍSTICA: NUEVAS CONEXIONES Y FUTURAS DIRECCIONES Travis Weiland, University of Houston; Christopher Engledowl, New Mexico State University

In continuing from past working groups on statistics education, this working group will seek to present new findings and connections, as well as work toward future directions. Each day of the working group will be based on a different theme including: international efforts, measurement, and issues of equity and social justice. Each day will start with short 3-5 minute minipresentations of a few projects in line with the theme, followed by discussion of the theme in statistics education, and ending with a discussion of future directions related to the theme. Such structure affords easy movement of people in and out of the group based on interest and affords more focused discussion and possible future efforts.

Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium

Sheraton: Floor Mezzanine - Salon 5

Participant:

Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium Mitchell J. Nathan, University of Wisconsin - Madison; Hortensia Soto, Colorado State University; Erin Ottmar, Worcester Polytechnic Institute; Avery Harrison Closser, Worcester Polytechnic Institute; Janet Walkoe, University of Maryland, College Park; Dor Abrahamson, Univ. of California, Berkeley

The EMIC Working Group aims to connect, engage, and inspire colleagues in this growing community of discourse around pedagogical, technological, theoretical, and methodological developments for advancing the study of embodied cognition for mathematics education. This year, our seventh at PME-NA, we organize our interactions around the theme of "productive struggle" by promoting inclusive mathematics education research and principles through a broad range of embodied activities, practices, and emerging technologies that contribute to teaching, learning, and assessment of mathematical reasoning, as well as to research on these phenomena.

Models and Modeling Perspectives Research Colloquium

10:05 to 11:35 am

Online Working Group – Join through conference hub at <u>https://cvent.me/9Kn5NL</u>

Participant:

Research Colloquium: Models and Modeling Perspectives Corey Brady, Vanderbilt University; Angeles Dominguez, Tecnologico de Monterrey; Hyunyi Jung, University of Florida

The Models and Modeling Working Group was initiated with PME-NA itself in 1978, and it has met frequently since then. This year, we propose to carry the conversation forward in the new Research Colloquium format: our goal is to establish the foundation for articulating a coherent North-American voice in the international modeling community. In fact, we conjecture that a distinctively

Pan-American perspective can be articulated, identifying the common emphases and complementary strengths among modeling researchers in North, Central, and South America. The colloquium is a testing ground for this premise, looking toward ICME and ICTMA.

Appendix 2: Poster Titles, Location, and Abstracts Friday Poster Session

Poster Location

1

Title, Author, and Abstract

Contrasting Cases in Geometry: Think Alouds with Students About Transformations Erin E. Krupa, North Carolina State University; Brianna Bentley, North Carolina State University; Joshua P Mannix, North Carolina 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 two-fold: to describe the design of mathematics curricular materials for geometry that focus on directly comparing different approaches to completing geometry tasks, and to examine how students engage with the materials during think aloud interviews. 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.

2 Productive Struggle Even in Mathematics Intervention? YES! Lisa Amick, University of Kentucky; Lara Jasien, CPM Educational Program

This poster presents data from three distinct studies of a middle level problem-based intervention course (Inspirations & Ideas) that provides opportunities for students who have struggled in mathematics to engage in conceptual understanding, collaboration, critical thinking, productive struggle, and mathematical visualization. The three studies were conducted in the academic years between 2018 and 2020. Each study involved 6-9 teacher participants and their students. Teacher and student surveys, teacher interviews, and classroom observations were used and the researchers seeked to learn if the course goals were being met and how teachers and students experienced and reacted to the curriculum. Data suggest that following one year with the program, students' habits of mind, such as motivation, confidence, and problem solving skills were fostered and students' academic achievement also improved.

- 3 A tool for comparing fractions or a tool for displaying conclusions? Students' fraction number line use *Jinqing Liu, Indiana University; Erik Jacobson, Indiana University* The number line is a powerful visual model of quantity and is widely prevalent in mathematical and technical media across society. This model has enjoyed a recent focus in the U.S. curriculum because of its prominence in the Common Core State Standards for Mathematics. Researchers have synthesized a wide range of pedagogical uses for the number line across several curricular topics in the elementary and secondary curriculum. Still, we know little about how students actually use the number line as a tool to solve mathematical problems. The purpose of this study is to examine elementary students' use of number lines for comparing fractions. We selected this topic because it is commonplace where number lines are introduced and used. The results indicate that many students' enacted use of number lines misaligns with the curriculum's intended use of number lines. Theoretical and practical implications are discussed.
- 4 Why Do Students Pick the Wrong Answer on Multiple Choice Word Problems? Erik Jacobson, Indiana University; Pavneet Kaur Bharaj, Indiana University Bloomington; Jinqing Liu, Indiana University The authors investigated why students select incorrect answers on multiple choice word problems by examining a sample of Grade 5 students' (N = 1465) written work using thematic coding. The study is guided by the notion of operation sense, defined as the ability to make sense of the quantitative meaning related to basic arithmetic operations (Verschaffel et al., 2000). Students reveal their operation sense both in how a word problem is transformed into a mathematical model (translation), and in how a mathematical process produces a result. We coded how students interpreted the problem situation and chose a specific arithmetic operation (translation) and performed a specific computation (mathematical process). The results illustrate how inferences about students' operation sense from multiple choice word problems are constrained by the set of answer choices provided. Further, they demonstrate that such inferences may be more warranted for translation than they are for mathematical operation.
- 5 The Effects of Operand Position and Superfluous Brackets on Student Performance in Math Problem-Solving Vy Vo Hoang Ngo, Worcester Polytechnic Institute; Luisa Perez, Worcester Polytechnic Institute; Avery Harrison Closser, Worcester Polytechnic Institute; Erin Ottmar, Worcester Polytechnic Institute Middle school students tend to follow the left-to-right principle when solving math problems, which may lead them to overlook the role of brackets within math expressions. However, previous studies suggested that using superfluous brackets—brackets that do not change the meaning of notation, but can serve as perceptual cues to guide learners' attention to the correct procedure—can help students achieve higher success rates in

solving problems (e.g., Marchini & Papadopoulos, 2011). This study examines how the presence of superfluous brackets and the position of higher-order operands (i.e., multiplication and division) within an expression affect student performance in an online assignment, as measured by assignment mastery speed and average response time. We hypothesize that the presence of superfluous brackets positively impacts student performance by providing perceptual cues to attend to the order of operations. Approximately 280 6th and 7th-grade students complete the study on an online tutoring system. Data collection is on-going.

6 Use of ZIG-ZAG to Represent Mathematical Thinking about Angle *Ekta Shokeen, University of Maryland; Amber Simpson, Binghamton University; Caro Williams-Pierce, University of Maryland; Nihal Katirci, University of Maryland*

In this paper, we discuss how an embodied cognition perspective can provide insights into the development of 'angle' understanding among groups of youth engaged in a making activity within a non-formal learning environment. Findings from video data reveal that students depend on their embodied cognition and informal mathematical language such as "zig-zag" to communicate their mathematical ideas and reasoning around the angle.

- 7 Consistency in Terminology and its Effect on Equity in Learning Mathematics: The case of Orientation Shahabeddin Abbaspour Tazehkand, University of Central Florida; Siddhi Desai, University of Central Florida; Farshid Safi, University of Central Florida; Janet Andreasen, University of Central Florida The term orientation has two different definitions within the mathematics education research literature, and these definitions are not consistently used within mathematics education research and curriculum material. These inconsistent uses and definitions often cause confusion for students as their everyday experiences are not always coherent with academic experiences. In order to support each and every student, and particularly multilingual students, it becomes necessary to discuss strategies to leverage the role of language to support students in learning math while also engaging them in learning the language through math.
- 8 Re-Encountering Rate of Change in Differential Equations Chris Rasmussen, San Diego State University; Talia LaTona-Tequida, San Diego State University; Naneh Apkarian, Arizona State University; Samer Habre, Lebanese American University

Rate of change is a core idea that cuts across secondary school and tertiary mathematics education. Prospective secondary school mathematics teachers re-encounter rate of change in a variety of undergraduate mathematics and science courses. However, simply re-encountering an idea in more advanced courses may not necessarily lead to any substantive enrichment in one's understanding of the idea. We conjecture that intentional instructional efforts are needed to realize the transformative potential of re-encountering an idea for enriching conceptual understanding of that idea. In this poster we take up this conjecture by analyzing the work of eight prospective secondary school teachers in an inquiry-oriented course in differential equations, focusing on rate of change. Results revealed that students significantly enriched their understandings of dy/dt as a rate of change, as compared to the meanings they reported on a pre-semester survey.

- 9 Structural Conventions for Equations in Middle School Mathematics Textbooks Chelsea Dickson, Brigham Young University; Daniel Siebert, Brigham Young University This study consists of an analysis of two series of 7th and 8th grade textbooks to identify the structural conventions used for writing solutions involving equations. We found that there were two main types of structures: lists of equations (LOEs) and strings of expressions (SOEs). Both structures were used regularly in all four textbooks. LOEs typically involved equations that were linked by equation operations. However, for some LOEs, it was not clear what equation operations linked the sequenced equations. SOEs involved a series of expressions linked by equal signs, ranging from 3-8 expressions. SOEs often involved multiple equation types and meanings for the equal sign. Analysis suggests that the complexity associated with structural conventions warrants explicit description and modeling during instruction.
- 10 Designing Assessment Items to Measure PCK for Proportional Reasoning Chandra Hawley Orrill, UMass Dartmouth; Martha Epstein, UMass Dartmouth; Hamza Malik, UMass Dartmouth; Kun Wang, University of Massachusetts Dartmouth; Yasemin CopurGencturk CopurGencturk, University of Southern California We report our work from two projects in which we developed assessment items to measure teachers' pedagogical content knowledge. Using data collected in think-aloud interviews, we have begun to identify challenges to writing PCK items. In this poster, we highlight aspects of items that were or were not effective for measuring teachers' PCK.
- 11 Japanese Teacher Instructional Circles *Matthew M Melville, University of Delaware* Japanese teacher instructional circles are one method of professional development that is focused on increasing a teachers' mathematical knowledge for teaching. This form of professional development is used to support Japanese teachers development of high-quality teaching practices, and to support teachers involvement in lesson study. This study is an in-depth look at how teachers engage in this practice, and in what ways this professional development can support them.
- 12 A Preliminary Investigation into Prospective Teachers' Productive Struggles for Making Sense of Mathematical Practices *Nitchada Kamlue, Western Michigan University; Laura Van Zoest, Western*

Michigan University

To effectively bring the Common Core State Standards Mathematical Practices (MPs) into future classrooms, prospective teachers need to both experience the practices themselves and reflect on what those practices mean for their future teaching. Since productive struggle is an opportunity for students to make sense of what they are doing and deepen their understanding, we engaged prospective teachers with a challenging engaging problem (Frogs) and investigated the struggles they encountered and the ways in which those struggles supported their developing understanding of the MPs. We analyzed videotapes of classroom discussions and written work to identify which MPs the prospective teachers struggled with and what they learned about MPs as a result. We share our findings and the insights we gained about how the idea of productive struggle extends beyond learning content to learning about teaching.

- 13 Leading Group Discussions Enactments in a Methods Course Melike Kara, Towson University The purpose of this study was to integrate leading group discussions (LGD) core practice into teacher preparation and document outcomes of this instructional effort. Participants consisted of 11 preservice teachers (PSTs) enrolled in a single semester middle school mathematics methods course during the Fall 2019 semester (face-to-face setting) or the Fall 2020 semester (virtual setting). PSTs were introduced to the components of the LGD practice, student thinking monitoring tools, and assessing and advancing questioning techniques. Next, they prepared mathematical tasks, planned the components of the LGD, and implemented their tasks in peer teaching format. Additionally, the Fall 2020 group conducted their second implementations with middle school avatar students. PSTs' reflections on their implementations were analyzed using comparative analysis. Overall, PSTs indicated that this instructional effort provided them with various learning opportunities related to orchestrating group discussions, eliciting and orienting student thinking, and/or responding with appropriate questions.
- 14 Preservice Teachers as Researchers: A Mentorship Model *Kimberly Corum, Towson University; Melike Kara, Towson University*

For pre-service teachers, participating in research activities can support their professional development as both action researchers and effective classroom teachers. By engaging in undergraduate research focusing on model eliciting activities (MEAs), PSTs can better understand mathematical concepts related to mathematical modeling, practice teaching mathematics with real-world contexts, and better conceptualize the research designs in the mathematics education field. Our goals for the PSTs engaged in undergraduate research are: 1) advance their mathematical content knowledge by designing and developing the modeling activities, 2) improve their pedagogical content knowledge by teaching mathematics in informal settings, and 3) strengthen their understanding and analysis of student thinking and learning (Ball, Thames, & Phelps, 2008). To attend to these goals, we designed a six-phase mentorship model for developing and implementing MEAs. This research model not only provides rich teaching and learning experiences for the PSTs, but it also benefits the faculty mentors.

- 15 What an Angle Measure Measures for Prospective Teachers *Hamilton Hardison, Texas State University* Researchers have argued that productive ways of reasoning about angularity can be engendered through principles of quantitative reasoning. Attributes must be conceptualized to be quantified; therefore, it is important to attend to the attribute(s) an individual holds in mind when considering an angle's measure. In this poster, I report on 19 prospective teachers' conceptions of the attribute characterized by an angle's measure. Using data from two prompts, I explore differences in prospective teachers' verbal descriptions of angularity and the drawings they produced to indicate what they are measuring when they measure an angle.
- 16 Exploring Relationships Between Teaching Experience and Teachers' Causal Reasoning about Positive and Negative Student Events Saman R Kittani, Middle Tennessee State University; Elizabeth B Dyer, Middle Tennessee State University; Georgia Latta, Middle Tennessee State University; Joy Yancey, Middle Tennessee State University (Chris Bergeron, Middle Tennessee State University)
 Recent studies have found that teachers tend not to use productive explanations with student difficulties and that teachers' relationships with their students change as teachers gain more experience. This paper extends the current literature by exploring the latter two phenomena (i.e., lack of productive reasoning with student difficulties and changing relationships with students) employing new coding methods and constructs, specifically using causal reasoning statements to explore how teachers attribute causes to student events. This paper explores how the relationship between productive reasoning and student difficulties evolves as teachers gain more experience. The study has found evidence implying that teachers are less likely to attribute negative student events to teachers' actions and does not differ for teachers with more experience.
- 17 Master's Program for In-Service Teachers with a Focus on improving Math Teaching and Learning *Teruni* Lamberg, University of Nevada, Reno; Lynda Wiest, University of Nevada - Reno; David Kirkland, University of Nevada, Reno

Twenty five in-service teachers participated at a Master's Program as a cohort. The program was designed to enhance teacher knowlege and practice. Data was collected on teacher reflections of program impact, teacher practice and student achievement. The analysis revealed that the program enhanced teacher knowlege, shifted practice and impacted MAP testing student achievement scores. The design of the program is shared

in the Poster.

- 18 Synchronous Online Video-Based Professional Development for Rural Mathemtics Coaches 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; Ryan Gillespie, University of Idaho We have designed, implemented, and started to research an innovative fully online video-based professional development model for mathematics coaches in rural contexts. The goal of the project is to support mathematics coaches to improve their ability to (a) facilitate productive planning and debriefing conversations with teachers; (b) notice salient coaching practices and their impact on teachers' thinking; and (c) use evidence of teacher learning to make decisions about their own coaching practices. We engage coaches in a three-part professional development model that includes an online course on content-focused coaching, one-on-one video-based coaching cycles with a Mentor Coach, and an online video club in which practicing coaches reflect on dilemmas of practice and the impact of coaching moves. The focus of the poster will be to share the overall project design, including descriptions of the three-part online professional development model as well as the data collection process and initial analysis processes.
- 19 "Let's Talk About Election 2020": Quantitative Reasoning and Youth Civic Composing in an Online Network Emma Carene Gargroetzi, University of Texas at Austin; Lynne Zummo, University of Utah; Alexandra Aguilar, University of Texas at Austin; Emma P. Bene, Stanford University; Antero Garcia, Stanford University; Esteban Cantu, University of Texas at Austin

This poster presents findings from an analysis of qualitative reasoning in youth civic digital media production posted to the educational web-based platform "Let's Talk About Election 2020." With a focus on the urgent challenges of Black Lives Matter, COVID-19, and climate change, the study examined the intersection of quantitative reasoning and youth civic composing in media produced by youth on these topics.

20 The Influence of a Values Affirmation Intervention on Students' Mathematical, Social, and Epistemological Empowerment *Carrie Olson Bala, Utah State University*

A proposed mixed methods transformative design to better understand the varying impacts of attending to identity construction on the development of mathematical, social, and epistemological empowerment of emergent bilingual students and native English-speaking students. Within the transformative paradigm, the author will investigate attention to identity construction using a values affirmation intervention, with critical theory forming the connecting structure of the study. Approximately 150 tenth-grade emergent bilingual and native English-speaking students will be recruited from a western high school to participate in the study.

21 Elementary Preservice Teachers Integrating Multicultural Literature to Design Culturally Relevant Mathematical Tasks *Alesia Mickle Moldavan, Fordham University; Dittika Gupta, Midwestern State University*

Teaching with a commitment to culturally relevant pedagogy recognizes the need for preservice teachers (PTs) to have structured learning opportunities to explore culture in the context of mathematics pedagogy and content. For PTs to engage in such practice, PTs must have mathematics methods courses that enable them to learn about and build on the cultural assets and identities that students bring to the classroom. This study explores how elementary PTs can integrate multicultural literature with mathematical concepts to design culturally relevant mathematical tasks. Findings report on the PTs' growth in awareness of and confidence in using multicultural texts to explore mathematical concepts as well as how the tasks elicited culturally relevant mathematical thinking with targeted concepts. Recommendations are made for how others can build on this work in mathematics education.

- 22 Making 'Talk' a (Non)Mathematical Activity *Abhinav Ghosh, Harvard University; Jon Star, Harvard* While facilitating talk is considered essential to 'reform-oriented' mathematics instruction, teachers often struggle to support student engagement in mathematical discussions. Given that students generally have spontaneous inclinations to talk with each other about various things, their lack of participation in mathematical conversations demands investigation. Using vignettes from Grade 9 mathematics classrooms, we argue that discipline-related teacher messages in the classroom might influence students to not see 'talk' as a legitimate mathematical activity and subsequently, inhibit their participation in mathematical discussions.
- 23 Mathematics Vocabulary Practices in Early Childhood Classrooms *Minnah Jirani Sabree, NYCDOE* Mathematics vocabulary knowledge is a critical component of students' success in the understanding, use, and communication of mathematics. This study reports on the instructional practices utilized by early childhood (K-2) educators to teach mathematics vocabulary words during mathematics instruction.
- 24 Supporting the Construction of Variables in an Inverse Function Context through Targeted Questions Andrew Spiteri, University of Michigan; Irma Stevens, University of Michigan; Pat G Herbst, University of Michigan

In three implementations of a problem-based lesson on inverse functions we designed with a teacher from a large midwestern public high school, we observed the teacher ask students in the problem launch and

subsequent questioning to consider "any value". After coding three implementations for inverse conceptions (Stevens et al., 2020), problem statements, and questions (Milewski & Strickland, 2020), we believe the teacher selectively asked these "any value" questions to students he viewed as holding inadequately generalizable inverse conceptions. We connected this idea to the concept of conceptualizing quantities as variables (e.g., Thompson & Carlson, 2017). To learn how teachers view this way of launching an exploration of inverse function, we designed three different ways of launching the problem (solving for an unknown value, generalized number, variable) and asked eight teachers to depict the remainder of the classroom discussions. Teachers employed different conceptions of variables to make sense of the different framings.

- 25 "What Got Flipped?": A Teacher's Use of Contrasting Conceptions to Support Students' Development of Inverse Functions *Irma Stevens, University of Michigan; Pat G Herbst, University of Michigan* This study builds on literature on teacher noticing and students' difficulties with reasoning about inverse functions to study how a teacher might support students with differing conceptions of inverse function in discussing ideas central to an instructional goal. To do so, our team used a framework we created of inverse conceptions to identify various conceptions discussed in a lesson on inverse functions. These conceptions were created by considering prior research on students' conceptions of inverse and refining the categorizations by analyzing student work and utterances during the lesson. In looking within coded conceptions, we learned how a teacher responding to different conceptions could be instrumental in achieving instructional goals. We provide an illustration in which the teacher focused on features of student work from students that indicated they were defining their variables differently to lead to a discussion on the role of quantitative referents in an inverse function.
- 26 What is Ambitious Mathematics Teaching? A Literature Synthesis William Zahner, San Diego State University; Christine Green, University of Rochester; Kristin Tenny, San Diego State University; Kevin Pelaez, San Diego State University and University of California San Diego; Jeffrey Choppin, University of Rochester; Saliha Al, University of Rochester

This poster describes a synthesis of the research literature related to Ambitious Mathematics Teaching (AMT). We summarize the evolution of AMT and consider implications for teacher educators and researchers. Early descriptions of AMT focused on aligning teaching and learning in school mathematics with disciplinary practices. Currently, several related constructs regularly appear in the literature alongside AMT, including classroom discourse, tasks, teacher noticing, and equity. For teacher educators, one implication of this shift is that while the original vision for and definition of AMT remains viable, the field is expanding this concept to address multiple overlapping concerns. For mathematics education researchers, the evolving definition of AMT implies we should be careful to specify what aspects of AMT are the focus of each investigation and how the definition matches prior research and each study's conceptual framework.

27 Introducing Function to Middle School Students: a novel representation *Michael S Meagher, Brooklyn College - CUNY; Jennifer Lovett, Middle Tennessee State University; Allison McCulloch, University of North Carolina at Charlotte*

Middle school students (n=138) worked with an applet specially designed to introduce the concept of function without using algebraic representations. The purpose of the study was to examine whether the applet would help students to understand function as a relationship between a set of inputs and a set of outputs and to begin to develop a definition of function based on that relationship. Results indicate that c.80% of students are able to distinguish functions from non-functions. Students' main conceptual difficulty was accepting non-intuitive outputs even if those outputs were consistent.

28 Learning Mathematics with Dynamic Representations: An Application of Variation Theory *Claudine* Margolis, University of Michigan

I apply the variation framework to analyze lessons from the representationally rich Desmos middle school curriculum. Variation theory centers the mathematical opportunities that students are provided as they relate to the learning goal. By using variation theory to create a map of each lesson, I can look for the role of dynamic representations within each lesson plan. From preliminary analysis, I've found that the individualized and exploratory nature of dynamic representations leads to opportunities for students to experience critical aspects of the learning objective but does not require that students explore that variation. This finding suggests that examining student work in relation to dynamic representations may provide a link between intended curriculum and learning outcomes.

29 Investigating the Impact of COVID-19 on Elementary Mathematics Test Scores Dara Bright, Drexel University; Christopher Joseph Fornaro, Drexel University; Yiyun Fan, Drexel University; Toni Ann Sondergeld, Drexel University; Jonathan David Bostic, Bowling Green State University The COVID-19 pandemic has significantly impacted student learning. Despite the continued unprecedented circumstances, state testing and assessments have resumed. Assessments during the pandemic are likely to produce invalid results due to "test pollution," which refers to the systemic "increase or decrease in test scores unrelated to the content domain" (Middleton, 2020, p. 2). Our data analyses suggest no statistically significant difference in 4th grade MAP math scores between cohort groups. While COVID-19 has a widereaching impact on school activities, our findings indicate that the COVID-19 pandemic may not necessarily affect student learning outcomes as measured using MAP scores.

- 30 MDISC for GTAs: A Discourse-Oriented Teaching Professional Development for Graduate Teaching Assistants Valentin Alexander Balthasar Küchle, Michigan State University The purposes of this poster presentation are twofold. First, I intend to discuss details of offering a teaching professional development (T-PD) to graduate teaching assistants who are beyond their first year of teaching mathematics. Specifically, I offered an adaptation of the "Mathematics Discourse in Secondary Classrooms" (MDISC) (Herbel-Eisenmann et al., 2017) T-PD. Second, I wish to share findings of a research study involving this T-PD, that is, I seek to present the discourse-oriented T-PD I offered as an instrumental case study (Stake, 1995) focused on two issues: (a) Which changes in discourse (as described by the usage of teacher discourse moves and dimensions of the EQUIP [Reinholz & Shah, 2018]) and positioning (of mathematics, oneself, and students) occur in the participants' classrooms over the course of the T-PD, and (b) which aspects of the adapted MDISC T-PD are perceived relevant by the T-PD participants and why?
- 31 A Local Instructional Theory for Emergent Graphical Shape Thinking *Teo Paoletti, University of Delaware; Allison L. Gantt, University of Delaware; Julien Corven, University of Delaware* Emergent graphical shape thinking (or emergent reasoning) entails conceiving of a graph as a trace that represents a covariational relationship between quantities' magnitudes. In this poster, we present our theoretically- and empirically-grounded LIT to support students developing stable meanings that entail emergent graphical shape thinking. Specifically, our theory posits repeated engagement with and a fundamental relationship between 1) quantitative and covariational reasoning, 2) reasoning within a coordinate system, and 3) emergent reasoning. We illustrate the interrelationship of these ways of thinking through examples from two focal students as they engaged in a task sequence designed in alignment with our LIT. We present implications that span both research and practice, with particular emphasis on designing instructional supports for supporting middle and high school students' graphical fluency.
- 32 Learning from Pedagogical Mistakes in Teacher Education *Rob Wieman, Rowan University; Jill A Perry, Rowan University*

Learning from mistakes has a strong and deep foundation in theory and research. However, researchers and teacher educators have generally failed to examine the role of mistakes in teacher learning, or to make a strong case for their planned and intentional use in teacher education. In this study, we examine what happens when mathematics teacher educators (MTEs) treat pedagogical mistakes as valuable sites for learning. Preliminary data indicate that preservice teachers (PSTs) see pedagogical mistakes as opportunities to learn about teaching, improve their plans, and as important in the development of their professional identity.
Saturday Poster Session

Title, Author, and Abstract

Poster Location

- Classroom Assessments Building Towards Standardized Assessments Christopher Joseph Fornaro, Drexel University; Timothy Donald Folger, Bowling Green State University; Toni Ann Sondergeld, Drexel University; Jonathan David Bostic, Bowling Green State University The purpose of this qualitative case study (Yin, 2018) is to explore how 4th-8th grade math teachers' preparation and instructional practices are influenced by the types of assessments administered to their students in one school. Findings showed teachers shared a progression of the ways they described their mathematics assessments.
- 2 Teachers' Interpretations of Assessment Results Timothy Donald Folger, Bowling Green State University; Christopher Joseph Fornaro, Drexel University; Jonathan David Bostic, Bowling Green State University; Toni Ann Sondergeld, Drexel University

The purpose of this poster presentation is to share findings from a qualitative research study exploring inservice teachers' assessment practices and their impact on student learning. These assessment practices include formative and summative teacher-created assessments and standardized assessments. Teachers' assessment practices and perceptions regarding assessment results were explored through semi-structured interviews. An analysis of these data indicate differences in how teachers perceive results from teacher-created assessments compared to standardized assessments when making inferences about student learning.

3 The Role of Human Beings in Mathematics Curriculum: Connecting Undergraduate Mathematics with Teaching Secondary Mathematics Rachel Tremaine, Colorado State University; Elizabeth G Arnold, Colorado State University

Mathematics and teaching are human activities; mathematics is taught and learned by people in a social and cultural context. Future teachers need opportunities to engage in practices that grow their understanding of mathematics as a human endeavor. We have designed and researched the use of tasks that reflect such practices in undergraduate mathematical content courses, and explore in this poster the nature of undergraduates' experiences with such tasks. From a qualitative analysis of written work and interview data, we present findings highlighting that undergraduates were thinking about human beings while doing the tasks, and found value in such tasks as opportunities to think critically. We view our results as confirmation that creating and using tasks that emphasize the human context of doing mathematics is a useful approach to give prospective teachers opportunities to engage in practices central to teaching and to see that mathematics exists in a human context.

4 Developing Preservice Mathematics Teachers' Political Conocimiento Through Data Science Kevin Pelaez, San Diego State University and University of California San Diego

This poster brings together a discussion about data science, teaching for social justice, and teacher knowledge. Statistics is a methodological discipline that is inherently transdisciplinary, making it an entry point for social issues. To fully realize this potential, it is important to provide preservice mathematics teachers (PMTs) opportunities to develop understandings of how statistics classrooms can serve as spaces to learn data science and how data can be used to identify, critique, and challenge educational injustices. In this study, I discuss how I designed a teaching experiment that uses a social justice approach to teach data science for PMTs. I am guided by the following research question: How can a social justice approach be used to develop PMTs political conocimiento for teaching mathematics? Findings from this study are used to guide considerations for designing data science, social justice, and teacher preparation learning environments.

5 Disability in Mathematics Education Research: A Call To Action Kathryn R. Westby, Michigan State University

"Nothing for us without us" is an off-repeated rallying call from disability rights movements. In this paper, I will describe ways that the structures and epistemologies of mathematics education research have impeded our ability to take up this call. Aligned with the theme of this meeting, "Productive Struggle: Persevering Through Challenges," and in a time of increasing political voices that seek to deny disabled people access to equitable educational spaces, I call on the mathematics education research community to struggle with our own ableist structures and rise to the challenge of increasing equity in mathematics education research through collaboration with and inclusion of disabled people. I will describe steps we have already taken to widen our epistemologies and identify three next steps. I will then describe obstacles to this call in our doctorate programs and identify three next steps.

Investigating Connections Between Covariation and Units Coordination in Middle School Students 6 Sarah Kerrigan, Virginia Tech

This report presents preliminary data from part of a larger on-going study that is examining connections between middle school students' Units Coordinating stage, covariation reasoning, and working memory. From the larger study, this report focuses on how pre-algebra and algebra middle school students use their units coordinating structures in solving covariation and related algebra tasks. Reported here is analysis of some typical student responses seen thus far in the data.

7 Representations as tools or tasks in functions of two variables M. Kathleen Heid, Pennsylvania State University; Matthew Black, Pennsylvania State University

After engaging in the construction of physical representations of functions of two variables, prospective secondary mathematics teachers took part in task-based interviews. They were given a symbolic representation of a function of two variables and then asked to describe the 3D graph of that function. Their treatments, conversions, and

interpretations within and across various representations of functions of two variables were analyzed. Participants were largely influenced by their physical experiences in developing the function rules. To varying degrees of success, participants developed shortcuts to demonstrated procedures. Some used incomplete representations—ones that captured a less than minimal set of relevant features. Questions were raised regarding the role and nature of use of representations in mathematical work.

8 Transforming an Elementary Teacher's Conceptual Understanding of Mathematics Through Coached Productive Struggle and Reflection *Asia Franks, Fordham University; Alesia Mickle Moldavan, Fordham University*

The COVID-19 pandemic has encouraged teachers to rethink their own conceptual understanding of mathematics to determine the most effective instructional practices to employ during remote teaching. This study reports on an elementary teacher's effort to improve their conceptual understanding during professional coaching used to elicit productive struggle and reflection. Three themes emerged: (1) realization of the importance to use appropriate mathematical terminology and child-friendly language to guide conceptual understanding; (2) a new understanding of how models can be used to aid in visualizing abstract ideas; and (3) new efforts by the teacher to use multiple problem-solving methods to make connections. Recommendations are shared for how teachers can transform their conceptual understanding of targeted concepts with the aid of professional coaching to improve one's practice.

9 Infusing proof and justification, mathematical modeling and technology: The case of mathematical series Shahabeddin Abbaspour Tazehkand, University of Central Florida; Farshid Safi, University of Central Florida

The study has shown that teachers believe that proof is a subject that not all students could learn. However, this is not the case for mathematical modeling or technology. This study aims to focus on enriching preservice teachers' knowledge by infusing other mathematical practices. In order to do this, we design a framework to build a structure in which the aim of learning and teaching proof and justification could be achieved. Since there are different definitions and frameworks for each mathematical practice that is mentioned, this is a very challenging task. The content that we chose for this purpose is arithmetic and geometric series, which helps the process since it is connected to a very rich context.

10 Prospective Elementary Teachers' Evaluations of Student Solutions to Division Story Problems Julien Corven, University of Delaware

Twenty-four prospective teachers (PTs) enrolled in an elementary mathematics content course were asked to evaluate seven student solutions to a division story problem and were interviewed about the criteria they used to do so. As part of the interview, participants were primed to engage in professional noticing before providing their evaluations. Though several PTs used evaluative criteria noted from prior research (e.g., correctness of the answer, if the student used a method the PT would have taught), other PTs employed criteria more aligned with centering student thinking (e.g., whether the student clearly communicated their process, whether the solution was a productive base upon which to build student understanding). Results indicate that the criteria PTs employ to evaluate student work are often complex and multi-dimensional.

- 11 Secondary STEM Preservice Teachers' Continuous Improvement: Focusing on Student Engagement During a Pandemic Jenifer Hummer, West Chester University of Pennsylvania This poster presents results from a qualitative study. For the study, lab assignments from field experience and teaching methods coursework were analyzed to see how preservice students practiced continuous improvement methods. Specifically, the preservice teachers worked to increase student engagement while teaching virtually during a pandemic.
- 12 Developing Sustainable Math Instructional Leadership in a Network of Under-Resourced Schools Caroline B Ebby, University of Pennsylvania; Lindsay Goldsmith-Markey, University of Pennsylvania; Brittany Hess, University of Pennsylvania; Jennifer Lynn Valerio, University of Pennsylvania; Joy Anderson Davis, University of Pennsylvania; Lizzy Pecora, University of Pennsylvania This poster presents a model for developing sustainable math instructional leadership along with emerging findings on how teachers are learning to take on leadership roles in their schools and in the network. We also show how a shift from a school-based coaching model to one of virtual cross-school collaborative lesson design, enactment, and reflection has provided more equitable and sustainable opportunities for instructional support across the network, particularly for those schools that face the greatest challenges around resources.
- 13 The Effect of Research Experience on Teachers' Beliefs and Instruction: Pilot Study Seyedehkhadijeh Azimi Asmaroud, Illinois State University; David Barker, Illinois State University This project analyzed the effectiveness of a survey in measuring the influence of a research experience (discovery learning) Professional Development (PD) on teachers' beliefs and future instruction. This study refers to the importance of using discovery learning in teaching mathematics and providing PD opportunities that prepare teachers for practicing this method. Furthermore, this study provides a rationale for the importance of studying the effect of PD on teachers' beliefs that consequently affects their teaching. In this study, qualitative analysis of the responses of 14 participants (3 pre-service and 11 in-service mathematics and teachers) revealed that this research experience PD changed teachers' beliefs about the nature of mathematics and teaching mathematics. However, it did not provide sufficient data to make connections between particular beliefs and subsequent changes in practice. Several modifications have been performed on the survey questions, and they will be used to collect data from a larger community.
- 14 Do visual fraction models help students compare fractions? Evidence from elementary students' written work *Jinqing Liu, Indiana University; Erik Jacobson, Indiana University* Both learning and teaching fractions can be challenging. To build students' conceptual understanding of fractions,

visual models are broadly promoted because they are theorized to communicate students' mental models and make abstract mathematical concepts more accessible. While the effectiveness of visual models for fractions has been well documented in small-sample studies, little is known about how students use visual models at scale especially after the wide adoption of the CCSSM. This study examined about how students use visual models at scale. We designed an open-ended task and surveyed 214 fourth-graders in seven elementary schools. Our findings imply that although visual fraction models are supposed to support students' fractional reasoning and are emphasized in the CCSSM, less than half of students elect to use such models and their accuracy is not higher than students who do not. Further, these results contribute knowledge about the constraints of each type of visual model.

- 15 Students' Reasoning in a Modeling Task: Modeling Dance with Mathematics Nicolette Colona, Towson University; Melike Kara, Towson University; Kimberly Corum, Towson University This paper describes a modeling task designed to have students analyze different dance moves using geometric concepts and generalize their findings to develop a model that could be used for future dance analysis. The modeling task was implemented in two different virtual settings: one was in a university class with 40 students who are prospective elementary and secondary teachers and one was in a high school class with 6 students. The common themes in students' analysis across both implementations included: 1) angles formed in the dance moves and 2) shapes formed in the dance moves. These themes also occurred as the most common themes in students' models that were created to be used as analysis guide for future dance moves.
- 16 Implications of the Unstandardized Nature of Standards-Based Grading in Middle School Mathematics Classrooms *Michelle Morgan King, Western Colorado University* This qualitative, multicase study focused on middle school mathematics teachers' implementations of standards-based grading, use of assessment and feedback, and instructional design. Focusing on the experiences of four middle school mathematics teachers, data collection for each case consisted of two interviews, lesson summaries and reflections, and classroom observations over the course of five consecutive class periods. Data analysis highlighted differences in the teachers' uses of mathematical tasks during instruction, implementation of instructional types, and teacher moves used to engage students in supporting student reasoning, assessment strategies, and evaluation practices. The evidence suggests the need for improved standards documentation, resource development, and professional development both at the preservice and inservice levels to better achieve the recommendations of the standards-based grading literature.
- 17 Student-Teacher Interactions during Student Presentations that Contain Mathematical Errors in Secondary Classrooms Hannah Hudson, Middle Tennessee State University; Amanda Wagner, Middle Tennessee State University; Teriney McIntoish, Middle Tennessee State University; Erika David Parr, Rhodes College; Elizabeth B Dyer, Middle Tennessee State University Student presentations of their mathematical work allow teachers to build on student thinking to optimize learning for

Student presentations of their maintenanceal work allow teachers to build on student thinking to optimize fearming for the class as a whole. Presentations of incomplete or incorrect student work can be opportunities for pivotal teaching moments (Stockero & van Zoest, 2013; van Zoest et al., 2017), rather than something to be avoided or brushed over. When teachers discuss and build upon student presentations of incomplete or incorrect mathematics, they may do so in a variety of ways. Our study investigates the question: How do students and teachers interact when students present incorrect or incomplete mathematics in secondary classrooms? We analyzed video of nine 100-minute lessons that contained student presentations from three secondary mathematics classrooms. From this analysis, we found three distinct ways in which the teachers brought other students into the conversation: restating student comments, prompting discussion with follow-up questions, and directly inviting students to support the presenter.

18 Teachers' Referencing Of Public Records Of Student Mathematical Thinking Ben Freeburn, Western Michigan University; Sini Graff, Brigham Young University; Nitchada Kamlue, Western Michigan University; Zeynep Arslan, Trabzon University; Joshua Ruk, Western Michigan University; Lincoln J Sorensen, MTU; Keith R. Leatham, Brigham Young University This poster reports our findings of how teachers used public records of student mathematical thinking throughout whole class discussions. In our work, we consider a public record to be a physical and visual representation of a student contribution that is accessible to all classroom members. We will share how teachers' explicit referencing of

student contribution that is accessible to all classroom members. We will share how teachers' explicit referencing of public records helped establish student thinking and engage students with each other's thinking in whole class discussions.

- 19 Using Process Mining to Analyze Teacher-Student Interactions Kathleen Melhuish, Texas State University; Christina Koehne, SUNY New Paltz; Brittney Ellis, Portland State University Process mining describes a set of data science techniques that extract processes from event logs of activities that occur over time. In the educational setting, these techniques have been used on data from online courses. In this presentation, we share some of our preliminary work adapting this technique to data from videos of live-classrooms in order to identify patterns in student and teacher discourse. We share several examples of how process mining can describe these classrooms and lead to conjectures about causality and differences amongst classrooms. We suggest process mining as a tool to be paired with qualitative analysis to more robustly link teacher and student activity or discourse over time.
- 20 Noticing Mathematics from Multiple Perspectives Karl Wesley Kosko, Kent State University; Richard E Ferdig, Kent State University; Enrico Gandolfi, Kent State University A key aspect of professional noticing includes attending to students' mathematics-specific actions. 360 video has been found to be useful in providing additional perceivable student actions, and this affordance has been found to increase the likelihood of such specificity. This paper examines the degree to which multiple 360 camera perspectives affects the specificity of preservice teachers' professional noticing.
- 21 Preparing Faculty to Teach with Technology: A Focus on Self-efficacy Kristen Fye, University of North Carolina - Charlotte; Nina Gabrielle Bailey, University of North Carolina Charlotte; Allison

McCulloch, University of North Carolina at Charlotte; Jennifer Lovett, Middle Tennessee State University

Seventy mathematics, statistics, and mathematics education faculty participated in a 6 day workshop on teaching undergraduate courses with mathematical action technologies (e.g., Desmos, GeoGebra, CODAP). An overarching goal of the workshop was to support the development of faculty self-efficacy for using the technology(ies) and self-efficacy for using the technology(ies) in their instruction. To study faculty self-efficacy participants each completed a pre- and post- self-efficacy survey regarding the technologies presented in the workshop sessions. Participants rated their comfort level in using the technology (ies) for themselves as well as teaching with the indicated technology(ies). A repeated measures ANOVA was performed to assess the difference in self-efficacy as rated on the pre- and post-surveys (Norman, 2010). A full analysis will be presented along with implications for future faculty development related to preparing to teach using mathematics and statistics technologies.

- 22 Student Perceptions for Technology Labs That Integrate WeBWorK and GeoGebra Valerie Long, Indiana University of Pennsylvania; Alfred Dahma, Indiana University of Pennsylvania Research and leaders advocate for the use of technology in undergraduate mathematics courses as it enhances student learning. The purpose of this presentation is to discuss research for student perceptions of cost free, innovative math resources for homework assignments that use cutting edge technology, for example WeBWorK and GeoGebra, to enrich student learning in undergraduate mathematics. This research is part of a larger project that aims 1) to revise the curriculum for a three-credit course and one-credit co-requisite technology lab that fulfills liberal studies math requirements for business majors at a large midwestern university, and 2) to develop an interface that embeds GeoGebra applets into students' technology lab assignments delivered in WeBWorK for the one-credit technology lab.
- 23 The Messiness of Research: A Montage Carlos Nicolas Gomez Marchant, The University of Texas at Austin; Stacy R Jones, The University of Texas at Austin; Hangil Kim, University of Texas at Austin; Gerardo Sanchez Gutierrez, University of Texas at Austin

In an effort to disrupt the whiteness in academia, we present the messiness of our research endeavors as we work towards amplifying the voices of elementary Raza students. We challenge the notion that the research process is prescriptive and clean; it does not always take place in an office or conference room, following neat and orderly guidelines. We reveal our vulnerabilities through a montage of research memos, emails, journal entries, and text messages to reimagine and retell what it means to do research. Finally, we highlight our missteps, challenges, and false starts in an effort to rehumanize the research process. Much like the theories we use become embodied within our lives and souls. Through our endeavors, we show the autobiographical nature of research through the use of theories which impact our own lived experiences as well as the work we choose to do.

- 24 Understanding Student Behaviour as Evidence of Students' Conceptions and Instructional Norms *Irma Stevens, University of Michigan; Nicolas Boileau, University of Michigan* In this poster, we open up the discussion on critiques of research on students' conceptions and instructional norms. On one hand, cognitive researchers have used methodologies such as the task-based interview to construct in-depth second order models of students' thinking, often using novel tasks. On the other hand, researchers on instructional norms have been able to describe the techniques students believe they are expected to use when completing familiar tasks. Both areas of research have been critiqued: the former for their ability to support teachers in classrooms and the latter for being limited in their ability to describe students' meanings for the same work. We use specific examples to propose ways in which teachers and researchers can benefit from simultaneously thinking of students' performance on familiar tasks as both decisions to follow or deviate from what they believe they are expected to do and as evidence of their mathematical conceptions.
- 25 Pandemic Instruction: A Tale of Spatial Collapse and Platial Collisions Valentin Alexander Balthasar Küchle, Michigan State University; Yaomingxin Lu, Western Michigan University Using the concepts of "space" and "place" from human geography, we position the shift to online instruction in response to the coronavirus pandemic as a collapse of spaces and a collision of places. Specifically, we explore how home and class places interacted for three undergraduate mathematics students. Beyond discussing spatial issues that arose for these students from learning at home during the pandemic, we also discuss educational implications and explore how asking questions of space and place can highlight inequities.
- 26 Persist and Thrive: A Review of Literature about Black Girls in Mathematics Olanrewaju Oriowo, University of North Carolina at Charlotte This proposal is for a review of literature about the experiences of Black girls in mathematics, the impact of those experiences on STEM participation and key findings. It cites the problematic prevalence of deficit-based research and lack of scholarship from anti-deficit perspectives, leading to a call to action.
- 27 Leveraging Teachers' Complex Perceptions of Students *Mari Altshuler, Northwestern University, School of Education and Social Policy; Erica N. Mason, University of Illinois, Urbana-Champaign* Current research indicates many teachers hold deficit views about their students' mathematical capabilities. We share two independent studies that, beyond reiterating this finding, highlighted complexity in teachers' understandings of their students. This raised questions of how to shift teachers' discourse and support analytical nuance in research.
- 28 Exploring Students' Statistical Thinking During an Entrepreneurial Design Challenge Michael Belcher, North Carolina State University; Joshua P Mannix, North Carolina State University; Erin E. Krupa, North Carolina State University

The Design & Pitch Challenges in STEM (Confrey et al., 2019) is a novel curricular framework that situates middle grades STEM learning within entrepreneurial pitch competitions and math-focused design challenges. In this session,

we report on a case study of students participating in one such challenge. Students were tasked with designing an app and building data representations that would help users monitor and reduce their "phubbing," or phone snubbing, behavior. We present results to show how the challenge created opportunities for students to define statistical questions, consider strategies for measuring and quantifying data relevant to those questions, and invent (or not) informative data representations for a specific purpose.

29 Entangling and Disentangling Inquiry and Equity: Voices of Mathematics Education and Mathematics Professors Amanda Jansen, University of Delaware

Inquiry – asking and investigating answers to meaningful questions (Brown & Walter, 2005) – is promoted for multiple purposes across mathematics education. However, the enactment of inquiry-oriented teaching alone does not ensure equitable outcomes or equitable experiences for students (Johnson et al., 2020; Lubienski, 2002). In this poster, we extend Tang and colleagues' (2017) reflections on alignment between inquiry and equity in pursuit of the following research question: How and in what ways can inquiry and equity be viewed as intersecting? Data for this study consists of interviews with 24 professors who identify as mathematics education professors and/or mathematics professors. Results illustrated three possible categories of intersections between inquiry and equity: (a) equity possibilities and dilemmas are always present during inquiry; (b) equitable inquiry is a vision for how collaborative inquiry can operate; and (c) inquiry can be a vehicle that moves us toward greater equity.

- 30 Prospective Teachers' Questioning Patterns in a Simulated Student Interview Sandy M Spitzer, Towson University; Christine M Phelps-Gregory, Central Michigan University
 This poster presents preliminary results from a study in which prospective teachers (PTs) interacted with a simulated student (programmed using an AI chatbot and the authentic responses of 5 children) to conduct a diagnostic interview about geometric thinking. We analyzed the transcripts of PTs' simulated interviews to classify their questioning types and patterns. Results reveal that PTs asked a variety of question types, focusing tightly on the example shapes that framed the interview, and used follow-up questions to probe the simulated student. Overall, these results suggest that PTs may need specific interventions to improve their ability to ask rich and meaningful questions to uncover student thinking in order to guide their instruction.
- 31 Perspective Taking and the Construction of an Intersubjective View Amber Simpson, Binghamton University; Signe Kastberg, Purdue University; Caro Williams-Pierce, University of Maryland In this presentation, we will illustrate how the use of multiple go-pro cameras and analysis of individual views allowed us as researchers to "see" more of an event with each new viewing of video data. We provide examples as to how the use of multiple go-pros within a group of fifth grade students afforded us as a research team the opportunity to piece together different student perspectives to form a larger possibility space of "truth" of one event (i.e., perspective taking). This approach has implications for the collection and analysis of video data in mathematics education.

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Title, Author, Abstract

A Comparative Study of Trigonometry Standards in Turkey, Zambia, and the United States *Rose Mbewe, PURDUE UNIVERSITY; Sezai Kocabas, Purdue University*

In this study, we compare the three nations' (the United States's CCSSM, Turkey, and Zambia) trigonometry standards to identify how the intended curriculum is similar and different. The content of trigonometry topics is similar while the sequence of the topics differs. Turkey and Zambia were more likely to focus on performing procedures whereas the United States' standards were more likely to support higher-order thinking skills, which might be related to American students' lower performance in ACT tests.

A Complicated Relationship: Examining the Effect of Strategy Use on Accuracy When Solving Multiple Ways Jeannette Garcia Coppersmith, Harvard University; Jon Star, Harvard

This study examines the relationship between strategy use and accuracy on arithmetic and algebra problems. Secondary school students were asked to solve the same set of five problems twice using different strategies. We found a significant interaction effect between strategy use and whether students were solving a problem for the first or second time. The first time students solved a problem, the standard approach had a higher rate of accuracy compared to the better-than-standard approach. However, for the second part of the assessment, the standard and better-than standard approaches were equally related to accuracy. Further, we found differences in the success of the two strategies in different parts of the assessment, with the standard approach being more successful in part 1 compared to part 2, and the better-than-standard approach being more successful in part 2 of the assessment compared to part 1.

- Advancing Preservice Mathematics Teachers' Cultural Awareness Through an Embedded Methods Course Experience *Blair Izard*, *University of Northern Iowa; Heather Gallivan, University of Northern Iowa; Chepina Rumsey, University of Northern Iowa* During the spring 2021 semester, a university in the Midwestern United States began offering a program that embedded preservice teachers (PTs) methods classes at a local elementary school. This allowed the opportunity for PTs to immerse themselves in a school where about 80% of students identify as Black or Hispanic and 68% are eligible for free and reduced lunch (Public School Review, 2018), very different demographics from PTs participating in this program, many of which identify as white, middle-class, and from small, rural towns in the Midwest. Throughout the semester, PTs participated in discussions and activities related to culture (e.g. culturally relevant math pedagogy). We explore how this program influenced PTs' sense of cultural awareness and ability to work across cultures. We argue that by the end of the program, many had become more aware of culture and the importance of including their students' cultures into their classrooms and curriculum.
- A Framework for Analyzing the Use of Language in Undergraduate Mathematics Ernesto D Calleros, San Diego State University & University of California San Diego

While there is a common notion that mathematics is a universal language, on closer examination we find that doing mathematics also involves engaging in mathematical practices that require sophisticated uses of language (Moschkovich, 2002). The issues related to language and mathematics have received less attention at the undergraduate level, though some research has considered the linguistic demand of undergraduate mathematics . Yet, much of this work focuses on "language as a problem" rather than as a resource. These observations warrant a careful analysis of the ways teachers and students use language in undergraduate math classes. To pave the way for this analysis, this poster develops a conceptual framework of language use in undergraduate mathematics, organized based on the use of several language components (and their relationships). I briefly elaborate on four such components: lexical ambiguity, students' linguistic resources, multiple-semiotic systems, and mathematical practices. Implications for researchers and teachers are provided.

- A Teacher's Struggles to Teach Conditional Probability for Understanding: The Case of Mr. Kantor *Jose Contreras, Ball State University* This study analyzes a teaching episode in which an experienced middle school teacher struggled to help his students understand a conceptually based explanation for the concept of conditional probability. Data collected through interviews and videotapes suggested that the teachers' explanation for conditional probability was supported by the coherence and connectedness of his mathematical content about conditional probability. This finding suggests that other factors, such as the intrinsic difficulty of a topic and students' cognitions about the topic, play an important role in the success of teachers' explanations.
- A Theoretical Framework for Describing Common Manifestations of Mathematical Anthropocentrism *Thomas Ricks, Louisiana State* University

This paper categorizes the most common mathematically anthropocentric manifestations of mathematicians and mathematics educators. I distinguish three main types of mathematical anthropocentrism: (1) absolute, (2) strong, and (3) weak mathematically anthropocentric perspectives, all of which center human mathematics over the mathematics of the non-human Other. I challenge mathematical anthropocentrism as anachronistic (in lieu of recent scientific developments in a wide range of scientific fields, such as animal cognition, plant behavior, bacteriology, genetics, etc.), significantly limiting the interpretation of what counts as legitimate mathematics (and hence, limiting the paradigms of mathematics education). I posit that mathematical anthropocentrism is a culturally reproduced phenomenon that can be troubled through adequate education about non-human Other mathematics. I recommend that mathematicians and mathematics educators consider post-anthropocentric mathematical perspectives legitimizing non-human Other mathematics onto an equal plane with the mathematics that humans do.

Authenticity in Elementary Preservice Teachers' Mathematical Task Design Yi-Jung Lee, University of Arkansas

The authors report a study of 30 preservice teachers (PSTs) who designed mathematical tasks based on children's mathematics literature in a methods course. The mathematical tasks were analyzed using the constant comparative method on the dimensions of context authenticity and task authenticity. The analysis reveals that PSTs used relatively more computational tasks in their lesson planning, but they showed the tendency to situate mathematical tasks for simulation and real-life contexts. In addition, we found that PSTs produced more tasks for the third grade than for other grade levels and more tasks for "Operations and Algebraic Thinking" and "Measurement and Data" than for other mathematics domains. The significance and pedagogical implications of the study will be discussed.

Blogs and Learning Journals: Mathematics Teacher Candidates' Reflections on Learning to Teach Corey Brady, Vanderbilt University; Teresa Dunleavy, Vanderbilt University This poster describes the authors' shared exploration of teacher candidates' (TC) engagement in two kinds of personal writing space across two courses in our secondary mathematics education program. In our courses, learning journals are semi-private student-instructor writing spaces where TCs relate to the subject of mathematics, while blog entries prompt candidates to "go public" with their ideas about teaching. We selected three Noyce scholars, Rhianna, Valerie, and Yolanda, who took our two courses simultaneously in Fall 2020, and analyzed the ways they used these different writing spaces for their learning.

Decentering Whiteness in a Social Justice Mathematics Course Michael Lolkus, Purdue University

- While teaching mathematics for social justice can support students to develop critical mathematics literacy the specific understandings about how mathematics can be used to determine whose knowledge is valued efforts to deliver equitable, social justice-oriented, mathematics instruction still run the risk of perpetuating whiteness. As such, my study details a necessary reflection of my own positionality as a white cis-gender male and consequential perpetuation of whiteness throughout a social justice mathematics course I designed and taught in Fall 2020 to 11 prospective mathematics teachers. In this action research study, I utilize thematic analysis to organize themes across various sources of evidence, including instructor reflections (i.e., weekly, pre-course, post-course) and curricular documents (i.e., lesson outlines, mathematical tasks, syllabus). This action research study provides insight to how social justice mathematics can implicitly perpetuate whiteness, and how mathematics teachers and teacher educators can work to confront and decenter whiteness in their respective classrooms.
- "Education Fish in a World Full of Sharks": Preservice Teachers' Experiences in Mathematics Content Courses *Limin Jao, McGill University; Gurpreet Sahmbi, Ontario Institute for Studies in Education University of Toronto* Secondary mathematics preservice teachers (PSTs) are required to take a number of mathematics content courses to develop their mathematical content knowledge. In these spaces, they are in the minority amongst students in STEM programs. Using a series of semi-structured interviews, we explored the experiences of secondary mathematics PSTs in these courses. Our findings suggest that PSTs experience a range of challenges, including being ignored and dismissed by mathematics professors, and difficulties connecting with and understanding course content. To cope with these challenges, PSTs developed community with each other. PSTs also became reflective practitioners and considered how their experiences in these courses applied to their learning as future teachers.
- Eliciting Kindergarten Students' Mathematics with a Coding Toy: A Pilot Study on Design Features *Joseph S. Kozlowski, Utah State University; Jessica Shumway, Utah State University; Jody Clarke-Midura, Utah State University; Victor Lee, Stanford University* Research is beginning to highlight the mathematics that young children demonstrate when using coding toys, yet little is known about how the design features of coding toys elicit children's mathematics. The purpose of this study is to understand how a coding toy's (i.e., Cubetto) design features elicit young children's mathematics. Researchers gathered video data of fifteen kindergarteners engaging in a coding toy task in small groups and analyzed the data to understand: (a) when students perceived design features of a coding toy, (b) what mathematics occurred as children perceived the design features, and (c) how the design features elicited mathematics. Results indicated that simultaneous linking features did not elicit mathematical concepts, anthropomorphic features elicited mathematical spatial concepts, and the grid square feature elicited number concepts.
- Emergent Self-Regulation Strategies of an Undergraduate Freshman in Calculus I: The Case of Isaac Kyle Russell Turner, University of Texas at Arlington

This preliminary report discusses one undergraduate freshman's transition into college mathematics and how his use of self-regulation strategies changed in response to his performance in a first-semester calculus course. I analyze interviews of Isaac focused on how early college experiences impacted his strategy formation and how his confidence in mathematics changed over the course of a semester. Findings suggest that productive strategy development can be triggered by seemingly negative course experiences. This raises awareness for considering how negative experiences influence development of undergraduates' productive self-regulation strategies and which attitudes promote their use of beneficial strategies.

EXAMINING PRESERVICE TEACHERS' RESPONSES TO AREA CONSERVATION and VOLUME TASKS Dae S. Hong, University of Iowa; Cristina Runnalls, California State Polytechnic University, Pomona

The purpose of this work was to explore how elementary pre-service teachers responded to area conservation and volume tasks that asked for a coordination of changes in one dimension with changes in volume. We carried out both written pre-assessments and follow-up interviews with preservice teachers, focused on exploring volume content knowledge. Our findings indicated that the PSTs in the study used primarily procedures to respond to the task correctly. In follow-up interviews, PSTs struggled to justify their answers in different ways, however. Recommendations for supporting pre-service teachers in similar teacher education programs are discussed.

Examining the Instructional Readiness of Pre-service Teachers via their Epistemic and Mathematics Instruction Beliefs *Guillermo J* Farfan, Florida State University

Following teaching-in-context theory, this study investigated pre-service teachers' (N = 104) instructional readiness in mathematics by looking at their beliefs about mathematics and mathematics instruction, as well as their knowledge of reform-based mathematical practice standards. Using both online survey responses and in-person interviews, this study found that most pre-service teachers at a preeminent research university in the U.S. were not familiar with reform-based mathematical practices, while subtle differences in their beliefs appeared among elementary education majors and education minors, who leaned more toward traditional mathematical practices and viewed mathematics through the prism of correct answers, and secondary mathematics education majors, who favored reform-based mathematical practices and viewed mathematics as a process of discovery. Implications for teacher education are also briefly discussed.

Fending For Themselves: Secondary Mathematics Pre-Service Teachers' Experiences as Outsiders in Their Program Gurpreet Sahmbi, Ontario Institute for Studies in Education - University of Toronto; Limin Jao, McGill University

This study investigated the experiences of secondary mathematics preservice teachers (PSTs) as they navigated mathematics content, general education, and mathematics teaching methods courses in their teacher education program. Through a series of semi-structured interviews, we learned that PSTs felt like outsiders in their mathematics content and general education courses and leaned on each other to get through each of these components. Because of the challenges they faced in those components of their program, PSTs developed a cohort based on shared goals, experiences, and support for one another; and the mathematics teaching methods course provided a formal space to allow this cohort to thrive. We conclude by calling teacher education programs to action as they consider ways of promoting positive/inclusive experiences for PSTs.

How do high school students justify probability of an event in a modeling activity?/¿Cómo justifican estudiantes de bachillerato la probabilidad de un evento en una actividad de modelización? *Beatriz Arellano, UPN; María Estela Navarro Robles, Universidad Pedagógica Nacional; Armando Paulino Preciado Babb, University of Calgary*

Throughout this poster, we present the results of the process carried out in four groups of 50 high school students, in which they made an activity

about throwing 2 dice using computing simulation. The students had to justify their results and predict what would happen in hypothetical situations. Se presentan los resultados de lo que ocurrió en 4 grupos de 50 alumnos de Bachillerato, al realizar la actividad del lanzamiento de 2 dados usando simulación, en la cual los estudiantes tenían que dar argumentos para justificar resultados y predecir qué ocurriría en situaciones hipotéticas.

- How Language Switching Facilitates Folding Back to Collect *Sitaniselao Stan Manu, University of the Fraser Valley* Untangling the relationships between teaching, mathematics, and language is indeed a complex affair. This report focuses on one aspect of this multifaceted relationship: that is, how teachers within a particular bilingual setting uses 'language switching' as a pedagogical tool in engaging, invoking, and facilitating "folding back" – a form of 'thickening' students' mathematical understanding by recalling, accessing and collecting their prior or existing knowledge. The author analyzed video data to identify bilingual teachers' verbal cues and practices that support students' access via language towards mathematical understanding.
- Identity Journey Maps: A geospatial road trip of math content identity *Dennis J DeBay, University of Colorado Denver* The goal of the Identity Journey Map project (IJM) is to explore the impact of student teachers creating IJMs is to allow for the opportunity to reflect and set the stage for all the (possibly different) ways student teachers will experience their mathematics content identity in the classroom. Through geospatial story-telling software (StoryMaps - https://storymaps.arcgis.com/en/), students will communicate their journey and experiences to this point that have brought them to be connected math educators in the hopes of exploring ways to connect their student's content identities in math.
- Impacts of a Computer Game-Based Early Algebra Intervention *Christopher Engledowl, New Mexico State University; Mohammad Saleh Al-younes, New Mexico State University; Germain Degardin, New Mexico State University; Ayman Alzaid, Student* Early algebra has potential for supporting students in overcoming the algebra gateway towards high school graduation and tertiary mathematics. Focusing on two key ideas of early algebra—writing and interpreting numeric and algebraic expressions, and expressing patterns and relationships between quantities—this study seeks to examine the impacts of a computer game-based inquiry-oriented early algebra intervention implemented with 457 students in 28 teachers' classrooms across 10 schools. Drawing on data from a knowledge assessment, demographic variables, affect and other contextual variables, multilevel modeling was used to investigate associations with students' post-test Rasch person-ability scores. Preliminary results indicate significant learning gains, as well as differential effects from teachers. Implications are discussed for future research and classroom practice.
- Informal Isomorphism Concepts in Abstract Algebra Texts Alison Mirin, Arizona State University; Rachel Rupnow, Northern Illinois University

Despite isomorphism's dual nature as both a property and a function, most research has examined "isomorphism" as a singular concept. We analyze how common introductory texts structure and relate the ideas of isomorphism property, isomorphism function, and homomorphism. We incorporate a discussion of the informal descriptions of these constructs and highlight most texts' use of the property to motivate the function. Findings include the need for instructional attention to the components of the isomorphism concept and the centrality of the isomorphism property to textbooks' treatment of isomorphism.

In-service Teachers' Perceptions about Virtual Collaboration in Mathematics Classrooms: Challenges and Possibilities Zareen Gul Rahman, James Madison University; Younggon Bae, University of Texas Rio Grande Valley; V. Rani Satyam, Virginia Commonwealth University

Three in-service mathematics teachers engaged in a task designed for virtual collaboration. They experienced the need for developing group norms and connected their experience to their own classrooms and their students. The teachers expressed several possibilities as well as perceived challenges of learning mathematics through virtual collaboration. Findings show there are possible benefits for virtual collaboration as implemented in K-12 classrooms.

Instructors' Modifications of Analysis Proofs into Pedagogical Proofs David Varner, Central Michigan University; Katrina Piatek-Jimenez, Central Michigan University

Mathematical proofs are an integral part of teaching undergraduate mathematics. However, interpreting mathematical proofs is known to be a difficult topic for students to grasp. In the study described in this paper, which is part of a larger study, we asked three mathematics instructors to modify several proofs so that they might be better understood by undergraduate analysis students. The modifications made by these instructors included providing more details, giving accompanying examples and diagrams, and rearranging the ideas of the proofs. The results of this study have implications for the teaching and learning of proof.

Interactions in Blended Mathematical Learning Environments Erin E. Krupa, North Carolina State University; Michael Hoyes, Jr., North Carolina State University; Karen Hollebrands, NC State

As a result of the Covid-19 pandemic teachers had to transition to new modalities of instruction. Interactions in mathematics classes are important for student learning, especially having opportunities to interact with their instructor, their peers, and mathematics content. It is important to understand the interactions in mathematics classes, as learning has shifted to online and hybrid formats. In this paper we analyze 19 videos of classroom instruction to characterize the interactions occurring in these mathematics classes. Results show that the majority of interactions are between the learner and instructor and we observed no interactions between mathematics learners. The most frequent type of interaction between the learner and instructor was the teacher presenting mathematics content or responding to a student question. This research has implications for supporting teachers to facilitate interactions in online instruction.

Knowing What, When, How and Why: Prospective Mathematics Teachers Talking about Mathematical Reasoning Doris Jeannotte, UQAM; Sarah Dufour, Université de Montréal; Stéphanie Sampson, UQAM; Florence Gentet, UQAM

Mathematical reasoning [MR] has been at the core of school mathematics in several countries for more than 30 years. However, the concept of MR remains vague both in research and in practice. For example, very little is known about the different ways in which teachers use this concept, uses that shape several of their pedagogical choices (Hill et al., 2005). This article aims at exploring how prospective mathematics teachers [PMT] conceptualize MR. Taking a commognitive perspective, PMT are viewed as a particular community that share a certain discourse. By analyzing their discourse, we were able to highlight what mathematical reasoning is for them. Two features are discussed: MR as knowing what, when, how and why and exemplifying as a particular MR process that supports other ones.

Learning to Ask Questions about Instruction from Video Sarah Larison, Northwestern University; Jen Munson, Northwestern University Practicum placements, where preservice teachers (PSTs) observe in a classroom over an extended period of time, are a typical feature of teacher education programs. PSTs' opportunities to learn from observations are influenced by discussions with their cooperating teachers (CTs), as discussions can reveal CTs' reasoning about instructional decision-making and student thinking. How can PSTs learn to elicit such discussions? We propose that learning to ask meaningful questions after an observation is a skill that can be learned using video. Video allows teachers the opportunity to reflect on the richness of real classroom interactions while providing needed time for examination (Sherin, 2003, 2007). In this exploratory study, we examine whether using video in a mathematics methods course to practice question-posing influenced the kinds of questions PSTs reported having posed or imagined posing to their CTs following observations of mathematics instruction.

Learning to code for mathematics teaching: The case of Maria *Robyn Ruttenberg-Rozen, Ontario Tech University; Nkechi Ibeh, Ontario Tech University; Ami Mamolo, Ontario Tech University* Coding and computational thinking are increasingly prevalent in K-12 mathematics curricula around the world. At the same time, women have been dissociating from ICT creating a challenge for teacher educators to support their preservice teachers in developing these new skills. Women make up a large part of the elementary teaching workforce and thus there is an imperative need to address their experiences and attitudes to support their coding learning. In this brief report we analyse a case study of a woman learning to code through a lens of affect, values, and personal goals. We highlight the

affective attributes that can help women override negative feelings toward computational thinking and coding, and that can lead to productive struggle and a sense of personal accomplishment. Making Sense of Non-Integer Exponents Using a Number Line Model John Gruver, Michigan Technological University; Mike Foster, San

- Making Sense of Non-Integer Exponents Using a Number Line Model John Gruver, Michigan Technological University; Mike Foster, Sa Diego State University/University of California, San Diego; Elizabeth Keysor, Michigan Technological University Research suggests students need richer meanings for non-integer exponents. We argue that in order to develop these meanings students both need to have a continuous image of exponential growth and be able reason about that growth over time periods of various sizes. This ability can be seen as being able to engage in scaling-continuous covariational reasoning. We suggest that modeling exponential growth on an exponentially scaled number line can support this type of reasoning and can be a helpful tool in building sensical meanings for non-integer exponents.
- Middle School Mathematics Teachers' Colloquial Evaluations of Digital Mathematics Resources *Jaime Kautz, The Ohio State University* The goal of this study was to better understand what guides middle-school mathematics teachers' colloquial evaluation (CE) of digital mathematics resources. 32 middle-school mathematics teachers and coaches participated in the study. Teachers explored digital mathematics resources and responded to informal prompts to judge the quality of the resource, which served as the data source for this study. These CEs were explored qualitatively through multiple lenses. Emergent findings showed that the digital mathematics resources' attributes of usability, student feedback, implementation, accuracy, and affect were the most frequently cited characteristics. When comparing teachers' perception of a digital mathematics resource to the nature of the supporting comments, the large majority of teachers' perceptions were confirmed and very few were contradictory.
- Mixed-Reality Simulation In Teacher Preparation: How Much Is Enough? / Simulaciones De Realidad Mixta En La Formación De Maestros: ¿Qué Cantidad Es Suficiente Para Que Sea Efectivo? Jair Aguilar, The University of Texas Rio Grande Valley
 Las Simulaciones de Realidad Mixta representan una alternativa para preparar maestros en formación durante los primeros años de los programas de educación. En esta propuesta se muestran evidencias de los beneficios de usar Simulaciones de Realidad Mixta para preparar maestros en formación en el uso de acciones productivas en el aula de matemática tales como cuestionar, validar o observar. Igualmente, se demuestra la efectividad del uso de simulaciones de Realidad Mixta al exponer a los maestros en formación a varias simulaciones durante un periodo determinado.
- Modeling Equitable Practices: Mathematics Teacher Educators' Reflection and Practice Crystal Kalinec-Craig, University of Texas at San Antonio; Colleen McLean Eddy, University of North Texas; Mark S Montgomery, Stephen F. Austin State University; Karisma Morton, University of North Texas; Dittika Gupta, Midwestern State University

The purpose of this poster is to explicate how a group of Texas Mathematics Teacher Educators used the methodology of Lesson Stud to explore how they could incorporate an equity framework into their practice, namely the Torres' Rights of the Learner. The lesson sought to support teacher candidates' use of non-standard units of measurement to fill a space. This lesson study served as a peer-professional development in which each of the authors brought their own ideas to the work as a means of collectively improving our practice. The poster will outline the following aspects of the Lesson Study and the results from the analysis and work.

Navigating the Implementation of Best Practices in Math Instruction While Student Teaching During COVID-19 Ashley Whitehead, Appalachian State University; Christina Tschida, Appalachian State University

This study explores the impact of COVID-19 on teacher preparation, specifically related to how the transition to online teaching and learning during early field experiences and then restrictions during student teaching impacted their ability to implement best practices for mathematics. Nine preservice teachers completed a series of journal prompts and interviews that examined their experiences of learning to teach during the pandemic. An important part of the study explored their knowledge of best practices and how they enacted them in their classrooms. Preliminary results of this study demonstrate the impact of moving field experiences online during the 2020 school year and teacher candidates' struggle to incorporate best practices into their teaching.

Participant Reasoning in a Multivariate Social Justice Context Related to Participant Identity and Lived Experiences Jennifer Seat, Middle Tennessee State University

As educators, we are thinking more about ways to value the contributions of our students in the classroom. This study examines the ways in which lived experiences and identity guide the interpretation of a social justice data sets. Examples from task-based interviews will be used to demonstrate how this phenomenon can be used to create a rich understanding of social justice issues.

Pre-service Teachers' Interpretations of Real-life Examples Related to Percent Ji-Eun Lee, Oakland University

This study investigates what types of understanding pre-service teachers (PSTs) demonstrate while engaging in the tasks of interpreting real-life examples related to percent. Elementary PSTs were asked to facilitate online discussion forums on the examples of their choice for four weeks using various questions/prompts and to report the conclusive interpretation of the initial problem upon completion. Results show that many PSTs focused on applying typical computation procedures they knew, but those efforts were often unsuccessful when using real-life examples where essential information was provided in a vague form compared to the typical textbook problems. One significant difficulty was identifying referent units to interpret relative sizes, which led to incorrect fractional relationships. Designing tasks that promote PSTs' flexible knowledge application in various mathematical content domains is necessary.

Preservice teachers' mathematical knowledge for teaching: Focus on lesson planning and reflection *Bima Kumari Sapkota, Purdue* University

Secondary Mathematics Preservice Teachers (PMTs) often struggle to conceptualize how content knowledge is utilized for rich mathematics teaching. Because Mathematical Knowledge for Teaching (MKT; Ball et al., 2008) offers a framework with six MKT domains to explore how content knowledge is associated with mathematics teaching, PMTs would benefit from attention to MKT-related dispositions and language. In this study, I investigated which MKT domains were evidenced in PMTs' lesson plans and how PMTs described MKT domains in their lesson plan reflections. The preliminary findings indicated that even though some domains were evidenced in PMTs' lesson planning, PMTs tended to pay less attention to mathematics content while planning and reflecting on lessons. Thus, PMTs would benefit from content-specific instructional activities that require them to explicitly utilize their content knowledge in several aspects of teaching because such activities potentially assist them in exploring and utilizing the content knowledge for rich mathematics teaching.

Productive Struggle in Learning Mathematics: Preservice Elementary And Middle School Teachers' Lesson Plans Reyhan Safak, Ohio State University; Sumeyra Karatas, University of Texas Rio Grande Valley; Veysel Karatas, University of Texas Rio Grande Valley; Gamze Bulut, Brooklyn College; Ozgul Kartal, University of Wisconsin-Whitewater

After learning and practicing various strategies for supporting productive struggle, preservice teachers (PTs) were asked to prepare lesson plans in a math methods course. Analysis of PTs' lesson plans showed that PTs plan for supporting productive struggle by means of giving time to struggle in small groups, asking assessing questions, and planning tasks with real life or familiar contexts; whereas their plans did not include scaffolding access to productive struggle, anticipating student thinking, and using mistakes/errors/confusion as a way to support productive struggle. Implications are discussed, in the context of lesson planning, and in relation to how to help PTs so that they can support productive struggle of their students.

Promoting interest in statistics with social justice data investigations Josephine Louie, Education Development Center; Beth Chance, California Polytechnic State University - San Luis Obispo; Soma Roy, California Polytechnic State University - San Luis Obispo; Emily Fagan, EDC; Jennifer Stiles, EDC

To promote interest in statistics and data science among students from historically marginalized groups, this project is developing and studying a set of high school curriculum modules with a social justice focus. Designed as multi-week applied data investigations, the modules allow students to examine U.S. social and economic conditions using online data analysis tools and U.S. Census Bureau microdata. In one module, students address questions such as: What is income inequality? How have incomes for higher- and lower- income groups changed over time? Does education help explain the wage gap between males and females? Pre- and post-surveys show that using the module is associated with increased student interests in statistics and data analysis. This report discusses these findings and research implications.

- Prospective Teachers Connecting Their Own Understanding of Elementary Mathematics *Marc Husband, York University* Expecting teachers to support their students in making mathematical connections is an unreasonable request when teachers themselves have not had opportunities to connect their own understandings. This study investigates how prospective elementary teachers can deepen their mathematical understanding using tools and strategies similar to those researchers recommend for teaching school students. This case study was conducted in a 10-day professional development course, where 15 participants worked on elementary mathematics tasks. The video data and prospective teachers' journals were analyzed using Pirie-Kieren's (1994) Theory for the Dynamical Growth of Mathematical Understanding. Tracing one participants' learning pathway revealed a connection-making process that deepened her understanding of elementary mathematics.
- Psychometric Analysis of 2019 Knowledge for Teaching Early Elementary Mathematics (K-TEEM) *Xiaotong Yang, Florida State University; Gizem Solmaz, Florida State University; Robert Schoen, Florida State University*We present a method for examining the structural validity of the 2019 Knowledge for Teaching Early Elementary Mathematics (K-TEEM), a web-based assessment of mathematical knowledge for teaching at the early elementary level. The 2019 K-TEEM test serves as a pretest measure for a randomized controlled trial of a teacher professional development program based on Cognitively Guided Instruction. A total of 645 teachers of grades K-2 completed the web-based assessment in spring 2019. Using methods based on classical test theory and item-response theory, we present the process used in our psychometric analysis, including: missingness in data, dimensionality analysis, model fit and selection, item and test analysis, person-ability estimates, reliability estimates, and equating posttest to pretest scores. The analysis and scoring process of the K-TEEM can present a
- Race in Mathematics Education: What Topics Appear and How They Change Over Time? Sheunghyun Yeo, University of Alabama; Taekwon Son, Korea National University of Education; Sunghwan Hwang, Seoul Gaju Elementary School; Jaepil Han, University of Missouri

model for researchers in mathematics education to use as they increase the methodological rigor of their measurement practices.

This study examined research topics and trends of race-math studies across the fields of educational research drawing the equity framework. Collecting 1600 articles, we employed a topic modeling method and yielded 20 topics. We found that a majority of the studies found in the search were mainly related to achievement and access. While we found a gradual increase in the studies related to power and identity, these studies have a relatively small portion compared to the other research areas. The findings of the current study will inform researchers how race and mathematics have been used in and beyond the field of mathematics education.

Reflections on the mathematical ideas in the design process/Reflexiones acerca de las ideas matemáticas en el proceso de diseño MIKE SALDAÑA, CINVESTAV MÉXICO

This research was conducted with pre-service teachers to report on how they solve problems posed by the design of objects for the classroom and the reflections they make about the mathematical ideas that are put into action./ Es una investigación que se realizó con profesores en formación para reportar cómo resuelven los problemas que les plantea el diseño de objetos para el aula y las reflexiones que hacen acerca de las ideas matemáticas que se ponen en obra

Relationships in mathematics education for Indigenous pre-collegiate students *Tarah Michelle Donoghue, University of Colorado - Boulder* This brief paper will elaborate upon a core principle for the design of culturally sustaining mathematics centered Indigenous epistemologies: relationships. Indigenous perspectives hold that relationships are the center of existence, both among human beings, but also with more-than-human entities. Relationships are maintained through storytelling, in this case, about mathematics and for mathematics learning. The paper explores Indigenous perspectives on relationships and storytelling within the context of a Geometry class for Indigenous pre-collegiate students.

Re-visioning support to prospective teachers using a lesson study model/Reimaginando el apoyo a los futuros maestros utilizando un modelo de estudio de lecciones Omar Hernández-Rodríguez, Universidad de Puerto Rico; Wanda Villafañe-Cepeda, Universidad de Puerto Rico; Gloriana Gonzalez, University of Illinois

The context of this study is an innovation using lesson study to establish connections between methods courses and clinical experiences. We use four hypothetical situations to explore how mentor teachers would use their knowledge to manage problems that could surface during Lesson Study. Data was analyzed using the discursive patterns described by Horn (2010) and the Toulmin (1958) model. The mentors stated that the lessons should be carefully planned, allocating time and opportunities for reflection. Nevertheless, unexpected situations may surface. To motivate participation in lesson study, the mentors would promote communication, but also allow opportunities for reflection. When dealing with unexpected situations, they would try to establish a balance between following lesson study protocols and exploring the reasons for disrupting the protocols./

Sixth-Grade Students' Perceptions of Mathematics Discussions Using Group Roles and Groupworthy Tasks Anna Fricano DeJarnette, University of Cincinnati; Elsheika Pennerman, University of Cincinnati; Nick Shaver, University of Cincinnati

On this poster we will share initial data and analysis of African American students' perceptions of groupwork in a 6th-grade classroom where a white teacher implemented Complex Instruction, a pedagogical approach designed to minimize status differences and establish more equitable classrooms. Our poster will share our analysis of the student interviews alongside excerpts of group discussions that we used as a basis for our interview protocol. This project prioritizes the experiences of students, and the types of interactions that they perceive as equitable and collaborative, to determine how students learn collaboration and learn mathematics through collaboration.

Students' conception of confidence intervals: statistical literacy reflected on the COVID-19 Vaccine media reports Joo young Park, Florida Institute of Technology

The need for statistical thinking, ability to understand, interpret, and evaluate data from numerous media reports in decision-making has been increased, especially since the COVID-19 pandemic. The purpose of this pilot study was to examine students' conception of Confidence Interval (CI) and identify student difficulties associated with CIs presented in media reports on the COVID-19 vaccines. The study's participants were fourteen graduate students in the STEM education program at a private research university in Southeastern State. The assessment consists of six questions, including open-ended items based on news media reports on COVID-19 vaccines efficacy presented with CIs. Students were asked to complete the assessment and answer probing questions through individual interviews. Findings highlight students' difficulties in interpreting confidence intervals displayed in graphic representations. The poster will present the assessment items and prevalent student misconceptions probed by the items in the context of media reports on the COVID-19 Vaccines.

Teacher Candidates' Teaching for Conceptual Understanding Through the Lens of Representations *Emily Elrod, North Carolina State* University

Teaching for conceptual understanding is a key tenet of current mathematics education efforts. Representations are an integral component of conceptual understanding. This embedded multiple case study examines teacher candidates' practice of utilizing multiple representations as a means to develop conceptual understanding within their student teaching placements. Document analysis was completed on written edTPA commentary responses, instructional materials, and transcripts of teaching segments. Through the lens of the study's conceptual framework, data were analyzed using a priori coding, along with open coding for recurrent themes. Data support that teacher candidates were able to harness qualities of teaching mathematics for conceptual understanding.

The Development and Validation of Mathematics Flow State Scale Jing Zhang, University of Virginia; Kyong MI Choi, University of Virginia; Wesley A Cox, University of Virginia

This study was to develop and validate the psychometric properties of the MFSS. Results showed that the psychometric properties including reliability and validity of MFSS were acceptable, which suggests that the MFSS can be used in mathematics classroom to test elementary school students' positive experience (i.e., flow) when learning mathematics. Possibility to measure students' positive affect would contribute valuable information to mathematics education research and practice as it can advance current knowledge about students' emotions and motivation in learning mathematics in a positive perspective.

The evolution of routine tasks in the collective Genevieve Barabe, Université du Québec à Montréal

While a lot of research has focused on what could be "good problems" for the mathematics classroom, I suggest that good problems can emerge from the mathematical inter-actions in the classroom, independently of the task being posed at first. This research investigates the evolution of routine tasks through the inter-actions in the mathematics classroom. To do so, my research invokes enactivism as a theoretical lens to look at the nature of the problem-solving activity of the classroom, taken as the unit of observation. Moreover, analysis of works conducted in the "teaching via problem-solving" area of study led me to develop a framework for analysis coherent and complementary to the enactivism grounding. Together, those frameworks allow me to look at how the mathematical practices that are brought forth by the collective contribute to the evolution of routine tasks in the classroom. In this poster, I offer some examples of preliminary analysis.

The Multiplicative Reasoning of a High School Senior Nick Shaver, University of Cincinnati

Multiplicative reasoning (MR) is essential for understanding elementary and secondary math concepts. Studies have found that students who have not fully developed their MR struggle to understand improper fractions (Hackenberg, 2007) and linear equations (Zwanch, 2019). Since MR is understudied for high school students, this research focused on: What is the MR of students who struggle in secondary math? To answer our question, we administered a standardized pre-assessment to determine the lowest performing students in a secondary classroom. We followed up with a written-based MR assessment (Ulrich & Wilkins, 2017) and then conducted diagnostic interviews with two students with the lowest MR. The focal senior in this research had strong evidence of not having fully developed their MR which impacted their work on the standards-based pre-assessment. We will show evidence of their reasoning and discuss implications for teachers, students and researchers.

The Story of Definite Integrals: A Calculus Textbook Narrative Analysis Amanda Huffman, Purdue University

Teachers have to choose appropriate textbooks from a plethora available for every course. While most textbooks incorporate the same content and organize it in a similar way, it is important for teachers to understand the textbook to support their students' learning. This study aims to understand how teachers can best use their resources and read curriculum through a different lens. Dietiker's (2015) narrative framework was adapted to analyze written calculus curricula introducing the definite integral in working to understand the story of definite integrals and students' knowledge construction of definite integrals when read as stories. Analyzing the mathematical story provided an in-depth comparison of one lesson from five different calculus textbooks. Preliminary findings suggested key similarities and differences in the stories. These insights provide teachers and researchers a new perspective and a deeper understanding of these textbook lessons and how the variances in a story can alter student learning.

The Struggle of Covariational Reasoning About Exponential Growth: Embrace it or Erase it *Julie Lang, University of Northern Colorado; Lida ML Bentz, University of Northern Colorado; Adam Ruff, University of Northern Colorado; Jodie Novak, University of Northern Colorado*

This paper discusses the approaches of two experienced high school mathematics teachers as they engaged in a non-routine task concerning exponential growth. Both teachers considered a covariational approach as well as relying on an equation. However, when encountering a partial growth period, one of the teachers used the equation to avoid struggling with covariational reasoning while the other allowed herself to struggle and revealed rich mathematical ideas. Este papel presenta los planteamientos de dos instructores de secundaria con mucha experiencia considerando una tarea de crecimiento exponencial que no fue de rutina. Los dos consideraron un planteamiento covariacional y usaron una ecuación también. Sin embargo, al encontrar un periodo parcial de crecimiento, uno de los instructores usó la ecuación para evitar el esfuerzo de razonamiento covariacional y la otra se permitió esforzarse y reveló ideas matematicales profundas.

- Theoretical Framework for a Mathematical Object in relation to Multiple Coordinate Systems *INYOUNG LEE, Arizona State University* This study outlines a theoretical framework for describing different modes of thinking involved in mathematical activities such as graphing and symbolizing. The framework includes two forms of students' practices within a single coordinate system: 'Naming' and 'Locating'. The two practices extend the framework to situations when there are multiple coordinate systems. Two perspectives for an object with multiple coordinate systems complete the framework, in which I noted 'Coordinates-open' and 'Coordinates-closed'. I use that framework as a lens to review descriptions of multiple coordinate systems in calculus and linear algebra textbooks.
- Through the Students' Eyes: Mathematics Teachers' Curricular Noticing in a Problem-Based Curriculum Sunyoung Park, Michigan State University; Kristen N Bieda, Michigan State University

This descriptive study investigated two middle school mathematics teachers' curricular noticing when they solved problem-based textbook problems from a student perspective during a lesson planning phase. As active learning is considered to be an effective teacher learning opportunity, we focused on teachers' problem-solving experience as leverage for curricular noticing. We utilize the Curricular Noticing Framework (Dietiker et al., 2018) in order to describe how teachers make sense of the curriculum and how they find opportunities in it for students' understanding. The findings indicate that, when they solved textbook problems from a student's perspective, the teachers considered how students would think based on how they thought about the problems. This consideration influenced them to search for resources in the curriculum materials in order to encourage students' different problem-solving strategies.

Topics Chosen by Pre-Service Elementary Teachers Engaging in Self-Directed Learning in a Geometry Class Susanna Molitoris Miller, Kennesaw State University

Pre-Service teachers were permitted to create and explore their own mini projects in a geometry class. This work examines themes among the types of projects they chose to generate to identify general topics relevant to this population.

Understanding the Evolution of a Teacher's Philosophy of Mathematics: Part I, His Initial Conceptions Jose Contreras, Ball State University

Teachers' beliefs and conceptions about the nature of mathematics affect their instructional practices (Thompson, 1992). Thus, considerable research has been done to understand the development of teachers' beliefs and conceptions using mostly qualitative methodologies (Cooney, 1985; Eggleton, 1995; Fernandes & Vale, 1994). The goal of this research is to understand the evolution of a teacher's philosophy of mathematics and the impact of his philosophy on his classroom practice. In this poster, I report on the teacher's conceptions about mathematics as he entered the teacher education program (thereafter called his initial conceptions) and the critical experiences that, from his own perspective, influenced those conceptions. As a main research method, I'm using the biographical approach, a particular method of narrative inquiry.

Universal Design of a Tier 2 Fraction Video Game Jessica H. Hunt, North Carolina State University; Michelle Taub, University of Central Florida; Matthew Marino, University of Central Florida; Alejandra Duarte, North Carolina State University; Kiera Anderson, University of Central Florida; Jacob Brewer, University of Central Florida

Simulated learning environments have the potential to significantly enhance engagement and conceptual understanding for students with learning disabilities and difficulties. Model Mathematics Education (ModelME) includes a web-based video game designed with the Universal Design for Learning framework to maximize access, advancement, and power for 4th, 5th, and 6th grade students in supplemental mathematics instructional settings. Considerations for the game's design and development are shared.

Using Field-Test Data to Inform Decisions About Using Constructed-Response and Selected-Response Item Format Robert Schoen, Florida State University; Charity Buntin, Florida State University

Selected-response (i.e., multiple-choice) item formats are commonly used in mathematics assessments in the United States. The selected-response format has raised concerns about the quality of the items and limitations to the inference that can be drawn from them with respect to student abilities or understanding. At the same time, constructed-response items require extensive resources to score, can yield ambiguous responses, and raise concerns about reliability among scorers. Constructed-response items can be especially difficult to score when they are administered to young children whose handwriting and other communication abilities are in nascent stages. We present an approach to decision making for item format used in the Elementary Mathematics Student Assessment (Authors, 2016; 2017; 2021). We think this approach serves to increase efficiency and reliability of the test without sacrificing the quality of the inference that may be drawn with respect to student performance or understanding.

Using Multiple Strategies to Solve Algebra and Arithmetic Problems Soobin Jeon, Harvard Graduate School of Education; Jon Star, Harvard

Knowing multiple strategies and being able to apply them adaptively to various situations, which is also known as flexibility, links to higher academic achievement and can increase transfer across many problem-solving domains (Hiebert & Carpenter, 1992). Students can solve math problems in many different ways that can vary in efficiency. In this paper, we explore high school students' use of standard and better-than-standard strategies when solving problems, with a particular focus on whether strategy differences exist between students' work on arithmetic and algebra problems. We find that students' reliance on the standard and better-than-standard strategies and students' strategy repertoires are influenced by exposure to multiple strategies and whether the problem is arithmetic or algebraic.

Young Children's Use of Gesturing During Durational Reasoning Amy Smith, CU Denver

When describing the duration of their lived experiences, 4- and 5-year-olds use of iconic gestures (gestures that parallel the action or object being described; McNeill, 1992) in conjunction with their words might serve as evidence of their conceptions of duration as a measurable quality of their world. This poster presents some initial evidence of how some young children used their gestures to communicate their conceptions of the duration of past experiences.

Thank you to our Session Facilitators!

Denish Akuom, Montclair State University Nigar Altindis, University of New Hampshire Carrie Bala, Utah State University Erin Baldinger, University of Minnesota Mona Baniahmadi, Duquesne University Brianna Bentley, North Carolina State University Steven Boyce, Portland State University Lori Burch, Indiana University Rob Ely, University of Idaho Nicole M. Wessman-Enzinger, George Fox University Ben Freeburn, Western Michigan University Julia St. Goar, Merrimack College Steven Greenstein, Montclair State University Lisa Hawley, Michigan State University Jose Martinez Hinestroza, Texas State University Jenifer Hummer, West Chester University of Pennsylvania Michelle Morgan King, Western Colorado University Keith Leatham, Brigham Young University Beth MacDonald, Utah State University Allison McCulloch, UNC Charlotte Alesia Mickle Moldavan, Fordham University Chelsea Muhs, Portland state university Nirmala Naresh, University of North Texas Olanrewaju Oriowo, University of North Carolina at Charlotte Blake Peterson, Brigham Young University Luke Reinke, UNC Charlotte Gizem Solmaz, Florida State University Megan Staples, University of Connecticut Irma Stevens, University of Michigan Shari Stockero, Michigan Technological University Travis Weiland, University of Houston Xiangguan Yao, The Pennsylvania State University Karen Zwanch, Oklahoma State University

Participant Index

Abbaspour Tazehkand, Shahabeddin, 091, 179 Abrahamson, Dor, 037, 125, 231 Acevedo, Carlos Ivan, 045 Acuña, Claudia Margarita, 102, 175 Adams Corral, Melissa, 031, 119, 215, 225 Adkison, Camryn, 156 Aguilar, Alexandra, 091 Aguilar, Jair, 002, 006, 094, 199 Ahrens, Sally, 188 Akuom, Denish Ogweno, 099, 202 Al, Saliha, 091 Alapala, Burcu, 009 Aljarrah, Ayman, 158 Altindis, Nigar, 209 Altshuler, Mari, 020, 179 Alyami, Hanan, 189 Al-younes, Mohammad Saleh, 002, 006, 094, 199 Alzaga Elizondo, Tenchita, 154, 163 Alzaid, Ayman, 002, 006, 094, 199 Amador, Julie, 025, 050, 091, 113, 219 Amick, Lisa, 091 Amidon, Joel, 031, 119, 225 Amman, Kristen, 015 Anantharajan, Madhuvanti, 161 Anderson, Kiera, 002, 006, 094, 199 Anderson, Nancy, 077 Anderson, Robin Keturah, 214 Andersson, Annica, 133 Andreasen, Janet, 091 Anthony, Monica, 213 Antonides, Joseph, 070 Apkarian, Naneh, 091 Appelgate, Mollie, 034, 122, 228 Aqazade, Mahtob, 063, 189, 201 Arbaugh, Fran, 062, 098 Arellano, Beatriz, 002, 006, 094, 199 Armstrong, Alayne, 087 Arnold, Elizabeth G, 179 Arslan, Zeynep, 179 Asempapa, Reuben, 135 Ataide Pinheiro, Weverton, 027, 115, 221 Atanga, Napthalin Achubang, 194, 211 Austin, Christine Kathryn, 067 Avila Zarate, Adriana Ines, 085 Ay, Busra, 198 Ayalon, Michal, 095 Aydar, Jason Celal, 213

Azimi Asmaroud, Seyedehkhadijeh, 179 Azmy, Christina, 022

Bae, Younggon, 002, 006, 094, 169, 199 Bailey, Nina Gabrielle, 079, 179 Bala, Carrie Olson, 091 Baldinger, Erin E., 020, 095 Baniahmadi, Mona, 131 Barabe, Genevieve, 002, 006, 094, 199 Barker, David, 179 Barker, Heather, 022 Barno, Erin, 110 Battista, Michael, 070 Belcher, Michael, 179 Bene, Emma P., 091 Bennett, Amy Been, 105 Benoit, Gregory, 077 Bentley, Brianna, 010, 091 Bentz, Lida ML, 002, 006, 094, 199 Bergeron, Chris, 091 Bertolone-Smith, Claudia Marie, 026, 048, 114, 150, 220 Bharaj, Pavneet Kaur, 019, 091, 108, 164, 197 Bianchini, Julie A, 081, 132, 173 Bianco, Kathryn, 017 Bieda, Kristen N, 002, 006, 094, 199 Bih, Janet, 104 Billings, Esther M, 129 Bingham, Gary, 054 Bishop, Jessica Pierson, 024, 112, 205, 218 Black, Matthew, 179 Blustein, Daniel, 170 Bock, Camden Glenn, 018, 103 Bofferding, Laura, 063, 195, 201 Boileau, Nicolas, 179 Bondurant, Liza, 035, 123, 229 Bostic, Jonathan David, 078, 091, 128, 179 Boyce, Steven, 026, 084, 114, 150, 220 Bovd, Brian, 007 Brady, Corey, 002, 006, 038, 094, 126, 143, 199, 232 Brandt, Carol, 088 Brewer, Jacob, 002, 006, 094, 199 Bright, Dara, 091 Broadway, Rachel, 153 Brown, Chandler, 154 Brown, David, 090 Brown, Rachael Eriksen, 046, 185 Brunner, Megan, 173 Buchbinder, Orly, 196, 200

Buchheister, Kelley, 214 Bulut, Gamze, 002, 006, 094, 199 Buntin, Charity, 002, 006, 094, 199 Burch, Lori, 131 Burnett, Miriam, 081 Busi, Rich, 206 Butler, Rebecca, 200 Byerley, Cameron, 026, 084, 114, 220 Callard, Cynthia H, 025, 091, 113, 219 Calleros, Ernesto D, 002, 006, 094, 168, 199 Campbell, Matthew P, 095 Cantu, Esteban, 091 Capozzoli, Michelle, 200 Carman, Luke B, 214 Carmona, Guadalupe, 101 Carney, Michele, 073 Carson, Cynthia, 025, 091, 113, 219 Cavanna, Jillian M, 057 Cavey, Laurie Overman, 051, 166 Cayton, Charity, 079 Cevik, Emel, 213 Champion, Joe, 073 Chance, Beth, 002, 006, 094, 199 Chao, Theodore, 215 Chapman, Olive, 030, 118, 224 Chazan, Daniel, 196 Chen, Lizhen, 068, 201 Cho, Youngkee, 096 Choi, Kyong MI, 002, 006, 094, 199 Choppin, Jeffrey, 025, 050, 091, 113, 219 Cirillo, Michelle, 029, 044, 117, 223 Clark, Kathleen Michelle, 013 Clarke-Midura, Jody, 002, 006, 094, 199 Closser, Avery Harrison, 037, 125, 231 Closser, Avery Harrison, 091 Collier, Crystal, 191 Colona, Nicolette, 179 Condon, Lara, 208 Conner, AnnaMarie, 029, 117, 192, 223 Conner, Kimberly, 061, 167 Contreras, Jose, 002, 006, 094, 199 CopurGencturk, Yasemin, 091 Cordero-Siy, Eric, 009 Corey, Douglas, 058 Correa, Priscila D, 028, 116, 222 Corum, Kimberly, 091, 179 Corven, Julien, 016, 032, 091, 120, 179, 186, 226 Cox, Jennifer Lynn, 131

Cox, Wesley A, 002, 006, 094, 199 Crawford, Angela R, 052, 073 Crawford-Ferre, Heather, 048 Cullicott, Catherine E., 172 Czap, Lindsay Nicole, 188 Czocher, Jennifer A, 045, 086 Dahma, Alfred, 179 Dames, Brendan, 042, 076 Davis, Joy Anderson, 179 Dawkins, Paul Christian, 096 de Araujo, Zandra, 146 DeBay, Dennis J, 002, 006, 094, 199 Degardin, Germain, 002, 006, 094, 199 DeJarnette, Anna Fricano, 002, 006, 024, 094, 112, 199, 218 Delaney, Victoria, 087 Desai, Siddhi, 091 Dexter Torti, Cameron John, 081, 132, 173 Dias, Ana, 027, 115, 221 Dick, Lara, 034, 122, 228 Dickson, Chelsea, 091 Dietiker, Leslie, 015, 110 Dimmel, Justin, 018, 103, 154, 195 DiNapoli, Joseph, 032, 120, 226 Dobie, Tracy Elyse, 081 Dogan, Muhammed Fatih, 033, 121, 227 Dominguez, Angeles, 038, 126, 232 Donoghue, Tarah Michelle, 002, 006, 094, 199 Donovan, Courtney, 089 Doore, Stacy, 195 Drake, Corey, 131, 178 Drimalla, James, 084 Driskell, Shannon O. S., 021, 153 Duarte, Alejandra, 002, 006, 094, 199 Ducloux, Kanita, 166 Dufour, Sarah, 002, 006, 094, 199 Dunleavy, Teresa, 002, 006, 094, 199 Dyer, Elizabeth B, 008, 091, 155, 179, 181

Ebby, Caroline B, 179 Eckman, Derek, 096 Eddy, Colleen McLean, 002, 006, 094, 199 Ehrenfeld, Nadav, 055 Eker, Ayfer, 164 Ellington, Roni, 170 Elliott, Rebekah, 173 Ellis, Amy, 033, 121, 171, 192, 205, 227 Ellis, Brittney, 017, 149, 179 Ellis, Ruby, 146 Elrod, Emily, 002, 006, 094, 199 Ely, Robert, 078 Empson, Susan B, 139, 157 Engledowl, Christopher, 002, 006, 036, 094, 124, 199, 230 Epstein, Martha, 091

Fagan, Emily, 002, 006, 094, 199 Fan, Yiyun, 091 Farfan, Guillermo J, 002, 006, 094, 199 Feder, Shon, 153 Feikes, David, 082 Ferdig, Richard E, 179 Ferguson, Kristen E., 131 Ferragud, Carlos Bernardo Gómez, 160 Figueras, Olimpia, 177 Fink, Heather, 083 Fisher, Molly, 176 Fisher, Thomas, 183 Fletcher, Samantha, 079 Flores Gasca, Carlos Enrique, 152 Folger, Timothy Donald, 179 Foran, Alexandra Lair, 134 Fornaro, Christopher Joseph, 091, 179 Foster, Alexandra, 195 Foster, Genie, 025, 113, 219 Foster, Mike, 002, 006, 094, 199 Francis, Dionne Cross, 019, 164, 197 Frank, Toya Jones, 003, 180 Franks, Asia, 179 Frazee, Leah Michelle, 012 Freeburn, Ben, 062, 075, 098, 179 Freeland, Sean P., 013, 095 Frost, Jodi, 070 Fye, Kristen, 179

Gallagher, Keith, 141 Gallivan, Heather, 002, 006, 094, 199 Galluzzo, Benjamin, 187 Galusha-McRobbie, Sailer, 047 Gandolfi, Enrico, 067, 179 Gantt, Allison L., 016, 091, 136, 186 Garcia, Antero, 091 Garcia Coppersmith, Jeannette, 002, 006, 094, 199 Garcia-Costa, Daniel, 160 Gardner, Amber, 089 Gargroetzi, Emma Carene, 091

Garza, Ruben, 082 Gearty, Zarina, 102 Geisler, Sebastian, 066 Gentet, Florence, 002, 006, 094, 199 Geotas, Anastasia M, 142 Germia, Erell, 184 Ghosh, Abhinav, 091, 128 Ghousseini, Hala, 009 Gibbons, Lynsey, 032, 120, 226 Gibson, Jennifer, 206 Gill, Sierra, 046 Gillespie, Ryan, 025, 050, 091, 113, 219 Gillette-Koyen, Linda, 060 Giorgio-Doherty, Kristin, 131 Giudice, Nicholas, 195 Goldsmith-Markey, Lindsay, 179 Gomez Alfonso, Bernardo, 177 Gómez-Arciga, Adrián, 210 Gomez Marchant, Carlos Nicolas, 029, 100, 117, 179, 223 Gonzalez, Gloriana, 002, 006, 094, 199 Gonzalez, Monica Lyn, 059 Goyer, Alysia d, 046 Grabhorn, Jeffrey, 026, 084, 114, 150, 220 Graff, Sini, 179 Grant, Melva R, 030, 118, 224 Graysay, Duane, 062, 098 Green, Christine, 091 Greenstein, Steven, 099, 202 Gresalfi, Melissa, 143 Grewall, Tejvir Kaur, 046 Griffin, Casey, 044, 167 Grimaldo, Francisco, 160 Grimes, Alexis, 156 Gruver, John, 002, 006, 094, 199 Gu, Zhiqing, 067 Gualdrón Pinto, Elgar, 085 Guan, Oiang, 067 Gucler, Beste, 138 Gunpinar, Yasemin, 135 Gupta, Dittika, 002, 006, 034, 091, 094, 122, 199, 228

Habre, Samer, 091 Hackenberg, Amy J, 072 Haiduc, Ana-Maria, 201 Hall, Jennifer, 027, 115, 221 Hallman-Thrasher, Allyson, 105 Hamilton, Michael, 171, 192, 205 Han, Chaeeeen, 056 Han, Jaepil, 002, 006, 094, 146, 199 Han, Simon Byeonguk, 130 Hanusch, Sarah, 052, 212 Hardee, Matthew, 131 Hardison, Hamilton, 091 Harper, Frances K, 039, 068, 127, 233 Harper, Suzanne R., 021 Harrington, Rachel, 153 Harrison, Taylor Ray, 110 Hartland, Kristin Sue, 155 Hawley, Lisa, 148 Headrick, Lorna, 207 Hebert, Michael, 056 Hegedus, Stephen, 170 Heid, M. Kathleen, 179 Heisler, Jennifer Lynn, 076 Herbel-Eisenmann, Beth, 049, 133 Herbel-Eisenmann, Beth, 147 Herbst, Pat G, 091, 196, 203 Hernandez, Damaris, 065, 148 Hernández, Luis Enrique, 175 Hernández-Rodríguez, Omar, 002, 006, 094, 199 Hernandez-Seca, David, 176 Herner-Patnode, Leah M., 056 Herrera, Christine Alyssa, 156 Herreros Torres, Diana, 160 Hess, Brittany, 179 Hetrick, Carolyn, 154 Hewitt, Amy, 054 Hicks, Michael Duane, 163, 205 Hillman, Susan L., 077 Hinden, Anna Cross, 019 Hohensee, Charles, 191 Hollebrands, Karen, 002, 006, 014, 094, 199 Hong, Dae S., 002, 006, 094, 199 Howell, Heather, 035, 123, 197, 229 Howell, Kay, 068 Hoyes, Jr., Michael, 002, 006, 094, 199 Hoyos, Veronica, 082 Hudson, Hannah, 179 Huffman, Amanda, 002, 006, 094, 199 Hummer, Jenifer, 044, 179, 188 Hunt, Jessica H., 002, 006, 094, 199 Huru, Hilja Lisa, 133 Husband, Marc, 002, 006, 094, 199 Hwang, Sunghwan, 002, 006, 094, 199

Ibeh, Nkechi, 002, 006, 094, 199 Izard, Blair, 002, 006, 094, 199

Jackson, Brent, 027, 057, 115, 221 Jackson, Christa, 039, 127, 214, 233 Jacobs, Victoria R., 139, 157 Jacobson, Erik, 091, 108, 179 Jansen, Amanda, 172, 179, 207 Jao, Limin, 002, 006, 094, 199 Jarry-Shore, Michael, 161 Jasien, Lara, 091 Jeannotte, Doris, 002, 006, 094, 199 Jeon, Soobin, 002, 006, 094, 199 Jiang, Shiyan, 049 Johnson, Heather Lynn, 089 Jones, Stacy R, 100, 179 Jones, Steven, 058, 107 Jong, Cindy, 176 Jordan, Will, 170 Jung, Hyunyi, 038, 126, 232 Kadiyali, Vaynu C., 020 Kahn, Jennifer, 049 Kalinec-Craig, Crystal, 002, 006, 039, 094, 127, 199.233 Kamlue, Nitchada, 091, 179 Kandasamy, Sindura Subanemy, 086 Kane, Britnie Delinger, 109 Kara, Melike, 091, 179 Karatas, Sumeyra, 002, 006, 094, 199 Karatas, Veysel, 002, 006, 094, 199 Karr, Josh, 059, 095 Kartal, Ozgul, 002, 006, 021, 094, 199, 213 Kastberg, Signe, 030, 077, 118, 179, 189, 224 Katirci, Nihal, 091, 104 Kautz, Jaime, 002, 006, 094, 199 Kenney, Rachael, 016 Kerrigan, Sarah, 179 Kersey, Elizabeth, 027, 115, 221 Keysor, Elizabeth, 002, 006, 094, 199 Khan, Ishtesa, 142 Kim, Doy, 014 Kim, Eun Mi, 184 Kim, Hangil, 179 Kim, Hee-Jeong, 056 Kim, Jungsung, 189 Kim, Youngjun, 184 King, Deborah, 089 King, Michelle Morgan, 179 Kinsey, GIna, 087 Kirankumar, Veena, 014 Kirkland, David, 091 Kirmizi, Mehmet, 177

Kittani, Saman R, 091 Klein, Valerie, 088 Kline, Kate, 197 Kling, Gina, 197 Knapp, Melinda, 129 Knowe, Madison, 143 Kocabas, Sezai, 002, 006, 094, 199, 201 Koehne, Christina, 179, 190, 205 Koestler, Courtney, 039, 127, 233 Konuk, Nursen, 062, 098 Kosko, Karl Wesley, 029, 067, 076, 117, 179, 223 Kozlowski, Joseph S., 002, 006, 094, 199 Krause, Gladys, 031, 085, 119, 225 Kreici, Brooke, 167 Krist, Christina, 008 Kruger, Jennifer, 025, 113, 219 Krupa, Erin E., 002, 006, 078, 091, 094, 179, 199 Küchle, Valentin Alexander Balthasar, 091, 179 Kwok, Michelle Mai, 152 Kwon, Minsung, 035, 123, 229 Kwon, Oh Hoon, 014

Lai, Yvonne, 011, 188 Lai, Yvonne, 035, 123, 229 Lamberg, Teruni, 046, 060, 091 Lambert, Rachel, 176 Lang, Julie, 002, 006, 094, 199 Langer-Osuna, Jennifer, 024, 112, 218 Larison, Sarah, 002, 006, 094, 199 LaTona-Tequida, Talia, 091 Latta, Georgia, 091 Leatham, Keith R., 075, 179 Lee, Carrie W, 035, 123, 229 Lee, Han Sol, 020 Lee, Hea-Jin, 056 Lee, Hollylynne S., 022 Lee, Inyoung, 002, 006, 094, 199 Lee, Ji-Eun, 002, 006, 094, 199 Lee, Victor, 002, 006, 094, 199 Lee, Yi-Jung, 002, 006, 094, 199 Lee-Hassan, Alexa W.C., 053 Leonard, Jacqueline, 170 Leshin, Miriam S, 140 Lew, Kristen, 149 Li, Yuhang, 215 Libberton, Jason, 051 Lim, Vivian, 049 Lin, Ho-Chieh, 215

Lischka, Alyson E., 011, 077, 181, 188 Liu, Jinqing, 007, 091, 108, 164, 179 Lloyd, Kemol Robert, 164 Lo, Jane Jane, 007 Lolkus, Michael, 002, 006, 016, 094, 156, 199 Long, Valerie, 032, 120, 179, 226 López-Iñesta, Emilia, 160 Louie, Josephine, 002, 006, 094, 199 Lovett, Jennifer, 079, 091, 179 Lovin, LouAnn, 206 Lowenthal, Patrick R, 051 Lu, Yaomingxin, 179 Lynch, Sararose, 129 Ma. Yue. 191 MacArthur, Kelly (she/her), 081 MacDonald, Beth L., 026, 114, 150, 220 Machaka, Nessrine, 008 Machalow, Rowan, 208 MacLean, Mark, 089 Maeda, Yukiko, 016 Magiera, Marta T., 017 Maldonado Rodriguez, Luz Angelica, 031, 119, 225 Malik, Hamza, 091 Mamolo, Ami, 002, 006, 094, 199 Mannix, Joshua P, 010, 091, 179 Manouchehri, Azita, 072 Mansour, Rue, 081 Manu, Sitaniselao Stan, 002, 006, 094, 199 Margolis, Claudine, 091 Marino, Matthew, 002, 006, 094, 199 Martin, Jason, 169 Martin, Stephanie, 025, 113, 219 Martinez, Ricardo, 031, 119, 225 Martinez Hinestroza, Jose, 043 Marynowski, Richelle, 028, 116, 222 Mask, Walker, 176 Mason, Erica N., 179 Matney, Gabriel, 128 Matranga, Anthony, 088 Mauntel, Matthew, 033, 121, 227 Max, Brooke, 106 Mbewe, Rose, 002, 006, 094, 159, 199 McCrone, Sharon M, 200 McCulloch, Allison, 079, 091, 179 McFeetors, P. Janelle, 028, 116, 222 McGraw, Rebecca, 177 McIntoish, Teriney, 179 Meagher, Michael S, 091

Mejía Ramos, Juan Pablo, 015 Melhuish, Kathleen, 130, 149, 179 Melville, Matthew M, 091, 191 Membreño Estrada, Sharon Samantha, 102 Menke, Jenna, 192 Middleton, James A, 172, 207 Milewski, Amanda, 154, 196 Miller, Claire, 192 Miller, David Allan, 212 Miller, Isabelle, 156 Mireles-Rios, Rebeca, 176 Mirin, Alison, 002, 006, 070, 094, 199 Mohammad Mirzaei, Amanda, 207 Mojica, Gemma F., 022 Moldavan, Alesia Mickle, 059, 091, 179 Molitoris Miller, Susanna, 002, 006, 033, 094, 121, 199, 227 Montero-Moguel, Luis Emmanuel, 101 Montgomery, Mark S, 002, 006, 094, 199 Moore, Alexander, 027, 115, 221 Moore, Jason, 152 Moore, Kevin, 084, 097, 136, 171, 192, 205 Moore-Russo, Deborah, 183 Morgado, Cindy Nathalia, 080 Morrissey, Susie, 021 Morton, Karisma, 002, 006, 094, 199 Moss, Diana L., 026, 114, 150, 220 Moussapour, Roya Madoff, 077 Muhs, Chelsea A, 043 Munson, Jen, 002, 006, 020, 094, 109, 199 Myers, John, 052 Myers, Kayla, 054

Nabors Olah, Leslie, 184 Nagar, Gal Gili, 170 Nagle, Courtney, 183 Naresh, Nirmala, 166 Nathan, Mitchell J., 014, 037, 071, 125, 231 Navarro Robles, María Estela, 002, 006, 094, 199 Newton, Jill, 029, 117, 131, 159, 223 Ngo, Vy Vo Hoang, 091 Nguyen, Phi, 042 Nguyen, Tomy, 132 Nieves, Hector Ivan, 110 Nirode, Wayne, 007 Norris-LeBlanc, Chris, 060 Novak, Jodie, 002, 006, 094, 199

O'Bryan, Alan, 142 Olarte, Royce, 065, 132, 148 Olson, Amy, 085, 131 Olson, Gary, 089 Oriowo, Olanrewaiu, 179 Orrill, Chandra Hawley, 046, 091, 170, 185 Otten, Samuel, 061, 146 Ottmar, Erin, 037, 091, 125, 231 Ozaltun Celik, Aytug, 171, 192, 205 Ozen Unal, Deniz, 014 Ozturk, Ayse, 215 Pajela, Hannali, 065, 148 Pak, Byungeun, 057, 178 Palisse, Jennifer, 089 Pandiscio, Eric, 018 Panorkou, Nicole, 184 Paoletti, Teo, 016, 091, 186 Park, Hyejin, 017 Park, Joo young, 002, 006, 094, 199 Park, Sunyoung, 002, 006, 094, 199 Parr, Erika David, 008, 078, 155, 179 Patterson, Cody L, 177 Pecora, Lizzy, 179 Pelaez, Kevin, 091, 168, 179 Pennerman, Elsheika, 002, 006, 094, 199 Peralta, Lee Melvin Madayag, 049, 147 Perez, Luisa, 091 Perry, Jill A, 091 Peters, Susan, 187 Peterson, Blake, 075 Pham, Autumn, 017 Phelps-Gregory, Christine M, 179, 187 Piatek-Jimenez, Katrina, 002, 006, 027, 094, 115, 187, 199, 221 Pinter, Holly Henderson, 129 Plaxco, David, 033, 121, 227 Pomponio, Erin, 202 Popovic, Gorjana, 021 Powell, Sarah R, 056 Preciado Babb, Armando Paulino, 002, 006, 094, 199 Prough, Sam, 009, 137 Przybyla-Kuchek, Julia, 027, 115, 221

Rahman, Zareen Gul, 002, 006, 094, 138, 169, 199 Rainwater, Tabatha, 068 Raja, Waleed Ashraf, 209 Rasmussen, Chris, 091 Reedman, Emma, 018 Reich, Justin, 077 Reimer, Paul N., 033, 121, 227 Reinke, Luke, 130 Remillard, Janine, 208 Rhine, Steve, 153 Richardson, Sue Ellen Ellen, 030, 118, 224 Ricks, Thomas, 002, 006, 094, 199 Roan, Elizabeth, 045 Roberts, Sarah A., 065, 081, 132, 148, 173 Rodriguez, Jon-Marc Gregory, 107 Roh, Kyeong Hah, 096, 142 Roman, Christopher Orlando, 026, 114, 150, 220 Rosencrans, Brenda, 090 Rotem, Sigal Hava, 095 Roth McDuffie, Amy, 135 Roy, Soma, 002, 006, 094, 199 Rubel, Laurie, 049 Ruff, Adam, 002, 006, 094, 199 Ruk, Joshua, 179 Rumsey, Chepina, 002, 006, 094, 199 Runnalls, Cristina, 002, 006, 094, 199 Rupnow, Rachel, 002, 006, 069, 094, 199 Ruttenberg-Rozen, Robyn, 002, 006, 094, 199 Ryan, Ulrika, 133

Sabree, Minnah Jirani, 091 Saclarides, Evthokia Stephanie, 109 Sacristán, Ana Isabel, 064 Safak, Reyhan, 002, 006, 094, 199 Safi, Farshid, 091, 179 Sahmbi, Gurpreet, 002, 006, 094, 199 SALDAÑA, MIKE, 002, 006, 094, 199 Salter, Diana G, 090 Sammons, Kaitlyn B, 131 Sampson, Stéphanie, 002, 006, 094, 199 Sánchez, Ernesto Alonso, 080 Sanchez Gutierrez, Gerardo, 179 Sanei, Hamid Reza, 079 Sanz, Maria Teresa, 160, 177 Sapkota, Bima Kumari, 002, 006, 094, 106, 159, 199 Sassman, Peter, 069 Satyam, V. Rani, 002, 006, 094, 169, 199 Savich, Theodore Michael, 108 Schack, Edna O'Brien, 176 Scharfenberger, Adam, 012 Schenck, Kelsey E., 014

Schoen, Robert, 002, 006, 094, 199 Schraeder, Matthew, 212 Schraeder, Nurul Wahyuni, 212 Scott, Mallika H, 147 Seat, Jennifer, 002, 006, 094, 199 Seiwell, Amanda, 044 Sencindiver, Benjamin D., 078 Sevinc, Serife, 198 Shaver, Nick, 002, 006, 094, 199 Shekell, Calli, 197 Shokeen, Ekta, 091, 104 Shumar, Wesley, 088 Shumway, Jessica, 002, 006, 094, 199 Sianturi, Iwan Andi Jonri, 131 Siebert, Daniel, 091 Silver, Ed, 154 Silverman, Jason, 088 Simon, Sarina, 015 Simpson, Amber, 033, 091, 104, 121, 179, 189, 227 Singh, indrani, 068 Singh, Rashmi, 015, 110 Singleton, Brandon K, 020 Slama, Rachel, 077 Slye, Jeffrey, 212 Smith, Amy, 002, 006, 089, 094, 199 Smith, Erin, 056 Smith, Ethan, 172, 193 Smith, James, 135 Smith, Robert A, 056 Smith, Shawnda, 156 Smucker, Karoline, 065 Solmaz, Gizem, 002, 006, 094, 199 Son, Taekwon, 002, 006, 094, 199 Sondergeld, Toni Ann, 091, 128, 179 Sorensen, Lincoln J, 179 Sorge, Brandon, 082 Sorto, M. Alejandra, 130 Soto, Hortensia, 037, 125, 231 Soto, Melissa M., 034, 122, 228 Spiteri, Andrew, 091 Spitzer, Sandy M, 179 Staples, Megan, 029, 117, 223 Star, Jon, 002, 006, 060, 091, 094, 199 Starkey, Christina, 156 Starks, Rachel N, 032, 051, 120, 226 Stephan, Michelle, 130 Sternberg, Kateri A, 010 Stevens, Alexis, 206 Stevens, Irma, 091, 179 Stewart, Maria Elizabeth Nielsen, 164

Stiles, Jennifer, 002, 006, 094, 199 Stockero, Shari L, 075 Stoddard, Elyssa, 173 Stoehr, Kathleen Jablon, 085 Stone, Gregory Ethan, 128 Strachota, Susanne, 105 Strayer, Jeremy F, 011, 181 Street, Ciera, 048 Strickland, Sharon, 130, 196 Sturgill, Derek, 135 Suárez, Mayra Zulay, 064 Suazo-Flores, Elizabeth, 030, 118, 159, 189, 224 Sugimoto, Amanda, 039, 127, 233 Sunbul, Ayse, 213 Sundrani, Anita, 019, 165 Sung, Hanall, 014, 071 Swars Auslander, Susan, 054 Swart, Michael I., 014, 071 Swartz, Barbara, 129 Swartz, Micah, 045

Tague, Jenna, 049 Tahlor, Carrie, 054 Tallman, Michael, 169 Tanguay, Carla Lynn, 054 Tasova, Halil Ibrahim, 136, 171, 192, 205 Taub, Michelle, 002, 006, 094, 199 Taylor, Cynthia E., 214 Tenny, Kristin, 091 Teuscher, Dawn, 058 Thacker, Ian, 153 Thanheiser, Eva, 017, 039, 090, 127, 233 Thomas, Casedy Ann, 132 Thomas, Jonathan Norris, 176 Thompson, Jennifer, 105 Thompson, Meredith, 197 Tillema, Erik S, 131 Totorica, Tatia Baum, 051, 166 Towers, Jo, 158 Tremaine, Rachel, 179 Tschida, Christina, 002, 006, 094, 199 Turner, Erin, 135 Turner, Kyle Russell, 002, 006, 094, 199 Tyburski, Brady A, 084

Udun, Yalcin, 213 Uysal, Seyda, 013 Vahle, Courtney, 146 Valenzuela, Carlos, 177 Valerio, Jennifer Lynn, 179, 204 Valero, Jonathan Rojas, 072 Vandenberg, Jana Elle, 174, 212 van de Sande, Carla, 174, 212 Van Zoest, Laura, 075, 091 Vargas-Alejo, Veronica, 101, 152 Varner, David, 002, 006, 094, 199 Villafañe-Cepeda, Wanda, 002, 006, 094, 199 Vogelstein, Lauren, 143 Vroom, Kristen, 149, 163 Wagner, Amanda, 179 Wagner, David, 133 Walker, William, 082, 189 Walkington, Candace, 014 Walkoe, Janet, 037, 125, 231 Walsh, Patricia A, 072 Wambua, Mitchelle Mbete, 061 Wang, Kun, 091 Wang, Xin, 089 Wang, Ze, 146 Ward, Jennifer, 030, 118, 224 Warshauer, Hiroko Kawaguchi, 156 Waswa, Anne Nyarotso, 192, 205 Wawsa, Anne, 171 Webel, Corey, 042, 076, 164 Weiland, Travis, 036, 124, 165, 230 Weinberg, Aaron, 169 Welder, Rachael Mae, 134, 152 Wessman-Enzinger, Nicole Marie, 047 Westby, Kathryn R., 147, 179 Wheeler, Ann, 153 White, Stephanie, 187 Whitehead, Ashley, 002, 006, 094, 199 Wieman, Rob, 091 Wiest, Lynda, 027, 048, 091, 115, 221 Williams, Ashley Marrie, 134, 152 Williams-Pierce, Caro, 033, 091, 104, 121, 179, 227 Wood, Marcy B, 131 Wrightsman, Elizabeth, 177 Wynn, Lynda, 168

Xi, Rose, 195 Xia, Fangli, 014 Yalman Ozen, Demet, 079 Yan, Xiaoheng, 175 Yancey, Joy, 091 Yang, Jing, 189 Yang, Xiaotong, 002, 006, 094, 199 Yang, Yuxin, 067 Yao, Xiangquan, 045 Yavuz, Selim, 131 Yeo, Sheunghyun, 002, 006, 094, 199 Ying, Yufeng, 020, 097, 171, 192, 205 York, Toni, 184

Zahner, William, 024, 091, 112, 168, 218 Zandieh, Michelle, 033, 121, 227 Zarkh, Anna, 066 Zbiek, Rose Mary, 187 Zhang, Jing, 002, 006, 094, 199 Zhang, Pingping, 072 Zhou, Lili, 007, 159 Zolfaghari, Maryam, 076, 150 Zummo, Lynne, 091 Zuniga Ruiz, Sandra, 147 Zwanch, Karen, 151