2023

PME-NA 45TH ANNUAL MEETING PROGRAM

HOSTED BY UNIVERSITY OF NEVADA, RENO

RENO, NEVADA

SUNDAY, OCTOBER, 1

001. Plenary: Motivation and Embodied Cognition
PMENA
Plenary Session
5:00 to 6:15 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Mitchel Nathan: Discusses the role of Embodied Cognition and Learning. James Middleton: An extended (and probably unnecessary) parallel is drawn between engagement in mathematics and engagement in musical performance. Key facets of engagement are described and a model of how mathematics engagement plays out in task-level activities is discussed in light of new findings related to its social and emotional facets.
Participants:

Welcome to the world of mathematics - Where anything is possible *Mitchell J. Nathan, University of Wisconsin - Madison*

In my Keynote Address to PME-NA 45, I offer an embodied framework for naming what makes mathematics powerful for mathematicians and scientists, yet intractable for many learners. The essential claim is this: Students reside in the Real World, where math is grounded, embodied and meaningful, while mathematics resides in the ungrounded, disembodied realm of the UnReal World. To make all educational experiences meaningful, I consider ways to prepare students to be tourists to the UnReal World, such as progressive formalization and immersion in eXtended Reality (XR). Even so, educators must remember that learners remain citizens of the Real World even when visiting the UnReal World. I share examples of how embodied learners make sense of UnReal things, methods of making bridges between these worlds, and concerns that entrenched assessment practices neglect the nonverbal ways of knowing expressed by embodied learners.

An argument for engagement as fundamental construct for understanding mathematical learning *James A Middleton, Arizona State University*

An extended (and probably unnecessary) parallel is drawn between engagement in mathematics and engagement in musical performance. Key facets of engagement are described and a model of how mathematics engagement plays out in task-level activities is discussed in light of new findings related to its social and emotional facets. Implications for instructional practices that flow from this research are presented. The article concludes with suggestions for future research that incorporates understandings of identity and emotional object as promising directions.

002. Welcome Reception
PMENA
Special Event
6:30 to 9:30 pm
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E
We will have plenty of food. No need to make dinner plans!

MONDAY, OCTOBER, 2

003. Breakfast
PMENA
Special Event
7:00 to 8:30 am
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E

004. Women in Math Education
Equity and Justice
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Board Room
Participant:

Figured Worlds of Women Mathematics Education Scholars *Lili zhou, California State University, Los Angeles; Jill Newton, Purdue University; Brooke Max, Purdue University; Hyunyi Jung, University of Florida; Lindsay M. Keazer, Sacred Heart University; Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Ricki Lauren Geller-McKee, Purdue*

In this proposal, we share a project of women mathematics educators' stories in figured worlds (Holland et al., 1998). The women in the group are from diverse backgrounds regarding race, class, and cultural contexts, and work as mathematics education scholars, including teachers, teacher educators, and/or researchers. In this project, we intend to forge new epistemologies of knowledge in mathematics education fields by incorporating women educators' lived experiences into the knowledge-building process (Hesse–Biber, 2012). Specifically, we center on women's perseverance, resistance, and resilience as we adapt our lives into figured worlds in which we are forming identity and self as mathematics education scholars.

005. Curricula Reasoning
Curriculum, Assessment, and Related Topics
Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Emerald A
Participant:

Classifying Curricular Reasoning: Ways for Capturing Teachers' Curricular Decisions *Shannon Dingman, University of Arkansas; Dawn Teuscher, Brigham Young University; Travis Austin Olson, University of Nevada, Las Vegas; Amy Roth McDuffie, Washington State University*

Mathematics teachers make numerous decisions that form lessons that in turn greatly influence what students learn. In making these decisions, teachers rely on their curricular reasoning (CR) to decide on what mathematics to teach, how to structure their lesson, and what problems or tasks to use to achieve their lesson goals. However, teachers differ with respect to the sophistication of their CR and the diversity of CR aspects used in their reasoning. In this paper, we detail two ways to classify teachers' CR: a leveled approach to capture the increasing sophistication of teachers' CR, and a heat map approach that highlights the extent to which teacher use various CR aspects in their planning. These methods provide stakeholders avenues by which CR can be studied and that teachers' CR abilities can be further developed.

006. Supporting High Quality Teaching Practices
Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

Clinical Simulations To Support Prospective Teachers' Knowledge Of Content And Students *Duane Graysay, Syracuse University; Hillary Bermudez, Syracuse University*

We report our systematic design of nine clinical simulations that

we hypothesized would, through systematic variation, support prospective teachers to develop an aspect of Mathematical Knowledge for Teaching. We report tentative findings from the case of Kristy, a prospective teacher whose experience across the simulations illustrates the potential and the limitations of our design.

Google Docs as a Tool to Support Rough Draft Math Discourse / Google Docs Como Una Herramienta Para Apoyar el Discurso Borrador de Matemáticas" *Tenchita Alzaga Elizondo, Portland State University; Brittney Ellis, Texas State University*

The transition back to face-to-face instruction from emergency distance learning due to the pandemic, begs the question: what benefits (if any) from this experience can be imported to face-to-face instruction? This study builds on previous work on students' use of Google Docs in a remote introduction-to-proofs course and explores the conjecture that the lack of permanency of text on Google Docs supports students' rough-draft math practices. By studying two days of a face-to-face introduction to proof course, we present how students' discourse surrounding the use of Google Docs explicitly and implicitly evidenced rough-draft math.

Making Time for Discourse: Effects of Time Scaffolds on Students' On-Task Mathematics Engagement *Kristy Litster, Valdosta State University*

This inquiry looks at differences in mathematics engagement for 34 groups of Grade 5 students with and without time scaffolds for individual and group reflections, discussions, and problem solving. Results showed no significant differences in the quantity of time engaged in individual work versus group discourse. Results showed that students without time scaffolds were more likely to run out of time to compete or discuss tasks at the end of a large task-set. In contrast, students with time scaffolds were more likely to complete tasks, but less likely to discuss them.

Reimagining the Emergent Perspective Within Research-Practice Learning Communities *Beth L. MacDonald, Illinois State University; Amanda L Cullen, Illinois State University; Allison M Kroesch, Illinois State University; Neet Priya Bajwa, Illinois State University; Edward Mooney, Illinois State University; Julien Corven, Illinois State University*

To approach Cai et al.'s (2017) call to blur the lines between research and practice, we examine how early childhood, special, and mathematics educators form a research-practice partnership with the shared focus of supporting young children's development of equitable problem-solving activity. To situate this work, we draw from Cobb and Yackel's (1996) Emergent Perspective, considering both the child's psychological construction of knowledge and the adaptations made by community members in a partnership framework. Thus, in this theoretical brief, we describe an Emergent Research-Practice Learning Community Framework and unpack its three main constructs: shared focus, shared work, and shared vision.

007. Building Communities and Pre-service Teacher Education

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

Building Online Communities of Teachers: An investigation of indicators of situational interest and persistence *Anthony Matranga, California State University San Marcos; Jason Silverman, Drexel University; Amanda Reinsburrow, Drexel University; Mikhail Miller, Drexel University*

This paper reports on our investigation of online community building efforts. We aimed to better understand mathematics teacher interest and persistence in a sequence of online workshops focused on ambitious instructional practice. We theorize that situational interest is related to teachers' decisions to persist in online professional learning and that an indicator of situational interest is the nature of teachers' institutional context. We found that teachers who described tensions around instructional practice in their local schools were less likely to persist in our workshops. Our findings suggest that situational interest may be an important construct to unpack to enhance community-building efforts and support teacher instructional improvement.

Developing Political Conocimiento: trajectories of mathematics teachers *Brenda A Aguirre Ortega, University of Colorado Boulder; Victoria Hand, University of Colorado Boulder; Tarah Michelle Donoghue, University of Colorado - Boulder; Victor Baldemar Leos, University of Colorado Boulder*

This paper focuses on the trajectories of two mathematics teachers in developing Political Conocimiento through one year of Professional Development (PD) on culturally responsive mathematics teaching. The PD was organized around teacher and student noticing, positionality, community partnerships and action research. The study found that the teachers' discourse practices shifted from whiteness pedagogies towards politicized notions of schooling, caring, and mathematics learning. The paper discusses the dominant ideologies that teachers reproduced in their discourses around mathematics education and interactions with students. It also illustrated the teachers' trajectories of Political Conocimiento through the deconstruction of the role that race plays in their positionalities, their classrooms, and school.

Multilingual Classrooms: Development of an Observational Analytic Tool to Examine Mathematics Instruction / Aulas Multilingües: Desarrollo de una Herramienta Analitica de Observacion para Examinar la Enseñanza de las Matematicas *Michael W Krell, University of Maryland, College Park; Abigayle Dirdak, University of Arizona; Beatriz Quintos, University of Maryland; Jonee Wilson, North Carolina State University; M. Alejandra Sorto, Texas State University; Claudia Galindo, University of Maryland*

This brief research report describes the refinement and testing of an observational rubric designed to identify and assess elements of classroom mathematics instruction that research has found to support multilingual student learning. The aim of this process is to (a) combine existing rubrics that capture teaching strategies and positioning construct protocol, (b) test the combined rubric in multiple elementary classroom settings, (c) revise the rubric in light of testing to create a more consistent version, and (d) retest with a larger sample of classrooms. Initial results include revised instrument category rubrics and level descriptors, and the creation of a new conjectural code category.

008. Developing Equity Based Practices with Pre-Service Teachers

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Scaffolding Preservice Teachers' Thinking About Equity-Based Mathematics Teaching Practices *Alesia Mickle Moldavan, Georgia Southern University; Laurel Dias, Utah Valley University*

This study examines how preservice teachers recognize and justify equity-based teaching practices within a mathematics task incorporating a multicultural children's story. With reference to

Aguirre et al.'s (2013) equity-based practices, the researchers designed a reflection guide to assist preservice teachers in recognizing ways tasks can be used to affirm students' mathematics identities, draw on multiple resources of knowledge, and challenge spaces of marginality while going deep with mathematics to leverage multiple mathematical competencies. Findings indicate that the preservice teachers were effectively able to use the reflection guide to recognize the practices and make reference to various components to justify each practice. Recommendations suggest that preservice teachers have explicit opportunities to use similar tools alongside strategic tasks to think deeply about equity-based teaching practices to develop their instruction.

Tool, Gatekeeper, Power, Vehicle: Mathematics Teacher Educators' Views of Mathematics and Its Purposes *Amy Brass, Pennsylvania State University*

What conceptions do mathematics teacher educators (MTEs) hold about mathematics and its purposes? The study reported here explored metaphors for mathematics used by MTEs and the purposes of mathematics these metaphors described. Without explicit prompting, MTEs used metaphors to describe mathematics in survey responses for a larger study. The data revealed four distinct metaphors used by three or more MTEs: mathematics is a tool, mathematics is a gatekeeper, mathematics is power, and mathematics is a vehicle. These metaphors and the six different purposes of mathematics they describe reflect complex conceptions of mathematics held by MTEs and provide opportunities to consider how conceptions and purposes of mathematics may influence instructional practice.

Using Simulations to Provide Secondary Mathematics Teacher Candidates with Opportunities to Build Equitable Teaching *Casedy Ann Thomas, University of Virginia*

Nationally, and at Crestmont University (pseudonym), secondary mathematics teacher candidates (TCs) often feel underprepared with classroom management, with consequences for career longevity and their learners. TCs at Crestmont University repetitively vocalized concerns with how to enact ambitious and responsive mathematics instruction while attending to classroom management. Mixed-reality simulations have the potential to provide TCs with a safe environment to build their skills. This study examined how simulations can be used with secondary mathematics TCs to engage in practice with classroom management while attending to lesson objectives, and to understand how such experiences impact TCs' self-efficacy with responsive, standards-based mathematics teaching. The findings focused on positive perceptions of learning despite anxiety, building discourse communities, and the actions of future educators.

Relationship between statistical and mathematical thinking: Do preservice teachers practice what they preach? *Zuhal Yilmaz, Louisiana State University; Engin Ader, Boğaziçi University; Beyza Olgun, Middle East Technical University*

Teachers' awareness of features of statistical thinking (ST), especially in comparison with mathematical thinking (MT) is emphasized as a key strand of research and working on statistical tasks to develop awareness of features of ST has been highlighted in the related literature. Semi-structured interviews were conducted with 14 preservice mathematics teachers (PMTs), aimed to explore PMTs' thoughts on differences and similarities of ST and MT as well as investigating the extent to which their verbal thoughts on ST overlap with their thoughts as they work on statistical tasks. Findings revealed that PMTs showed a high level of awareness regarding the differences and similarities between both thinking types, and the tasks supported their further elaboration on some key features of ST such as role of context, defensible multiple answer, reasoning involved and use of representations.

009. Developing Instructional Vision

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Grand 2
Participants:

Intuición y simbolización en la comprensión del infinito matemático: el caso de Omar *Liliana Aurora Tabares Sánchez, CINVESTAV IPN; Luis Moreno-Armella, Cinvestav-IPN; Isaias Miranda, IPN, CICATA-Legaria*

El desarrollo del concepto infinito matemático, a través de las reflexiones que surgen de las nociones y percepciones personales y el análisis de algunas ideas de Galileo y Cantor, nos invita a indagar en la relación de la intuición y la formalización para la comprensión del concepto. En este artículo se pretende observar y describir el vaivén de la intuición a la formalización por el que transita Omar, un estudiante de primer semestre de licenciatura en matemáticas aplicadas, al dar cuenta del número de objetos que hay entre dos espejos iguales, uno frente al otro. Los resultados indican que el entrelazamiento entre la intuición y el formalismo es necesario para que Omar pueda concebir el infinito matemático.

Literatura infantil y modelación matemática **Samantha xx, Universidad Autonoma de Coahuila; José David Zaldívar, Universidad Autónoma de Coahuila, Facultad de Ciencias Físico Matemáticas*

La modelación matemática, vista como estrategia didáctica, busca entender la matemática como una herramienta que permite la resolución de problemas en contextos extra-matemáticos. Los tipos de contextos que se pueden utilizar en modelación matemática suelen ser diversos, siendo los principales aquellos relacionados con situaciones de la vida cotidiana y los relacionados con otras ciencias como la física, química, biología, entre otras. En la presente investigación se describe una situación cuyo contexto se relaciona con la literatura infantil, que desencadena un proceso de modelación matemática. La implementación de esta se llevó a cabo con profesores en formación de educación primaria. Los resultados muestran las representaciones informales que los profesores y las profesoras utilizaron y las diferentes estrategias para llegar a la respuesta correcta.

Teachers' Attitudes of Instructional Gestures in Math and Science Learning *Rebecca Boncoddo, Central Connecticut University; Mitchell J. Nathan, University of Wisconsin - Madison; Teruni Lamberg, University of Nevada, Reno; Travis Austin Olson, University of Nevada, Las Vegas*

A teacher's role in helping students understand mathematics and engage in sense-making is crucial. Therefore, we investigated how teachers viewed instructional gestures after they participated in a content and pedagogy-based professional development project. The findings revealed that teachers thought about gestures as a means of communication and cognition. Implications for supporting teachers' use of instructional gestures to help students to make mathematical connections through integrated content-based professional development are discussed.

The Development of the Instructional Vision of Early Career Secondary Mathematics Teachers *Amanda Huffman Hayes, Purdue University*

Using narrative inquiry, I share the beginning stories of the instructional visions of secondary mathematics teachers throughout their undergraduate studies of pedagogy and content-specific methods and evidenced in undergraduate coursework and student teaching experience. Guided by Munter's (2014) Visions of High-Quality Mathematics Instruction Role of the Teacher rubric, I answered the following research question: How do the instructional visions of secondary mathematics teachers

develop throughout their undergraduate coursework and student teaching? Understanding the instructional visions of mathematics teachers as evidenced in undergraduate coursework and student teaching reveals the impact of discussions, activities, and readings in their education studies and field experiences.

010. Developing Teacher's Vision of Teaching Mathematics

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Grand 3
Participants:

Academical Self Concept in Mathematics: Comparing between Sexes/Autoconcepto Académico en Matemática: una comparación entre sexos *Fabiola Arrivillaga, Instituto Politécnico Nacional, México; Martha Leticia García-Rodríguez, Instituto Politécnico Nacional*

This research aims to establish wether young students - 12 to 13 years old - show differences in academical self concept y mathematics, and in that case, wether this differences favor boys over girls, and in which categories. The study was conducted in Quetzaltenango, Guatemala, and the results confirm what has been said for researchers about gender and mathematics education, but also show in which spaces can we, as teachers, intervene to improve girls situation.

Combined Focus on Teaching Mathematics for Social Justice and Mathematical Modeling to Support Teacher Agency *Manjula Joseph, Fresno Pacific University; Christopher S. Brownell, Fresno Pacific University*

This study was conducted in two phases in a graduate program in mathematics education. Phase I, in the context of a course on teaching mathematics for social justice revealed that participant teachers were unconvinced of their agency to address frustrations with administrative expectations and job-related concerns in implementing social justice lessons. Phase II followed, with an intentional pairing of two courses: Teaching Math for Social Justice (TMfSJ) and Mathematical Modeling (MM) in the Classroom to investigate their combined impact on teacher agency. Data came from teachers' reflective writings, forum discussions, and a final project. Preliminary findings are reported.

Developing a Survey to Access Mathematics Teachers' Perceptions toward Students with Disabilities *Offir Neil Romero Castro, Western Michigan University; Laura R. Van Zoest, Western Michigan University*

Negative perceptions held by teachers toward students with disabilities create environments that make students feel uncomfortable and often incapable of participating actively in classrooms. Much of the research about these perceptions is focused on teachers of students with learning disabilities, which leaves out teachers' perceptions toward students with other disabilities. We are developing a responsive online survey to access what mathematics teachers identify as disabilities and their behavior toward students with disabilities in their classroom. In this paper, we describe the process we have developed for constructing this survey. We also share our conceptualization of the relationship between teachers' perceptions and equity affirmations toward disability, and the results of applying that conceptualization to our research context.

Investigating a Survey Measuring Vision of High Quality Mathematics Instruction *P. Holt Wilson, UNCG; Robert Henson, UNC Greensboro; Allison McCulloch, University of North Carolina at Charlotte; Cathy Holl-Cross, UNC Charlotte*

Research has shown that instructional vision is related to teacher learning, instructional quality and change, and an important consideration for large scale improvement efforts. To date, these studies have primarily relied on resource-intensive methods to measure instructional vision. In this paper, we detail the development of a survey instrument to measure vision of high quality mathematics instruction and explore its relation to established rubrics for assessing vision in interview settings.

011. Error Patterns and Language in Mathematics Learning

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participants:

Error patterns of at-risk students in solving additive word problems before and after the intervention *Yan Ping Xin, Purdue University; Soojung Kim, Purdue University, West Lafayette, IN; Jingyuan Zhang, Purdue University; Qingli Lei, University of Illinois Chicago; Busra Yilmaz Yenioglu, Purdue University; Samed Yenioglu, Purdue University; Bingyu Liu, Purdue University*

Students with learning disabilities/difficulties in mathematics often apply ineffective procedures to solve word problems. Given that current mathematics curriculum standards emphasize conceptual understanding in problem solving as well as higher-order thinking and reasoning, the purpose of this study was to evaluate the impact of a model-based problem-solving (MBPS) intervention program on elementary students' word problem-solving performance through analyzing the error patterns. Results indicate that after the MBPS intervention, participants significantly improved their problem-solving performance and made less errors on solving problems across a range of problem situations. Implications of the study will be discussed in the context of National Council of Teachers of Mathematics' calling for teaching big ideas to help students develop a deep understanding of mathematics knowledge.

Secondary Teachers' Conceptualizations of the Relationships between Mathematical Modeling and Problem Solving *Rui Kang, Georgia College & State University*

The purpose of this study is to gain understanding of how secondary teachers conceptualize the relationships between mathematical modeling and problem solving. Eight secondary teachers participated in semi-structured, think-aloud individual interviews. Some conceptualizations include (a) modeling and problem solving are two distinct processes; (b) modeling including traditional applied problems is a subset of, or a tool for, problem solving; (c) the two processes share similar characteristics such as a real-life scenario but are different in terms of whether a single correct answer exists; (d) the two processes are inseparable, completely enmeshed in each other, and co-dependent; and (e) problem solving is a reduced process of modeling. Teachers' conceptualizations are related to their preferred instructional sequence and the types of problems or activities they'd rather use.

Transitioning Across Languages: How Language and Accountability Policies Shaped Mathematics Instruction in Dual-Language Classrooms *Rosa Chavez, Texas Tech University; Paola Montufar Soria, New York University*

This study explores how dual-language teachers' decision-making was shaped by language policies, accountability policies, and standardized assessments. The study draws on interviews with third and fourth grade elementary teachers in California and Texas (N=17) to understand how they balanced accountability policies and assessments that worked in opposition to being able to provide mathematical learning opportunities within a dual language context. In particular, this study highlights how teachers contended with tensions when the language of instruction was different from the language of assessment. These

findings raise the need for coherence across federal, state, and local policymaking in order for dual language programs to remain student-centered in the implementation of mathematics curriculum to meet the needs of all learners.

Understanding One Calculus Instructor's Class Practices Using a Possible Student Cognitive Model *Richard Velasco, University of Oklahoma; Dae S. Hong, University of Iowa*

In this study, we examined one experienced mathematician's class practices, with particular attention to cognitive model described in genetic decomposition. Four limit lessons and implemented tasks were analyzed to determine if students had opportunities to be familiar with the first three steps in genetic decomposition. Our findings indicate that students only had limited opportunities to be familiar with the first three steps in genetic decomposition, which may potentially lead students to answer limit tasks correctly, but not necessarily having a deep conceptual understanding behind those tasks.

012. Engagement and Modeling

Mathematical Knowledge for Teaching

Brief Research Report Session

8:30 to 10:00 am

Atlantis Hotel and Casino Conference Center: Paradise A

Participants:

Fold to mold: Origami-based activities' effect on middle school students' beliefs about mathematics *Yi-Yin Ko, Indiana State University; Connor Goodwin, Indiana State University; Erick Herrera, Indiana State University*

Keeping students engaged in learning mathematics meaningfully has become even more prominent because of the COVID-19 pandemic. To better support middle school students whose mathematics learning has been affected by the pandemic, we designed a series of origami-based activities to improve their attitudes and beliefs towards mathematics throughout a semester-long program. The results suggest that students' beliefs about solving time-consuming mathematics problems and the importance of understanding mathematical concepts shift positively from the pre-assessment to the post-assessment. The results also show that the majority of students strongly agreed that understanding the correctness of solutions is important in the pre-assessment, mid-assessment, and post-assessment.

Increasing Student Engagement in Mathematical Modeling Through Teacher Professional Development *Geena Taite, Montclair State University; Amanda Provost, Montclair State University; Frank Forte, Montclair State University; Andre Perkoski, Montclair State University; Youngjun Kim, Montclair State University*

This research is part of an ongoing action research study that supported in-service mathematics teachers engaging STEM high school students in mathematical modeling. A teacher-researcher and her team of doctoral students designed and implemented professional development on mathematical modeling as a community of practice to meet the challenges teachers faced. This brief research report focuses on our findings related to teachers' mathematical modeling experiences with student engagement while implementing mathematical modeling over the course of the 2021-2022 school year.

Mutability of Stem Majors' Abstracted Quantitative Structures *Jennifer A Czocher, Texas State University; Andrew Baas, Texas State University; Elizabeth Roan, Texas State University; Abigail Lois Quansah, Texas State University*

Recently, abstracted quantitative structures (AQS), a construct from quantitative reasoning, has been offered as a means to conceptualize and study mathematization during mathematical modeling. Extending this theoretical work, we provide empirical evidence that an intervention targeting participants' AQS can assist in aligning modelers' models with normatively-correct models. We report on a pre/post intervention study designed to elicit alignment between symbolic forms and AQS and alignment between AQS and modeling scenarios, utilizing the Sørenson-Dice coefficient and cluster analysis to identify shifts in student associations of symbolic forms with modeling scenarios.

Underrepresented Students' Motivational Attitudes in Mathematics *Dalton Dayne Marsh, California State University, San Bernardino*

It is widely agreed that attitudes about mathematics play an important role in students' performance, choice, and persistence in STEM. Motivational theories posit this link and suggest that differences in these attitudes should explain in part why female, Black, Hispanic, low-income, and first-generation students are underrepresented in STEM fields in the United States. This study employed nationally representative data from the High School Longitudinal Study of 2009 (HSLS:09) and structural equation modeling to study five types of math attitudes: self-efficacy, identity, interest, utility, and cost. Multi-group factor analytic methods were used to compare mean levels of these attitudes across subgroups based on STEM career expectations, college generational status, parent income, gender, and race. The results suggest that explaining underrepresentation in STEM via differences in motivational attitudes is not straightforward.

013. Factors that Impact Belonging in Math Learning

Equity and Justice

Brief Research Report Session

8:30 to 10:00 am

Atlantis Hotel and Casino Conference Center: Treasures A

Participants:

Factors that Influence College Students' Mathematics Identity and Beliefs about the Nature of Mathematics/ Factores que Influyen la Identidad y Creencias sobre la naturaleza de Matematicas de los Estudiantes Universitarios *Cindy Jong, University of Kentucky; Parker Parrent, University of Kentucky; Pooja Gupta Sidney, University of Kentucky; Benjamin Braun, University of Kentucky; William Brad Wiseman, University of Kentucky*

Students' beliefs about the nature of mathematics can impact many aspects of their academic and life pursuits and be influenced by a myriad of prior educational experiences. To examine undergraduate college students' (n = 50) past mathematics education experiences, beliefs about the nature of mathematics, and experiences in a College Algebra course, pre- and post-surveys were administered in Spring 2022. The figured worlds conceptual framework was used to understand in the multi-layered components of identity in varying mathematical learning contexts. Results of open-ended responses demonstrated four themes, including: affective factors (e.g., stress, enjoyment, confusion), achievement (e.g., success, failure, course requirements), acknowledgement (e.g., feeling seen, participation) and application (e.g., careers, daily life) of mathematics among undergraduate college students.

A Longitudinal Study of Women's Sense of Belonging in an Active Learning Undergraduate Calculus Course *Casey Griffin, University of Delaware*

Low sense of belonging has been identified as a key reason for women's decisions to leave STEM majors. Prior studies indicate that incorporating active learning opportunities may support students' sense of belonging. Calculus is an especially ripe setting for investigating STEM students' sense of belonging, as it often acts as a gatekeeper course for STEM majors. This mixed methods study investigates changes in women's sense of belonging during the first semester of a year-long active learning Calculus course. Women who reported large changes were interviewed to investigate the influence of active learning

opportunities on their sense of belonging. Results indicate an initial significant increase followed by a plateau in women's sense of belonging. Six women who experienced changes in their sense of belonging agreed to be interviewed, and this analysis is ongoing.

Pre- Service Teachers' Interrogation of Mathematics Education Following a Digital Clinical Simulation *Erin Barno, Boston University; Gregory Benoit, Boston University/ MIT TSL*

This preliminary study explores how digital clinical simulation can how pre-service teachers relate equity and mathematical instructional decisions. Pre-service teachers engage in a digital clinical simulation where their responses to scripted mathematical small group scenarios leads them to different simulated outcomes. The analysis of the full class debrief conversation following the simulation experience surfaces how pre-service teachers interrogated the boundaries of mathematics education. This revealed how they feel tension about and value certain conceptualizations of mathematics teaching and equitable pedagogies. This study suggests that digital clinical simulations could support pre-service teachers' understanding of the inherent relationship between mathematical pedagogy and equitable orientations through moments of tension within the simulation, and interrogation of that norm during the debrief.

A Mathematics Mentoring Program: Post-Pandemic *Jenna Tague, Clovis Community College*

The purpose of this report is to share the supports created as part of a mathematics mentoring program in a mid-sized western university. The research is longitudinal, and the current paper will share results from the fourth (of six) years of a project. I use a mixed method approach to examining the efficacy of the mentoring program, and the results indicate that the program may have helped students through the pandemic and to shift back afterwards.

014. Games, Virtual Sessions and Experiences to Support Math Learning

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Investigating Probabilistic Contexts Using Computer Simulations *Karoline Smucker, Eastern Oregon University; Azita Manouchehri, The Ohio State University*

Simulations are considered essential instructional tools in teaching probability and statistics, with computer simulations in particular receiving emphasis in recent years. Despite this, little research has been reported on how learners use computer simulations to solve problems and investigate stochastic contexts. Clinical interviews with four preservice secondary mathematics teachers investigated this issue as they worked with a series of probabilistic tasks in CODAP. This report presents findings based on participants' performance on one of the tasks, which involved making predictions about a school board election based on simulated polling results.

A Gamified Approach To Mathematics *Nicholas Grande, The Pennsylvania State University*

This paper looks at the theoretical implications of gamifying certain elements of teaching mathematics.

Challenging Math-Music Integration *Sandra Hall, University of Saskatchewan; Katryne Dubeau, University of Saskatchewan; Egan J Chernoff, University of Saskatchewan*

Cross-curricular integration is an effective way to enhance student understanding and create real-life connections. Research has shown that the math-music connection increases students' conceptual knowledge, spatial-temporal reasoning and improves motivation. Through the lens of the cognitive-affective model of conceptual change, we will identify reasons non-musical teachers struggle to integrate math and music and offer an approach that addresses this disconnect. We argue that the expectation for non-musical mathematics teachers to integrate music into their lessons is discouraging and ineffective due to their lack of musical literacy.

Understanding Slope Thru Tactile and Whole-body Experiences *Joy Ann Oslund, Grand Valley State University; Paul Woo Dong Yu, Grand Valley State University*

This case study explores theories and enactments for using whole-body movement in helping a student with visual impairment understand slope. While technology has made learning algebraic concepts easier for many students, much of it relies on sight. To accommodate the student's learning, tactile and whole-body experiences were used to give meaning to the concept of slope. The results show that the learner constructed deep, profound, and novel notions of slope. In this paper, we illustrate the way mathematical knowledge was understood and communicated through motion and language and raise theoretical questions about the relationship between the body, the environment, and mathematical ideas. We propose these pedagogies be used with all students reflective of universal design principles.

015. Mathematical Proof and Functions

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

An Application of Habermas Construct of Rationality to Support Students in Proof Validation *Yuling Zhuang, Emporia State University*

The ability to judge the acceptability of purported proofs is considered to be one of the most important skills in university mathematics. Research has shown that students were lacking in proof validation skills. However, how to improve students' proof validation skills so far have received limited academic attention. Building on Habermas' construct of rationality, this study developed a proof validation framework to help students learn to validate proofs based on rationality components under the guidance of rational questioning. The present study explored how students validate purported proofs through the use of the developed proof validation framework. The results showed that the framework may help students to be aware of the requirements of rationality components inherent in proving activities and support teachers to scaffold students to meet the requirements of rationality components according to the teacher's evaluation criteria. Some educational implications of teaching proof validation are provided.

Changing Teachers' Conceptions of Proof *Oscar Chavez, Illinois State University; Seyedehkhadijeh Azimi Asmaroud, Virginia State University; Alicia Erwin, Illinois State University; David Barker, Illinois State University*

Proof is a fundamental aspect of mathematics. However, in the high school curriculum, it often receives uneven attention that is focused on form rather than understanding. One avenue for addressing this issue is to change and strengthen teachers' conceptions of proof. To explore this idea, we followed a group of teachers as they participated in a summer mathematics research experience. During this experience, proof was not an isolated exercise but part of the mathematical process of discovery. In this study, we analyzed pre- and post-survey data and participants' critique of proofs to uncover the influence of the mathematics research experience on their concept of proof. We present data on the criteria participants used to evaluate

proofs, their conception of proof, and how the mathematics research experience changed their conception of proof.

A Study of What Students Focus On and Notice About Quadratic Functions Representations During Instruction *Charles Hohensee, University of Delaware; Sara Gartland, National University of Ireland Galway; Yue Ma, University of Delaware; Srujana Acharya, University of Delaware*

Student focusing and noticing, which drive reasoning, are important but underresearched aspects of student learning. Quadratic functions representations are perceptually and conceptually complex and thus, offer much for students to focus on and notice. Our study compared a teacher's goals for student focusing and noticing during quadratic functions instruction with what students actually focused on and noticed. Qualitative analysis revealed some alignment but also informative ways that the teacher's goals and student outcomes for focusing and noticing were misaligned. These results will further the field's understanding of how students learn about quadratic functions and may have implications for student focusing and noticing of other mathematics topics as well.

Students' Understandings of the Definition of a Function *Camille S. Burnett, Prairie View A&M University*

The goal of the study to be discussed here is to describe high-performing students' understandings of the definition of a mathematical function, which was achieved through a pilot case study of clinical interviews with four participants – two ninth graders and two twelfth graders. The four participants were recruited from the same urban public high school in the northeast of the United States, which serves a diverse racial, ethnic, and cultural community. All four participants were considered high-performing students by their mathematics teachers and were selected for the interviews because of the same reason. The participants were interviewed individually about questions pertaining to the definition of a mathematical function. Analyses of the interview responses revealed that the twelfth graders have a more sophisticated understanding of the definition of a mathematical function than do ninth graders.

016. Noticing and Engagement in Math Learning

Equity and Justice
Brief Research Report Session
8:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Rehumanizing Mathematics Through Embodiment-Focused Noticing *Liza Bondurant, Mississippi State University; Diana L. Moss, University of Nevada, Reno; Claudia Marie Bertolone-Smith, California State University Chico; Lisa L Poling, Appalachian State University; Hortensia Soto, Colorado State University; Jonathan David Troup, CSUB*

In this manuscript we, six math teacher educators (MTEs), share a collaborative self-study investigation into increasing our embodiment-focused noticing. Initially, we individually viewed cognitive interview videos and recorded our embodiment-focused noticings. Next, we met as a group to share, compare, and merge our noticings. We used the merged noticings to develop an exemplar and a rubric. We will discuss how layering an embodiment lens over our noticings can contribute to rehumanizing mathematics.

Inservice Teachers' Attributions for Mathematical Success *Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Naomi Jessup, Georgia State University; Selim Yavuz, Indiana University; Jeffery Franklin, Indianapolis University Purdue University Indiana; Sheniqua Pierce, Georgia State University; Anna Gustaveson, University of North Carolina; Erik Jacobson, Indiana University*

Beliefs teachers hold influence the judgments they make about their students, and opportunities they provide for engaging them in rigorous mathematics. While math-related beliefs have been widely studied, less is known about teachers' attributional beliefs (i.e., beliefs about people's actions or behaviors) for mathematical success. In this study we investigated in-service elementary teachers' stated beliefs about mathematical success. Findings show that teachers attribute mathematical success to factors that are both internal and external to the student. Although teachers explicitly stated that race and gender were not factors, many used descriptors that served as proxies for students' demographic markers.

Mentor and Novice Teacher Co-Learning to Promote Student Participation and Engagement *Torrey Kulow, Portland State University; Imani Goffney, University of Maryland-College Park; Heather Fink, Portland State University*

This design research study describes how one mentor teacher-teacher candidate dyad co-learned to promote student engagement and participation through using a "Collaborative Learning Structure" (CLS) tool that we are designing and studying. We share how the dyad used the CLS, with support from a professional development facilitator and fellow teachers, to better identify student assets (a critical component of promoting student engagement and participation). Our analysis demonstrates that (1) co-noticing is a productive means of supporting dyad co-learning to promote student engagement and participation and (2) teachers need to co-learn across time while using tools supportive of their learning. We discuss implications for how to support teachers in promoting student engagement and participation.

017. Coffee Break

PMENA
Special Event
10:00 to 10:30 am
Atlantis Hotel and Casino Conference Center: Foyer

018. Culturally Responsive Teaching

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Board Room
Participants:

"I Understand that Their Minds may be Elsewhere": Towards a Culturally Responsive Pedagogy *Tarah Michelle Donoghue, University of Colorado - Boulder; Victoria Hand, University of Colorado Boulder; Brenda A Aguirre Ortega, University of Colorado Boulder; Victor Baldemar Leos, University of Colorado Boulder*

This brief research report examines the discursive shifts of a secondary mathematics teacher participating in a collaborative learning community centered on culturally responsive mathematics teaching. We draw on two frameworks to analyze the teacher's discursive moves. The first framework comes from Lefstein et al., (2020) on generative discourse practices in learning communities. The second framework — FAIR (Louie et al., 2021) — offers noticing practices for deficit versus anti-oppressive mathematics teaching. Through these lenses, we found that the teacher's initial discourse practices were marked by deficit framing and noticing. The teacher's discourse practices begin to shift towards a culturally responsive pedagogy in response to a particular artifact that captured student noticing and reframed the teacher's problem of practice.

Queer High School Students' Takeaways from the Teaching of Mathematics for Social Justice *Weverton Ataide Pinheiro, Texas Tech University; Rosa Chavez, Texas Tech University*

This study investigated Queer high school students' participation in the teaching of mathematics for social justice. The goal of this research was to introduce the TMSJ to Queer students and understand their experiences with this type of teaching. This study is centered on the transformative paradigm using a poststructuralist approach. Therefore, knowledge about oneself and the world is the product of discursive constructions. Queer, Critical, and poststructuralist theories guided this study. In addition, a TMSJ framework was implemented in a three-lesson experiment about the injustices Queer high school students go through in schools. Through qualitative analysis using inductive coding and thematic analysis, findings show that Queer high school students see a great value in the TMSJGS and had a positive experience with the learning of math. However, efforts are still needed to make this teaching successful in current schools.

019. Algebraic Thinking and Tasks

Pre-Service Teacher Education
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Algebra and Algebraic Thinking Interventions at the Elementary and Secondary Levels: Search for a Definition *Sheree Sharpe, University of New Hampshire; Matthew MAUNTEL, University of New Hampshire*

This paper is a part of a larger research study that we are conducting to develop a framework consisting of the data-driven best practices around teaching and learning algebra (or algebraic thinking) in K-12 classrooms. The purpose of this paper is to develop a usable definition for algebraic/algebra interventions for the second stage of screening within the larger study, which will be done by reviewing seminal or systematic reviews in the algebraic/algebra field across grades K-12. Combining the algebraic/algebra definitions with the type of interventions produces three questions to ask during the second stage of screening to decide if a study is an algebraic/algebra intervention.

Worthwhile Problems: How Teachers Evaluate the Instructional Suitability of Contextual Algebra Tasks *Cody L Patterson, Texas State University; Mai Bui, Texas State University; Lino Guajardo, Texas State University; Carlos Ivan Acevedo, Texas State University; Brandi Rygaard Gaspard, Texas State University; Rebecca McGraw, University of Arizona*

We investigate the beliefs that influence middle and high school algebra teachers' appraisals of contextual problems having diverse mathematical and pedagogical features. We asked six teachers to analyze six contextual algebra tasks and indicate how they would apportion instructional time among the six tasks based on their structure, pedagogical features, and connections to the real world. We recorded small-group discussions in which teachers shared their responses to this activity, and qualitatively analyzed their discussions for evidence of beliefs that influenced their appraisals of the tasks. The teachers' beliefs about contextual problems attended to task authenticity, opportunities for mathematical activity, obligations of tasks, and pedagogy and access. Our preliminary findings can inform future efforts to equip teachers with contextual tasks that develop students' algebraic reasoning and problem solving.

020. Teacher Positionings and Moves

Early Algebra, Algebraic Thinking, and Function
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

An Emerging Framework for Elementary Student Teacher Positions and Positionings *Eric Partridge, University of Missouri; Phi Nguyen, University of Missouri; Corey Webel, University of Missouri*

Positioning theory has been used in research to understand how elementary student teachers are positioned while working with their mentor teacher. While this research has identified four general positions, there remains a lack of clarity about these positions, particularly in how they differ. This study explores three contrasting student teacher-mentor teacher pairs to explore how different student teacher positions are constructed. Through qualitative coding of interviews that followed a math lesson observation, an emerging framework is proposed along two dimensions: interactional positioning and actional positioning. Within each dimension, two sub-dimensions are proposed: discursive patterns and intellectual authority within interactional positioning and teaching experiences and planning experiences within actional positioning. This framework provides a foundation for further research on student teacher positions.

Brokering Moves to Support Advances in a Preservice Elementary Teacher's Discourse about Hierarchical Geometric Relationships *Ian Whitacre, Florida State University; Domonique Caro-Rora, Florida State University; Azar Kamaldar, Florida State University*

Limited literature addresses how elementary preservice teachers (PSTs) can advance their thinking about hierarchical geometric relationships. Informed by a commognitive perspective, we investigated this phenomenon as a matter of discursive change, focusing on word use, visual mediators, and narratives. We report on a teaching experiment involving a PST whom we call Mariah. Mariah's progress seemed to be driven primarily by making new distinctions in word use and interpretation of Venn diagrams. These changes supported shifts in her narratives regarding hierarchical geometric relationships. Instructor moves related to these discursive changes primarily involved interpreting between discourse communities. Our analysis reveals nuances of communication that we do not see highlighted in the literature on PST education.

021. Geometry and diversity

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Emerald C
Participant:

Conceptualizing Diversity as a Resource through Social Design-Based Experiments: An Exploratory Study in Geometry Education *Emmanuel Nti-Asante, University of Massachusetts, Dartmouth*

Challenges with the increasingly diverse nature of the STEM spaces have informed education experts to recommend teachers use social-design-based experiments to design teaching-learning activities that frame this diversity as a resource. However, the response to this call-in mathematics education needs to extend to other content areas and an outlined lens for analyzing diversity as a resource. I explore how to design geometry teaching-learning activities from an SDBE-informed perspective to attain diversity as a resource. As a lens for analyzing diversity as a resource, I report the findings under three constructs of SDBE. The design: (a) incorporates and sustains everyday practices of non-dominant groups like Africans, like how they play games (b) brings the history of geometry into the present to transform to new frontiers as students re-mediate it (c) metaphorically describes learning as movement across contexts and timescales.

022. Playfulness and Engagement

Mathematical Processes and Practices

Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Assessing Mathematics Engagement in the Moment *James A Middleton, Arizona State University; Adi Wiezel, Arizona State University; Amanda Jansen, University of Delaware*

We report on the development of an online instrument to assess students' mathematical engagement in the moment of learning. Background on engagement and its assessment is provided, the development and testing of an instrument assessing facets of cognitive, affective, behavioral and social engagement is described, and the implications of researching task-level engagement is discussed.

Creating Monsters isn't Fun: Challenges in Creating Playful Math Professional Development *Candice Love, Vanderbilt University; Amy Noelle Parks, Michigan State; Brittany Caldwell, University of California- Santa Cruz*

This paper examines two activities in a weeklong Professional Development (PD) focused on implementing mathematical play in kindergarten classrooms. Though the weekly activities all had different goals, the two focal activities (Pattern Blocks and Create-a-Monster) were designed specifically to be both playful and mathematically engaging for the kindergarten teachers taking part in the PD. This analysis looks at why Create-a-Monster fell short of those goals, and compares it to the more successful Pattern Blocks to better understand how to design activities that are playful and mathematically interesting activity for early elementary educators. We finish with implications and future directions on playful PD design.

023. Word Problems and Modeling Tasks
Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Grand 2
Participants:

A new classification of semantic structures of one-step word problem situations *Oh Hoon Kwon, University of Wisconsin - Madison*

A new classification for semantic structures of one-step word problems is proposed in this paper. The classification is based on illustrations of word problem situations in Common Core State Standards (CCSSM, 2010) and related historical studies (e.g. Weaver, 1973, 1979, 1982), as well as conceptual elaborations of embodied and grounded nature in Lakoff et al. (2000). The classification identifies two main classes: action on/change of an initial quantity and coordination/comparison of two quantities, providing a unifying characteristic of basic operations of quantities. This classification is more comprehensive and differentiated than the classification of CCSSM (2010) and Polotskaia et al. (2021), as it emphasizes conceptual demands of children's mathematics, coherence and continuity of progressions, and consistency with thinking modes and/or problem-solving strategies.

Mathematizing fairness: How elementary students draw on funds of knowledge while solving a modeling task *Amy Been Bennett, University of Nebraska-Lincoln; Julia Aguirre, University of Washington Tacoma; Erin Turner, University of Arizona; Elzena McVicar, University of Washington-Seattle; Erin Carll, University of Washington*

Mathematical modeling is a process in which students investigate authentic problems and everyday situations using mathematics. In doing so, they bring their multiple mathematical knowledge bases and cultural funds of knowledge into their solution strategies. During a task called “Abuelo’s Birthday”, 297 students in grades 3-5 decided how to split the costs of a gift “fairly” and justified their work using early notions of ratio and proportional reasoning. We argue that these young students were successful with a complex task due to the way the realistic context connected to students’ lived experiences and funds of knowledge related to home and family life. We share rich examples of how students included elements outside of the task to justify and enhance their mathematical models and conclude with implications for the importance of modeling and non-routine tasks in elementary classrooms.

024. Graphical Reasoning and Statistics
Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Grand 3
Participants:

Bridging Situational and Graphical Reasoning to Support Emergent Graphical Shape Thinking *Allison L. Gantt, University of Delaware; Teo Paoletti, University of Delaware; Srujana Acharya, University of Delaware; Claudine Margolis, University of Michigan*

Emergent graphical shape thinking (EGST) entails conceiving a graph as being dynamically generated via the trace of a moving point constrained by two changing quantities. As such, Authors (in press) argue that meanings for quantities within a situation and meanings for graphical representations must be connected, or bridged, to engage in EGST. In this report, we explore this bridging process through a case study investigating how two students made connections that bridge their situational and graphical meanings during their work on a mathematical task. We found that the pair’s connections between situational and graphical meanings emerged most prominently only after recursive engagement with reasoning in both contexts. We discuss the implications of these findings for researchers and practitioners seeking to support students as they develop EGST.

Developing Teachers’ Expertise to Teach Data Science and Statistics using the Project Professional Learning Platform *Gemma F. Mojica, NC State University; Emily Thrasher, NC State University; Adrian Kuhlman, North Carolina State University; Bruce Michael Graham, North Carolina State University; Hollylynne S. Lee, NC State University; Michelle Pace, North Carolina State University*

In this study, 83 middle and high school teachers engaged with the Project online professional learning platform to develop their expertise in teaching data science and statistics. We investigated teachers’ engagement with the platform, aspects of the platform that were most and least effective in building teachers’ expertise, and the extent to which teachers’ self-efficacy changed. Using mixed methods, we collected, analyzed and integrated multiple data sources.

025. Problem Posing and Reasoning
Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participants:

Combining Covariational Reasoning and Causality to Conceptualize Feedback Loops/ Combinando el Pensamiento Covariacional y la Causalidad para Conceptualizar Bucles de Retroalimentación *Dario Andres Gonzalez, Universidad Autónoma de Chile*

This paper introduces two theoretical constructs, open-loop covariation and closed-loop covariation, that combine covariational reasoning and causality to characterize the way that

three preservice mathematics teachers conceptualize a feedback loop relationship in a mathematical task in the context of climate change. The study's results suggest that reasoning about feedback loop between quantities requires the ability to conceive closed-loop covariation, which is characterized by two cognitive realizations: (i) the conception of simultaneous change and (ii) the recognition of circular causality. These realizations appeared to be independent from one another. The theoretical distinction between open- and closed-loop covariation could inform instructional strategies to develop students' ability to think about and model feedback loops.

Problem Posing in Investigations: The Case of Brandi and Ben *Andrew Kercher, Simon Fraser University; Canan Gunes, Simon Fraser University; Rina Zazkis, Simon Fraser University*

Extant research has demonstrated that problem-posing and problem-solving mutually affect one another. However, the exact nature and extent of this relationship requires a detailed elaboration. This is especially true when adidactical problem-posing arises within a problem-solving context. In this study, we analyze the scripting journey used by two students to record their investigation of sums of consecutive integers. We analyze the adidactical problem-posing found within the scripting journey using three facets of a problem posing framework: mathematical knowledge base, problem-posing heuristics, and individual considerations of aptness. Our analysis reveals how these aspects of problem-posing emerge within a mathematical investigation, how they are related to surrounding problem-solving, and what types of activity act as catalysts to promote further problem-posing activity.

026. Learning High School Algebra

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Paradise A
Participants:

College Students' Conceptions of Symbolic Properties in Algebra *Claire Wladis, BMCC/CUNY, CUNY Graduate Center; Benjamin D. Sencindiver, City University of New York; Kathleen Offenholley, BMCC/CUNY*

In this work, we investigate how college students may conceptualize symbolic algebraic properties. This work uses the theory of Grundvorstellungen (GVs) to analyze how learners' conceptions may or may not align with some desired goals of instruction. Through the analysis of interviews with students across a variety of courses, we describe several categories of conceptions, or descriptive GVs, that emerged in the data. We expect these categorizations to be a helpful first step in understanding learners' thinking and improving instruction on algebraic properties.

Using exit tickets to learn from mistakes and developing growth mindset in an algebra class *VEENA PALIWAL, University of West Georgia*

This study was designed to examine the use of mistakes to promote students' performance in undergraduate Algebra classes by developing a growth mindset. Participants were seventy-four students from three Algebra classes and received one of the three interventions along with regular instruction: (a) growth mindset feedback on mistakes (growth-feedback, n=27), (b) regular feedback on mistakes (feedback-only, n=23), and (c) watching video presentation (control, n=24). Participants from the growth-feedback and the feedback-only classes performed significantly better than the control group in the exams conducted after the intervention. Also, the growth-feedback participants outperformed the other two classes. Findings highlight the importance of valuing mistakes, providing feedback and fostering growth mindset in developing students' math skills and promoting their academic achievement.

027. Routine Tasks and Making a Claim

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Claim Making as a Tool for Analyzing Student Thinking in STEM Contexts *David Slavit, Washington State University Vancouver; Kristin Lesseig, Washington State University Vancouver; Amber Simpson, Binghamton University*

We articulate a framework for delineating student thinking in active, STEM-rich learning environments. Researchers have identified ways of reasoning that relate to specific content areas and practices within each of the STEM disciplines. However, attempts at characterizing student thinking in transdisciplinary STEM environments remains in its infancy, in need of theoretical and analytic frameworks to support this emerging research area (Li et al., 2019). This paper advances the field along both of these dimensions by articulating an analytic framework for student thinking in STEM contexts, and operationalizing it through an analysis of two groups of students in elementary, informal learning situations. Our results suggest that student thinking, in these environments, is often grounded in personal experience and authority and consists of a rich mix of general and disciplinary-oriented reasoning. Implications are provided.

Collective investigation of routine tasks and mathematical uncertainties/ Exploitation collective de tâches routinières et émergence d'incertitudes mathématiques *Genevieve Barabe, Université de Montréal*

This research, grounded in the enaction theory, studies the evolution of routine tasks through the collective activity of solving these tasks. Such a study allows to focus on the potential use of this type of task in the mathematics classroom. The analysis of videos of classroom sessions shows that the collective resolution of this type of task can bring out uncertainties and generate an authentic problem-solving activity in the classroom. Cette recherche, ancrée dans la théorie de l'enaction, étudie l'évolution de tâches routinières à travers l'activité collective de résolution de ces tâches. Une telle étude permet de s'intéresser au potentiel de l'exploitation de ce type de tâche en classe de mathématiques. L'analyse de vidéos de séances de classe montre que la résolution collective de ce type de tâche peut faire émerger des incertitudes et générer une activité authentique de résolution de problèmes en classe.

028. Supporting Equity in Mathematics Instruction

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Considering The Alignment Between Teachers' Conceptions of Justification and their Visions for Equitable Instruction *Kristen N Bieda, Michigan State University; Megan Staples, University of Connecticut; Kristin Doherty, Michigan State University; Serena Anthonypillai, University of Connecticut; Alicia Matthews-Johnson, Michigan State University; Jihye Hwang, Michigan State University*

While proving, and more broadly conceived "reasoning and sense-making," have received a great deal of attention in mathematics education research over the past three decades, recently scholars have argued for the importance of justification as a learning and teaching practice. As teachers work toward realizing goals for more equitable classroom environments, little

is known about whether teachers' conceptions about mathematical practices, such as justification, reflect an understanding of how students' engagement in those practices can support more than just mathematical achievement. In this paper, we present findings from our analysis of interviews with 10 secondary mathematics teachers engaged in participatory action research to explore connections, and potential disconnections, between teachers' conceptions of justification and their visions for equitable instruction.

Enhancing Our Theoretical Lens: Second-Order Models as Acts of Equity *Amy J Hackenberg, Indiana University-Bloomington; Erik S Tillema, Indiana University; Andrew M Gatza, Ball State University*

In this theoretical paper, we respond to a call for all Mathematics Education researchers to become equity researchers (Aguirre et al., 2017) by articulating how equity is foundational to making second-order models of students' mathematics. First, based on prior research, we view equity to be about power and respect. We define an act of equity as acting on social boundaries with the intent of changing them in order to address known inequities. Second, we explain why making second-order models is an act of equity, showing how it respects students and can affect power in research settings. Third, we demonstrate how attention to social identity categories and social identities can enhance current second-order models to better support acts of equity.

029. Assessment Tools

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

Developing a Tool for Measuring Student Orientations with Respect to Understanding in Mathematical Learning *Siqi Huang, University of California, Berkeley*

The goal of this paper is twofold. First, the paper clarifies and elaborates on an important theoretical construct called orientation with respect to understanding in mathematics, which refers to the extent to which students are interested in and care about understanding in mathematical learning. Second, the paper reports on the creation and evaluation of a methodological tool for measuring the aforementioned construct. The tool was operationalized from analyses of 38 college students' problem solving behaviors as well as their verbal self-reflections in semi-structured task-based interviews. Results showed decent validity and reliability evidence on the proposed research tool. This study contributes to a better conceptualization of learning orientation as a fundamental shaper of how students engage with mathematics; it also holds practical potential for enhancing mathematics classrooms.

Establishing Statistical Significance for Comparisons Using Pattern-Based Items: Change at Scale *Walter M. Stroup, University of Massachusetts, Dartmouth; Anthony Petrosino, Southern Methodist University; Corey Brady, Southern Methodist University; Karen Leary Duseau, University of Massachusetts, Dartmouth*

Tests of statistical significance often play a decisive role in establishing the empirical warrant of evidence-based research in education. The results from pattern-based assessment items, as introduced in this paper, are categorical and multimodal and do not immediately support the use of measures of central tendency as typically related to interpretations of measures of statistical significance. Responses from the duplicate implementation of selected pattern-based items (PBIs) in successive grades (3-8) as part of the statewide Interim Assessment Program in Texas are used to illustrate how non-parametric methods can be used to establish statistically significant comparisons of student results. Not all the repeat-item results improved across years.

030. Curriculum, Problem Types and Reasoning

Mathematical Processes and Practices
Research Report Session
10:30 to 11:30 am
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Detectives, Ninjas, and the Taste of Math: Elementary Teachers' Reasoning About Mathematics Curricular Resources *Doris Fulwider, Purdue University; Amy Olson, Duquesne University*

Teachers hold complex goals when making decisions about their curriculum. In particular, the proliferation of supplemental resources means teachers negotiate both how to use the adopted curriculum and how to supplement it with additional resources. Through a study of the language teachers use, the decision-making of three elementary classrooms is brought to life. This study highlights the unique curricular decisions each teacher makes within the context of their own classroom and reveals curricular decision-making themes that emerge across the teachers' classrooms.

Examining opportunities to learn definite integrals in widely used calculus textbooks *Dae S. Hong, University of Iowa*

This study explores opportunities to learn definite integrals in three widely used textbooks in the U.S. Definitions, worked examples, and exercise problems were coded using research–based cognitive resources in definite integrals.

031. Lunch, and Business Meeting

PMENA
Special Event
11:30 to 1:00 pm
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E

032. Plenary: Connecting Math to Real-world Experiences, Culture and Technology

PMENA
Plenary Session
1:00 to 2:00 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participants:

Storytelling, Mathematics and Community *Theodore Chao, The Ohio State University*

In this plenary discussion, Dr. Chao presents his research framework and reflections from engaging in Digital Mathematics Storytelling within Black, Asian American, and Asian American communities in multiple countries. The framework, based heavily around storytelling, counter-storytelling, and Critical Race Theory, has been employed as a workshop to elicit mathematics video stories from youth and mathematics teachers. Here, Dr. Chao reflects on what he's learned from these workshops and how he's started to recognize not only the power of storytelling for forging mathematics and community identities, but the dangers to our society because of social media and weaponized uses of mobile video everywhere. He ends by calling for a new critical digital media literacy within our field of mathematics education.

Designing Instructional Resources to Support Teaching *José Luis Cortina, Universidad Pedagógica Nacional, México*

We discuss the importance of bringing teaching to the forefront of instructional design. We do so by describing the process of developing an instructional sequence for early number, using design research. The instructional sequence was developed with the specific aim of supporting teaching, conceived as a complex and demanding job, not reducible to predictable routines. The sequence has caught the interest of an unexpected number of

teachers in Mexico. We have followed up with some of them and have documented that the resource has benefited their practice significantly. In our account of the design process, we highlight what—from a theoretical point of view—we have come to regard as three guiding ideas that are central to designing for supporting teaching: (1) designing for a resource to be viable in teachers' classrooms, (2) designing for a resource to be regarded by teachers as relevant to their practice and (3) designing so that a teacher who has just taken an interest in a resource might fruitfully engage with it in her practice.

Presenter:

Lisa Lunney Borden, St. Francis Xavier University

033. Semiotic Theory and Perceptions of Learning

Curriculum, Assessment, and Related Topics
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Board Room
Participants:

Perceptions of Learning in a Calculus Course Infused with Multimodal Writing *Aaron Trocki, Elon University*

Student multimodal writing has gained attention in the teaching and learning of mathematics with the anticipation that these assignments will benefit student engagement and learning in a variety of ways. This study investigates students' perceptions of learning in a post-secondary calculus course, which contained four multimodal writing assignments. A course designed with multimodal writing is described along with student-generated products and feedback. Study results suggest that multimodal writing may assist students with understanding the complexities of calculus content and increase collaboration and engagement.

What Can Semiotic Theory Contribute to an Enactivist Analysis of Sense Making with Multiple Artifacts? *Steven Greenstein, Montclair State University; Denish Ogweno Akuom, Montclair State University; Erin Pomponio, Montclair State University; Allison L. Gantt, University of Delaware*

This project seeks to understand the emergence of mathematical meanings mediated by learners' interactions with multiple artifacts. Extending our prior work which took an enactivist approach and revealed the dynamics of embodied interactions fundamental to understanding fraction division, we now employ a semiotic lens to illuminate how learners make personal meanings from their engagement with multiple artifacts and translate them into more generalized mathematical meanings. We are doing so by taking a semiotic approach to tracking the emergent phenomenon of two learners' meaning making as it arises from the complex interplay of signs. We rely on our findings to argue that semiotic theory can be used as a resource to complement and enhance an enactive analysis of the unfolding of sense making with multiple artifacts. Implications for the design of learning experiences with multiple artifacts are proposed.

034. Pre-service Teacher Noticing

Curriculum, Assessment, and Related Topics
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Investigating Pre-service Teachers' Problem Solving Ability and Their Curricular Noticing Ability Through Pedagogical Sequencing Activities *Mi Yeon Lee, Arizona State University; Ji-Eun Lee, Oakland University*

This study investigated how 155 pre-service teachers solved three pattern generalization problems in a two-part written test and sequenced them for teaching purposes to demonstrate their curricular noticing. Participants' solutions were analyzed using inductive content analysis, which showed that only 8.4% of PSTs produced correct answers to all three problems, and 14.2% proposed the same sequence as the researchers. As criteria for their sequencing, 52.9% used the problem's difficulty, variously associated with visuality, complexity, and feasibility, and 11% used their own understanding of how to solve the problem. It was also suggested that some participants' incorrect problem-solving influenced their curricular noticing. Implications for helping pre-service teachers improve their curricular noticing ability are discussed.

$\pi/5$ … Wasn't on the Unit Circle": A Preservice Mathematics Teacher's Meanings for Radian *Hanan Alyami, Purdue Fort Wayne*

Researchers have reported that preservice mathematics teachers' (PMTs') thinking about radian angle measure is procedural. However, PMTs' procedural thinking could be connected to conceptual ways of thinking that are yet to be unpacked. I share in this report the thinking of a PMT, Henry's (pseudonym), as he engaged in three task-based interviews that involve radian angle measure. In the first interview, Henry described radian angle measure procedurally, by emphasizing special angles written in terms of π. By the end of the last interview, Henry's description of radian angle measure was more conceptual, including a generalization of his thinking of the special angles. I conclude by highlighting the importance of tasks that support connecting procedural thinking to a solid foundation of conceptual thinking.

Reflecting on and evaluating tasks: What happens when learning goals are not met? *Dana Olanoff, Widener University; Neet Priya Bajwa, Illinois State University; Jennifer M. Tobias, Illinois State University; Rachael Mae Welder, University of Nevada, Reno*

In this paper, we discuss the learning goals and design elements of one task in a four-task sequence focused on the array model of multiplication, designed for mathematics content courses for prospective teachers. We highlight how we used student responses to determine that our learning goals were not being met, and how we modified the task to better meet our learning goals.

035. Student Reasoning and Discourse

Professional Development/ In-Service Teacher Education
Brief Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

Exploring High School Students' Careless or Insufficient Effort Survey Responses When Investigating Students' Attitudes Toward Mathematics *Xiaohui Wang, University of Texas Rio Grande Valley; Mayra Lizeth Ortiz Galarza, University of Texas Rio Grande Valley; Sergey Grigorian, University of Texas Rio Grande Valley; Aaron Thomas Wilson, University of Texas Rio Grande Valley; John Knight, University of Texas Rio Grande Valley*

Data collected from the administration of a modified, bilingual Attitudes Toward Mathematics Inventory (ATMI) instrument to N = 1,258 high school students on the Mexican border of the US are used to explore survey response behaviors, and examine the existence of careless or insufficient effort (CIE) responses. This is empirical research for handling the CIE responses existence challenge and thus improving the survey data quality obtained from high school students.

Fraction as a Quantity: Describing Students' Reasoning *Jennifer Talbot, Illinois State University; Amanda L Cullen, Illinois State University; Cheryl Lizano, Southern Illinois University Edwardsville*

Understanding fraction as a quantity has been identified as a key developmental understanding. In this study, students in Grades 5,

8, and 11 were asked to compare the areas of two halves of the same square—a rectangle and a right triangle. Findings from this study suggest that students who understand fraction as a quantity use reasoning related to a generalization, whereas students who understand fraction as an arrangement use reasoning related to visualization, computation, or characteristics of the specific shapes involved. Knowing the reasoning exhibited by students can inform both teachers and mathematics curriculum writers in the creation of and planning for instructional tasks.

Schema Revision on Monty Hall Problem *Yuriko Hoshiya Brown, Pennsylvania State University*

The importance of statistical and mathematical literacy has been argued for a long time from social justice and equity perspectives. In this study, the famous brain teaser in math literacy, the Monty Hall Problem is used to investigate if schema revision is possible with a minimal intervention. The participants are 55 undergraduate students. Three participants' schema revision was observed during the assessment with a questionnaire focused on reversible thinking, i.e., what would have caused the favorable future outcome. The result could lead to reform in teaching and learning on reversible thinking in counterintuitive statistical and mathematical problems.

Significant Features of Number Talks as Perceived by Prospective Teachers *Byungeun Pak, Utah Tech University; Jillian M Cavanna, University of Hartford; Brent Jackson, WestEd*

Number talks, a popular mathematics teaching routine in the United States, may offer early support for prospective teachers (PSTs) to engage in ambitious instruction. Studies on teacher noticing, particularly attention, show a need for understanding what PSTS attend to as significant in teaching. There are few studies on what PSTs attend to in their enacted NTs. In this study, we analyzed interview transcripts of 11 PSTs to identify themes that show what they attended to as significant in their enacted NTs. We found three themes in relation to establishing a safe learning environment, allowing the PSTs to focus on students' conceptual understanding, and inviting students to see multiple strategies of others. Discussions and implications are offered in relation to mathematics teacher education and research.

036. Pre-service and In-service knowledge of Fractions

Professional Development/ In-Service Teacher Education
Brief Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

"Exploratory study of pedagogical knowledge about fractions of future primary school teachers"/"Estudio exploratorio del conocimiento didáctico sobre fracciones de futuros docentes de educación primaria" *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*

The present study, of an exploratory nature, aims to inquire about the pedagogical knowledge of future Primary Education teachers about the concept of fraction and its specific meaning of operator. For this, the CoRe instrument is adapted according to three focuses within teaching practice: students, methodology and curriculum, and it is supplied to a sample of 263 teachers in training at a Spanish university. The results show a low level of pedagogical knowledge about the content of fractions, as well as about the concept of fraction as an operator, manifested in a pronounced way in relation to the detection of teaching and learning difficulties and the evaluation process. El presente estudio, de carácter exploratorio, tiene por objeto indagar acerca del conocimiento pedagógico de futuros docentes de Educación Primaria sobre el concepto de fracción y su significado concreto de operador. Para ello se adapta el instrumento CoRe atendiendo a tres focos dentro de la práctica docente: estudiantes, metodología y currículo, y se suministra a una muestra de 263 docentes en formación de una universidad española. Los resultados evidencian un escaso nivel de conocimiento pedagógico sobre el contenido de fracciones, así como en torno al concepto de fracción como operador, manifestado de manera pronunciada en lo relativo a la detección de dificultades de enseñanza y aprendizaje y al proceso de evaluación.

"I Understand It Even More Although I Used It All the Time." Promoting Preservice Teachers' Relational Understanding of Fractions *Jinqing Liu, University of California, Irvine; Yuling Zhuang, Emporia State University*

Preservice teachers (PSTs) are expected to possess a relational understanding (i.e., knowing how to do and why) of mathematics for ambitious instruction. This study aimed to shed some light on the possibilities of supporting PSTs' development of relational understanding of fractions through engaging them in writing collective argumentation. Drawing data from a larger project, we explored the development of a PST's understanding of fractions through the engagement of collective argumentation. The results indicated that the PST's relational understanding of fractions developed from both structural and content perspectives. Some educational implications for teacher education are discussed.

Teachers' Knowledge and Use of Visual Fraction Representations *Karl Wesley Kosko, Kent State University; Christine Kathryn Austin, Kent State University; Maryam Zolfaghari, Kent State University*

The purpose of this study was to examine the relationship between in-service teachers (ISTs') reported use of manipulatives and their pedagogical content knowledge for teaching fractions (PCK-Fractions). The study's results indicated no significant relationship between ISTs' reported use of visual representations and their PCK fractions. However, trends were observed across ISTs' education, taught grade levels, PCK, and use of visual representation. The implications and future needs for the study are discussed in the paper.

037. Student Centered Pedagogy and Equity

Mathematical Knowledge for Teaching
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Emphasizing Prospective Secondary Teachers' Actions and Ideas to Introduce Student-Centered Pedagogy in Teaching Rehearsals *Alicia Erwin, Illinois State University; Matthew Winsor, Illinois State University*

This study investigated the effect of teaching rehearsals on 22 preservice secondary mathematics teachers (PSMTs) who were in their first mathematics pedagogy course. The objective of the teaching rehearsal was to introduce PSMTs to student-centered teaching. PSMTs worked in groups to complete a learning cycle consisting of analyzing a mathematics task, preparing to teach the task, implementing the task with their peers (the teaching rehearsal), and reflecting on their experience. Although PSMTs struggled to teach using student-centered practices, they gained more insight into student-centered practices via self-reflection and class discussion that was centered on PSMT's experiences during the rehearsal. Through the learning cycle, PSMTs also started to develop a vision for creating a classroom culture that values student thinking.

Envisioning the Role of the Teacher in Equitable Mathematics Instruction *Cara Haines, University of Nevada-Las Vegas;*

Charles Munter, University of Missouri; Erica N. Mason, University of Illinois, Urbana-Champaign

We investigated the development of teachers' and other practitioners' visions of equitable mathematics instruction. This involved analyzing data from annual interviews conducted across three school years with 25 practitioners who were working in an urban school district that was trying to decrease a racial opportunity gap in secondary mathematics. During this time, participating teachers attended two five-week professional learning workshops that were designed to support them in confronting sources of racial inequity in school mathematics. Our results include rubrics that model developing visions of equitable mathematics instruction along five dimensions: role of the teacher, mathematical tasks, grouping, evidence of equity, and race consciousness. In this paper, we focus on our findings regarding the role of the teacher.

038. Student thinking and Algebraic Thinking

Mathematical Knowledge for Teaching
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Grand 2
Participants:

Effective instructional practices that foster the development of students' early algebraic thinking *Boram Lee, University of Texas at Austin; Ingrid Ristroph, The University of Texas at Austin; Despina Stylianou, The City College of New York; Eric Knuth, National Science Foundation; Maria Blanton, TERC; Angela Murphy Gardiner, TERC; Ana Stephens, University of Wisconsin-Madison; Rena Stroud, Merrimack College*

Is it possible to identify instructional practices that have an impact on student learning in mathematics? The work described here is part of ongoing efforts to understand and characterize effective instruction. We drew on the work of several recently developed frameworks for understanding teaching effectiveness to develop a protocol for studying effective instruction that both coordinates and extends existing research in the context of early algebra. Using a large-scale study, we characterized effective instruction in this context and documented the impact of such instruction on students' performance using both qualitative and quantitative analyses. Findings suggest that teachers' abilities to take up curriculum openings are important aspects of teaching. Furthermore, the manner with which teachers react to these moments strongly correlates with gains in student performance.

Responsive Evaluation of Student Work: A Theoretical Process *Julien Corven, Illinois State University*

To base teaching on student thinking requires analyzing and interpreting students' thinking, key components of the construct of professional noticing (e.g., Jacobs et al., 2010). Although substantial research has been conducted using this construct, less attention has been paid to teachers' evaluations of student work based on these analyses and interpretations. In this theoretical report, I argue that evaluation of student thinking is a key prerequisite for effective instructional decision making for responsive teaching. I then present a synthesized framework of evaluation criteria and an elaborated process for effective and responsive evaluation of student written work using these criteria. Finally, I analyze an excerpt from an interview with an elementary prospective teacher to demonstrate the utility of these products.

039. Whole Class Discussions and Learning Opportunities!

Mathematical Knowledge for Teaching
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Grand 3
Participants:

Eliciting Cycles as Pre-service Teachers Lead Whole Class Discussion: An Investigation of Moments of Tension *Kristen N Bieda, Michigan State University; Brady A Tyburski, Michigan State University; Rileigh Luczak, Michigan State University; Michelle Cirillo, University of Delaware*

Eliciting student thinking is a core practice of ambitious mathematics teaching, yet it is one practice that is difficult for novice teachers to do consistently and proficiently. To better understand how to support pre-service teachers (PSTs) to enact this practice, our study sought to investigate how secondary PSTs engage in eliciting when they experience instructional dilemmas during whole-class mathematics discussion. We analyzed video-recorded data of 18 PSTs instruction in a university-based early field experience setting in a College Algebra course. The findings shed light upon aspects of eliciting student thinking that PSTs need particular support with as they encounter common dilemmas of leading whole-class discussions.

Exploring the mediating role of Teacher Expectancy on participation in whole class mathematics discussion *Mehmet Kirmizi, Texas State University*

TE refers to the inferences that teachers make about academic achievement, and future career choice of their students, it is a teacher level variable, and it mediates the teacher-student interaction. I hypothesize that the TE impacts the distribution of learning opportunities in 8th grade mathematics classes. So, I investigate the distribution of learning opportunities in terms of TE. An 8th grade class interaction is recorded (n =16), and investigated by using the EQUIP. The result of this study reveals that seven high expected students despite being the 35% of the class have 76.71% of entire student talk. In other words, a big chunk of the class interaction is only between teacher and high expected students.

040. Research Colloquium: Embodied Mathematical Imagination and Cognition (EMIC)

Working Groups and Research Colloquia
Working Group
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participant:

Research Colloquium Embodied Mathematical Imagination and Cognition (EMIC) / COLOQUIO DE INVESTIGACIÓN: COGNICIÓN E IMAGINACIÓN MATEMATICA INCORPORADA / COLLOQUE DE RECHERCHE : IMAGINATION ET COGNITION MATHÉMATIQUES INTÉGRÉES *Mitchell J. Nathan, University of Wisconsin - Madison; Candace Walkington, Southern Methodist University; Dor Abrahamson, Univ. of California, Berkeley; Erin Ottmar, Worcester Polytechnic Institute; Martha W Alibali, University of Wisconsin-Madison; Michael I. Swart, University of Wisconsin - Madison*

Embodied approaches to mathematics learning, instruction, design, and assessment offer natural inroads for engaging all learners. Since 2015, the Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium has organized hands-on, collaborative, and generative activities for experiencing the contributions that embodied mathematics has to offer. During this 3-part research colloquium, participants are invited to explore notions of engagement and design activities intended to transform teaching, learning, and assessments. This experience can lead to a deeper understanding of the value of embodiment for math education, its theoretical foundations, and its potential to transform education.

041. Parent Influence and Parenting

Curriculum, Assessment, and Related Topics
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Paradise A
Participants:

Kindergarten Students' Mathematics Identity And Parents' Mathematics Learning Experience: A Phenomenological Case Study *Kudirat Alli-Balogun, University at Buffalo; Ji-Won Son, The State University of New York at Buffalo*

Underpinned by the Vygotsky theory of sociocultural perspective and learning and Bronfenbrenner bioecological theory of human development that social interaction plays a fundamental role in the process of cognitive development, this study explored the interrelations between parents' mathematics learning experience and their kindergarten children's mathematics identity. As a first phase of two intended studies; though each is complete on its own, this study illustrated the diversity of mechanisms through which parents engage their young children at home in mathematics learning. Using Colaizzi's seven steps, five themes emerged that expounded on how to engage parents in mathematics learning for kindergarteners, offer ways of educational support for mathematics learning of young children, as well as add to the existing body of literature of this trajectory.

Learning to Parent Mathematically: Critical Factors in Parent-Child Math Engagement *Anastasia Betts, University of Buffalo SUNY; Ji-Won Son, The State University of New York at Buffalo; Hee Jin Bang, Age of Learning, Inc.*

Dramatic differences in children's math knowledge at school entry are thought to originate in the Home Math Environment (HME), where parents and caregivers are the primary provider of experiences that influence children's early math knowledge development. Little is known about what informs parent decision-making around "mathematical parenting" (i.e., parents' cognitions, motivations, and behaviors that impact and influence child math development in the HME). This study uses the RESET Framework and survey instrument to investigate parents' mathematical parenting perceptions (n = 847) across the domains of Role, Expectations, Skills, Efficacy, and Time. Parent self-reports of early childhood math knowledge and of shared math activity are also examined to shed light on the factors that influence mathematical parenting of 4-5-year-old children in the home.

Parents and Teachers Doing Mathematics Together *Erin Turner, University of Arizona; Pilar Ester Mariñoso, Universidad Camilo Jose Cela; Marta Civil, University of Arizona; Beatriz Quintos, University of Maryland; Fany Salazar, University of Arizona; Maura Varley Gutierrez, University of Arizona*

Collaborative partnerships between families and teachers have the potential to support and transform students' mathematics learning experiences. This study focused on interactions among mothers and teachers of multilingual elementary grade students who participated together in workshops focused on teaching and learning mathematics. We analyzed participants' engagement in open-ended, culturally responsive mathematics tasks designed to foster collaboration and equitable participation. We describe several findings related to the potential of these tasks, including how they supported opportunities a) to recognize one another's strengths; b) to challenge traditional power differentials between parents and teachers, and c) to collaboratively generate mathematical ideas. We also discuss challenges that arose, and implications for the design of collaborative learning experiences for teachers and parents.

042. Mathematical Play and Engagement
Mathematical Processes and Practices
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Liberating Agency And Transforming Competence Through Mathematical Play *Melissa Gresalfi, Vanderbilt University; Madison Knowe, Vanderbilt University; Jamie Vescio, Vanderbilt University*

Many scholars have argued that mathematics classrooms often offer narrow conceptions of mathematical excellence, recognizing only some kinds of thinking and some kinds of people as valuable, and conflating mathematical aptitude with overall intelligence. Play offers the potential to disrupt such classroom mathematical practices, by offering new and broader ways to exercise agency, and, relatedly, more expansive visions of who is seen as mathematically capable. Offering an in-depth analysis of the participation of two students as they engage in mathematics in their Kindergarten class, whole group rug time and small group play centers, we investigate how different activity structures create space for students to exercise agency in ways that demonstrate multiple forms of competence, creating liberating mathematical spaces.

Mathematics Instruction and Mathematical Vocabulary: Engaging a Neurodivergent Student *Angela R Crawford, Boise State University; Aysia Kernin, Boise State University*

This study explores volitional and affective responses to instructional activities aimed at developing geometric and spatial vocabulary of a neurodiverse student. Using teaching experiment methodology across 15 instructional sessions, we observed how the student responded to games, direct instruction, and vocabulary support embedded in spatial reasoning activities. A narrative microgenetic analysis explored how these activities were associated with evidence of engagement and confidence in learning. We describe how embedding vocabulary in the student's own mathematical activity was supportive of developing vocabulary, engagement, and confidence, while games and direct vocabulary instruction were not.

043. Challenges and Affordances in Using Technology to Support Learning
Mathematical Processes and Practices
Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Rise of the Machines: Navigating the Opportunities and Challenges of AI-Assisted Research and Learning *Justin Dimmel, University of Maine; Izge Bayyurt, University of Maine*

This commentary was written by ChatGPT, an artificial intelligence language model developed by OpenAI. It was conceived by the first author as a test for how the advent of predictive language modeling will create opportunities and challenges for researchers and teachers in mathematics education. The commentary reviews literature about AI in mathematics education and makes connections to the conference theme, casting an eye toward the present and future of AI assisted learning, teaching, and research. A reflection that was written by the authors explains how the model was prompted to generate the text and how we worked with ChatGPT to validate and edit the text that was produced.

Utilizing asynchronous number talks as a way to engage all learners *Simon Byeonguk Han, Portland State University; Eva Thanheiser, Portland State University*

Due to the sudden and unexpected move to remote learning in 2020 influenced by COVID-19, both mathematics teacher educators (MTEs) and prospective elementary teachers (PTs)

faced a new challenge in creating a productive remote teaching and learning environment. In this study, we used Parrish's (2014) addition strategies and Thanheiser's (2009) conception of multidigit numbers to analyze 41 prospective elementary teachers' responses in Number Talks (NTs) from two online asynchronous mathematics content courses for prospective elementary teachers. We found that (1) the order in which NTs are posed influences the strategies used, (2) some PTs identified the sameness of strategies differently than us (MTEs), and (3) PTs' conception of digits developed over time. In online asynchronous NTs, all PTs are asked to share their strategies before they see strategies provided by other students. This allowed all students to contribute and for instructors to observe and trace every PT's use of strategies over time. Therefore, we argue that asynchronous NTs can be a way to pursue the engagement of all learners in both face-to-face and online learning environments.

044. Unit Coordination and proportional thinking

Professional Development/ In-Service Teacher Education
Brief Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

Connecting Units Coordination and Covariational Reasoning: The Case of Daniel *Sarah Kerrigan, George Fox University*

Units Coordination and Covariational Reasoning are powerful frameworks for modeling students mathematics in arithmetic reasoning with whole numbers and fractions and construction and interpretation of relationships between changing quantities, respectively. This case study of an advanced stage 2, 8th grade algebra student, Daniel, investigated connections between his units coordination and covariational reasoning on non-graphical covariation tasks. Results show Daniel leveraged his units coordination structures to reason about how two quantities varied together in several distinct ways. From Daniel, new insight was gained into underlying mental structures and actions involved in Carlson and colleagues' (2002) covariational reasoning framework. Implication for engage a diversity of learners is included.

First Graders Coordination of Counting and Movements on a Grid when Programming with Tangible Blocks. *Abigail Erskine, Purdue University; Laura Bofferding, Purdue University; Sezai Kocabas, Purdue University; Haoran Tang, Purdue University*

As elementary students begin to program using tangible blocks, they must coordinate their use of counting with the movements, directions, and numbers they use to move a character. In our study, we analyzed 13 first graders' first attempts at coordinating these elements when playing a programming game on the iPad that used tangible programming blocks. We further analyzed how their programs changed over the six sessions. Our results highlight the challenges students faced when counting on a grid, representing movements with numbers, and distinguishing between movement blocks. We also present factors that influenced their improvements. The results indicate that game hints supported some students' use of numbers, while the highlighted path helped some and challenged others. Partner talk and having the opportunity to make iterative changes in their code also supported some groups.

Engaging and Empowering Prospective Teachers' Through Their Ability to Coordinate Units *Rich Busi, James Madison University; Alexis Stevens, James Madison University; Jennifer Gibson, James Madison University; LouAnn Lovin, James Madison University*

This session will share the theoretical basis, setup, and findings from a study conducted around improving prospective teachers' abilities to coordinate levels of units within their understanding of fractions. Unit coordination is a well-defined construct within the literature in terms of how students understand fractions and progress through understanding them. However, much is to be learned about the specific ways in which we can identify and impact this understanding within undergraduate mathematics content courses for future teachers. This study investigated an intervention designed to allow prospective teachers to explore fractional situations requiring the coordination of three levels of units to solve. We hypothesized participants might better internalize this coordination through explorations and activities in classroom settings. Specifics for data collection, analysis, findings, and next steps will be shared.

Relative reasoning and the transition from additive to multiplicative thinking in proportionality *Jerome Proulx, Université du Québec à Montréal*

Research studies are abundant in pointing at how the transition from additive to multiplicative thinking acts as a core challenge for students' understanding of proportionality. This said, we have yet to understand how this transition can be supported, and there remains significant questions to address about how students experience it. Recent work on proportional reasoning has pointed to a type of strategy, called "relative", that appears to be lodged right between additive and multiplicative ways of thinking. This sort of "in-between" strategy raises significant interest and motivates further analysis. In this paper, I explore several of these relative strategies engaged in by a 13-year-old student, Marie, during a series of individual interviews. The analysis outlines several dimensions that can inform as much the transition from additive to multiplicative thinking than proportional reasoning itself.

045. Technology and Education

Professional Development/ In-Service Teacher Education
Brief Research Report Session
2:15 to 3:30 pm
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Relationships Between Students' Micro-Identities and Students' Mathematics *Christopher Orlando Roman, Portland State University*

This paper investigates the relationships between adult students' mathematical micro-identities (informed by positioning theory) and their mathematics (informed by radical constructivism). The data for this study was made up of one 67-minute video recorded math lesson that was taught remotely through Zoom. I used positioning theory to conduct a detailed turn-by-turn analysis of students' micro-identities, and to inform my models of students' mathematics. Results showed that (1) capable mathematical micro-identities are associated with persistence and vulnerability in students' mathematics, (2) supportive mathematical micro-identities are associated with flourishment in students' mathematics and (3) mathematical micro-identities involving explanations and thought processes are associated with the visibility of students' mathematics.

Supporting Preservice Secondary Mathematics Teachers To Develop Their TPACK Knowledge *Enrique Galindo, Indiana University; Mehmet Fatih Öçal, Ağrı İbrahim Çeçen University; Selim Yavuz, Indiana University*

Secondary mathematics preservice teachers enrolled in a methods class at a large Midwestern University were supported to develop their TPACK knowledge. . Preservice teachers included a variety of digital technologies in their portfolio entries, but most of the uses described aligned with ways to use technology to support reasoning and sense making. Findings suggest that the course helped preservice teachers develop their TPACK knowledge.

Surveying Instructors of Geometry for Teachers Courses: An

Illustration of Balanced Incomplete Block Design *Michael Ion, University of Michigan; Pat G Herbst, University of Michigan; Inah Ko, University of Michigan, Ann Arbor; Carolyn Hetrick, University of Michigan*

Higher education involves numerous stakeholders, which, coupled with the dynamic conditions of the processes involved in providing mathematics coursework for preservice teachers leads to variability in outcomes for these courses. The misalignment of content courses for teacher certification with current standards and best practices is a problem that can be mitigated through collaboration between multiple institutions and the creation of shared resources and support networks. To better understand the feasibility of such collaboration, there is a need to address practical challenges, such as disseminating the work of online professional learning communities in developing student learning outcomes for mathematics content courses taken by preservice teachers. This paper presents an illustration of a survey-based research design that addresses these practical challenges, demonstrating the benefits of a Balanced Incomplete Block Design in being able to collect consensus from a larger collective of instructors about a course.

The Impact of a Technology Methods Course on Prospective Teacher Technological and Epistemological Beliefs *Jon D. Davis, jon.davis@wmich.edu; Fnu Pujiyanto, Western Michigan University*

This study examined the effect of a teaching mathematics with technology course on preservice elementary teachers' (PSETs) and preservice secondary mathematics teachers' (PSTs) beliefs about teaching with technology and beliefs about the nature of learning and teaching mathematics. All preservice teachers enrolled in the methods course engaged in technology lesson rehearsals, critiqued peers' technology lessons, taught a lesson involving technology in an area school, and reflected on that teaching experience. The group of PSTs had larger change values from the initial to final belief questionnaire than the group of PSETs, but both changes were statistically significant. PSETs experienced a statistically significant change from initial to final belief in five out of ten belief categories. PSTs experienced a statistically significant change from initial to final belief in seven out of ten belief categories.

046. Coffee Break

PMENA
Special Event
3:30 to 4:00 pm
Atlantis Hotel and Casino Conference Center: Foyer

047. Geometry and Visual Representations Using Technology

Curriculum, Assessment, and Related Topics
Research Report Session
4:00 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Opportunity to Learn Function Transformations in Dynamic Mathematical Environment: An Analysis of 347 GeoGebra Applets *Xiangquan Yao, Pennsylvania State University; Nicholas Grande, The Pennsylvania State University*

This study examined the opportunity to learn function transformations afforded by the GeoGebra applets available on the GeoGebra website. Our analysis focused on the functions and their representations through which function transformations are explored in these GeoGebra applets, the effects and components of transformations that the GeoGebra applets afford students to learn, and the scaffolding provided in these applets. The results show that function transformations in the GeoGebra applets are often explored in the context of particular function families (e.g., quadratic and trigonometric functions) that use specific representations (e.g., graphical and symbolic). Moreover, the defining parameters of transformations and corresponding points on the graphs of parent and child functions are not visible in most GeoGebra applets. Only a small number of GeoGebra applets include questions or tasks that aim to scaffold students' exploration of function transformations. These results invite us to rethink how to design GeoGebra applets that maximize students' opportunity to learn function transformation conceptually in dynamic mathematical environments.

The Role of Beliefs, Visualization and Technology in Teaching and Learning Proof: The Case of Skylar *Shahabeddin Abbaspour Tazehkand, University of Central Florida; Farshid Safi, University of Central Florida*

This study aims to investigate how the integration of dynamic geometry software (DGS) and visual representations can enhance the understanding of proof in calculus concepts among pre-service secondary mathematics teachers. The study focuses on the teaching and learning of proof by using technology and aims to contribute to the field of mathematics education. The research question guiding the study is how dynamic technology integration and visual representations can support teachers' experiences and beliefs regarding the process of proving calculus concepts.

048. Improving Classroom Practice

Mathematical Processes and Practices
Research Report Session
4:00 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

Tracing the Co-Evolution of Teacher Learning Between Professional Development and Classroom Practice *Hala Ghousseini, University of Wisconsin-Madison; Burcu Alapala, UW Madison; Rahul Panda, University of Wisconsin-Madison*

How teachers can experience adaptive professional learning experiences is still understudied in the literature on teacher learning, which for the most part reflects an emphasis on learning outcomes rather than the process of learning. In this study, we use a situated perspective on teacher learning to investigate the co-evolution of a teacher's sensemaking about facilitating classroom discussions between her classroom practice and the school-based PD experiences. The study contributes to an understanding of how studying the process of teacher learning can be supported through continuous, adaptive professional learning experiences and of the co-evolution of teacher learning between settings of practice.

Using a Formative Evaluation Framework to Validate a Teaching Observation Tool *Kathleen Melhuish, Texas State University; Brittney Ellis, Texas State University; M. Alejandra Sorto, Texas State University*

Teaching observation protocols serve purposes beyond research, such as providing formative feedback for teachers' growth in their practice. Such observation tool usage requires different approaches for validation. For this reason, we developed the formative teaching evaluation framework adapted from the student-assessment literature. We used this framework as a guide toward collecting and organizing evidence of the Math Habits Tool's use as a means for formative assessment of teaching. This report focuses on how we designed surveys and interviews to collect usage validity evidence related to the formative teaching evaluation intentions of the MHT. Overall, we established that the MHT was being used as intended by teachers and school leaders, and we provide details about the development and analysis procedures we took toward validating this observation tool for practitioner use.

049. Math Anxiety and Social and Emotional Learning

Mathematical Knowledge for Teaching
Research Report Session
4:00 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

"I Don't Know What To Do: A Mixed Method Study Of Math Anxiety As Perceived By Students And Their Parents" *Dr. Andrea M Elizondo, Del Mar College*

A continuing problem influencing mathematics performance and student's perceptions of their ability to learn mathematics is mathematics anxiety (MA). This mixed method study examined the perceptions, correlations, and mathematical conversations of fourth and fifth grade low-performing students and their parents. A psychological approach provided the framework necessary to understand the theories behind self-concept, academic self-concept, and mathematics self-concept. Instrumentation included the Mathematics Anxiety Rating Scale for Elementary students (MARS-E), the Mathematics Anxiety Rating Scale for adults (MARS-SV) and interviews. Findings disclosed specific characteristics to better understand students and parents experiencing low, moderate and high mathematics anxiety. Various mathematical situations and mathematical conversations were found to affect mathematics self-concept, mathematics performance, and mathematics anxiety. In addition, mathematical conversations between parent and children, positive parent support, and a positive attitude concerning mathematics contributed towards a positive mathematics self-concept. These particular psychological developments and findings will be further explored at the conference presentation.

Integrating Social Emotional Learning (SEL) into Mathematics Teacher Preparation: A Trauma-Informed Approach *Jenna R O'Dell, Bemidji State University; Rebecca Hoffman, Bemidji State University; Todd Frauenholtz, Bemidji State University; Stacy Bender, Peacemaker Resources*

In this study, we investigated preservice mathematics teachers' growth and application of their emotional intelligence skills after participating in monthly social emotional learning (SEL) workshops for an academic year. SEL workshops were led by a local nonprofit specializing in universal prevention tools for systemic changes that benefit individuals and communities. We interviewed three students who participated in all the workshops about their experiences with SEL skills in their personal lives, practicum experiences, and how they will use it in their future classrooms. We found the most common SEL competency areas they discussed were responsible decision making and social awareness. The undergraduate preservice mathematics teachers were clearly able to identify instances in both their personal and professional lives where they observed SEL skills being used.

050. Poster Session: Student Learning
PMENA
Poster Session
4:00 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Paradise Terrace
Participants:

Algebraic Structure Sense *David Feikes, Purdue University Northwest; William Walker, Purdue University; Natalie McGathey, Prairie State College*

The importance of algebraic structure is highlighted in research (e.g., Warren et al., 2016), but it is not clearly defined. The purpose of this paper is to provide a definition of algebraic structure and identify six research-based features of algebraic structure sense: symbol sense; processes/relationships of algebra; process as an object, reification; solution strategies, solution formats, and relationships among representations. A goal is to further discussion on the development of the theoretical perspective on algebraic structure and how it relates to opportunities for students to learn algebra.

Approaching similarity by using geometric representations: enhancing high school students' learning experiences *Mayra Lizeth Ortiz Galarza, University of Texas Rio Grande Valley; Luis Miguel Fernandez, The University of Texas Rio Grande Valley*

For many high school students, the type of reasoning required for learning trigonometric concepts has not been fully developed. Research indicates that in traditional instruction, trigonometry is typically taught using the ratio method. The purpose of this study is to contribute to the efforts that enhance the education of trigonometric functions by proposing novel ways to teach critical concepts (i.e. similarity, ratio and proportion, angles, etc.) in trigonometry by using multiple representations.

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

In this study, I report on developmental shifts of a middle school student's (Naya) graphing activity as I implement an instructional sequence that emphasizes quantitative and covariational reasoning. Naya initially assimilated the points on the plane in relation to the physical objects that appear in the situation, and her meanings for points were based in iconic or transformed iconic translation (i.e., picture of the situation). As she began to conceptualize the quantities in the situation, Naya's graphical meanings included representing two quantities in the non-canonical Cartesian plane. Subsequently, her attention to quantities in the situation, mapping those quantities' magnitudes onto the number lines and assimilating the axes of the plane as number lines afforded Naya to develop a meaning of points in terms of representing two quantities' magnitudes by reorganizing the space consistent with a Cartesian plane.

A Trivium Curriculum for Students' Mathematics Competency with regard to Indigenous Mathematics Knowledge *Emmanuel Chukwuebuka Umeh, University of Missouri Columbia; Samuel Otten, University of Missouri at Columbia*

This poster examines the connection between the trivium curriculum and mathematical competencies. With the growth of ethnic and linguistically diverse student populations in schools, there is a need for pedagogical tools that will improve cognition and develop mathematical competencies. Mathematical instruction needs to change significantly to accommodate these changes in student populations. Therefore, the main goal of this work is to explore how the trivium curriculum, which comprises literacy, matheracy, and technoracy, can build learners' mathematical competencies using an indigenous learning approach. The three dimensions of curriculum can provide insight into competencies, allowing for a pursuit of equity and inclusion for students.

Barriers to Perceived Usefulness of Mathematics Among Middle School Students *Tracy Elyse Dobie, University of Utah*

This poster examines a diverse group of adolescents' perspectives on the usefulness of mathematics. In particular, this research asks what potential barriers to perceiving mathematics as useful are experienced by early adolescents. Four themes emerged through an open coding process: viewing mathematics as useful in ways that are relevant for others but not oneself; contrived examples of math's utility; narrow definitions of mathematics; and trusting the messages of significant others without question. This poster provides examples of each potential barrier and then unpacks those themes by applying literature on both adolescent development and the role and framing of mathematics in society. Suggestions are provided for future research to further explore and overcome these barriers.

Characterizing Calculus I Students' Participation in The Parallel Spaces of Coursework And Inquiry-Oriented Supplemental Instruction *Karmen Yu, Montclair State University*

Calculus has been known as a "gateway course" to STEM fields in postsecondary education. To address this issue, university researchers designed a model of supplemental instruction that features peer-facilitated workshops where Calculus I students work in groups on inquiry-oriented, groupworthy tasks. The purpose of this poster is to present preliminary findings of a multiple-case study that seeks to answer the question, How undergraduate Calculus I students experience and navigate their learning of calculus in the parallel spaces of coursework and inquiry-oriented supplemental instruction? Preliminary findings presented in this poster include characterizations of the different forms of agentive participation in each of the two spaces, contrasts between the two spaces, and their complementary nature relative to learning calculus with understanding. As this study progresses, the findings presented here will be used to address this research question more.

Designing for Students' Joyful Mathematical Engagement through Responsive Rehumanizing Mathematics *Madison Knowe, Vanderbilt University*

This study proposes that students' joyful mathematical engagement can emerge by designing for responsive rehumanizing mathematics. I investigate what information is important to know about students and how that information translates into designing for humanizing mathematical learning. Findings demonstrate the importance of attending to bodies through physical activity, ownership of mathematics, and participation in game play and emphasize the complexity of designing for varied human experiences and interpretations of joy.

Designing Mathematical Reasoning to be a Form of Inoculation Against Unwarranted Beliefs *Samuel Otten, University of Missouri at Columbia; Mitchelle Mbete Wambua, University of Missouri-Columbia; Emmanuel Chukwuebuka Umeh, University of Missouri Columbia*

Conspiracy theories and unwarranted beliefs are a substantial problem in society but if mathematical reasoning is taught in a narrow and procedural manner, it provides little or no protection against those unwarranted beliefs. This poster draws on social science research about effective inoculations against unwarranted beliefs to design learning experiences for secondary mathematics students that increase the likelihood of mathematical reasoning being used to critique and reject unwarranted beliefs such as conspiracy theories. Using boundary crossing as a design theory, examples are shared of mathematical reasoning prompts that can cross into political spaces (e.g., "Could that possibly be wrong?") as well as political claims that can be brought into the mathematical classroom.

Digital wall: a reflective tool for students' self-regulating online learning within a problem-solving approach *Daniel Ortiz, CINVESTAV-IPN; Tania Azucena Chicalote Jiménez, CINVESTAV-IPN*

A digital wall is a tool for students to structure and register their online work on mathematical problem-solving activities that involve the coordinated use of digital technologies. How could students use such digital wall to understand mathematical concepts and to develop problem-solving competencies? The aim of this study is to analyze and document the extent to which the students' use of the wall became a powerful tool to share, discuss, and refine their problem-solving approaches.

Engaging and Supporting Learners to Count Permutations: Explicating Early Levels of a Learning Trajectory *Joseph Antonides, Virginia Tech*

Prior research has revealed that student reasoning While research has demonstrated how students, especially with more advanced multiplicative concepts, can progress from systematic construction to recursive additive and multiplicative reasoning, research has not yet captured how to support students to initially develop ways of constructing permutations systematically. Toward this goal, this report contributes insights into two undergraduate students' initial ways of reasoning about and constructing permutations, along with a psychological account of the mechanisms that enabled their developing reasoning.

Engaging with a Geometric Translations Task Using Computing *Karmen Williams, Louisiana State University; Zuhal Yilmaz, Louisiana State University; Fernando Alegre, Louisiana State University; Juana Moreno, Louisiana State University; Rose Kendrick, Louisiana State University*

This poster presents the findings of a study focusing on how 9th grade students engage with a geometric translations computation task and their teacher's ideas about how the task supports students' understanding of translations. Geometric translations can be interpreted as either motion or mapping (Hollebrands, 2003; Yanık, 2011). When students engage with geometric translations, they use patterns, congruence, generalization, and spatial reasoning (Portnoy et al., 2006). Computational media provided opportunities for students to identify patterns, defining functions, and perform manipulations (Schanzer et al., 2015). We collected data from a classroom in which students created a translation of a bird silhouette through coding. Data analyzed consisted of observation field-notes, students' code artifacts, and debrief notes with the teacher. Preliminary results suggest that students observed the motion interpretation of the translation through manipulation and explored the mapping interpretation by defining a function for the translations.

Examining Mathematics Identities of Successful University Developmental Students *Francis Nzuki, Stockton University*

Nationally, about 60 percent of high school graduates are referred to one or several developmental courses (Attewell, Lavin, Domina, & Levey, 2006; Bailey, Jeong, & Cho, 2010) before they are eligible to enter college-level coursework. Furthermore, a vast majority of first-year college students taking a developmental course at four-year institutions are required to do so in mathematics (Duranczyk & Higbee, 2006). This study uses a narrative inquiry to explore developmental students' experiences and construct stories for their academic success, viewed through the lens of the Schlossberg's transition theory, by addressing their home and school experiences during the mathematics transition from pre-college and beyond. In addition, the mathematics identity framework is utilized to examine how these experiences helped to shape their mathematical identities and how these identities in turn influenced their successful completion of developmental mathematics.

Expanding on Complex Instruction through Learner Agency *Larissa Peru, University of Arizona; Kasie Betten, Sunnyside Unified School District*

Since the social turn in mathematics education pushed mathematics educators and researchers to "see meaning, thinking, and reasoning as products of social activity" (Lerman, 200, pg. 8), there has been a growing field of research regarding the design and implementation of collaboration in mathematics instruction. From a secondary teacher perspective, the application of this pedagogical philosophy often falls short without critical self-reflection. Students cannot reap the benefits of mathematics from a social lens if educators do not provide the classroom structures to allow for agentic learning. This poster will present the theoretical framework, methods, and implications of an expansion on Complex Instruction (Cohen & Lotan, 2014) as a means to address the following research question: How does designing instruction around learner agency impact students' mathematical identity?

Explicating Students' Unit Structures in Combinatorial Contexts *Joseph Antonides, Virginia Tech; Erik S Tillema, Indiana University*

We discuss students' combinatorial reasoning (with a focus on permutations) from the perspective of units coordination. We describe the unit structures that students construct within combinatorial contexts along with the mental actions that they seemed to use to construct them.

Exploring Lunar Phases by Co-Splitting Fractions and Angles *Amanda Provost, Montclair State University; Nicole Panorkou, Montclair State University*

Extensive research on integrated STEM education has shown that mathematics is usually underrepresented compared to the other disciplines. Our research group aimed to design instructional modules that provide a more balanced focus on each of the disciplines. In this paper, we present our findings from a module we designed that engaged students in dynamic digital tasks exploring the science phenomenon of lunar phases and the mathematics of angle measurement, covariation, and co-splitting. Our results indicate how the two disciplines can be integrated to support students' forms of both mathematical and scientific reasoning further.

Exploring the Affordances and Limitations of Between-Group Movement in Elementary Mathematics Classrooms *Tye Campbell, Utah State University; Sheunghyun Yeo, University of Alabama; Erin Rich, University of Alabama; Mindy Green, Revere Jr./Sr. High School*

In this exploratory study, we examine the affordances and limitations of between group movement in one sixth-grade classroom. Between-group movement refers to a classroom structure wherein groups can physically move to visit other groups within the classroom when they get "stuck" during problem-solving. Rather than relying solely on the teacher, between group movement allows groups to access "between-group" resources to autonomously problem-solve and make sense of mathematics. We share one case study of two sixth-grade groups engaging in a between-group conversation to explore the affordances and limitations of between-group movement in upper elementary classrooms.

Geometry Students' Ways of Thinking About Adinkra Symbols *Steven Boyce, Portland State University; Michael Ion, University of Michigan*

This research regards college students' mathematical reasoning when engaging in explorations of the meanings and mathematical properties of Adinkra. We analyzed responses to four tasks involving student-created symbols, identifying categories of geometric justifications they exhibited. We look forward to discussions with participants at the poster session about the potential for introducing Adinkra to prospective and in-service teachers to support their students' engagement in varieties of geometric reasoning.

Analyzing the Impact of Corequisite Remediation on Developmental Students in Statistics *Shawnda Smith, Texas Woman's University; Brandi Falley, Texas Woman's University; Lorianne Gillander, Texas Woman's University; Jackie Hoermann-Elliott, Texas Woman's University*

In our study, we analyze the performance of students enrolled in a corequisite Elementary Statistics course compared to students in the traditional (on-level) Elementary Statistics course. Students deemed not college-ready, based on the standardized state placement exam, were placed in an additional three-hour developmental mathematics course (corequisite course) paired with an Elementary Statistics course. The students in the corequisite course received instruction covering developmental mathematics topics necessary for their understanding of the topics immediately being addressed in the on-level course. The Elementary Statistics courses administered three common exams and a common cumulative final exam. We analyzed the performance of the corequisite students and the on-level students' exam scores and found no significant difference between the grades.

Impact Of Take-Home Manipulative Kits In An Elementary Mathematics Content Course *Barbara Swartz, West Chester University*

This project builds on our current understanding of effective mathematics teaching practices and the need to develop prospective elementary teachers' mathematical content knowledge. By implementing NCTM's (2014) effective mathematics teaching practices in an undergraduate mathematical content course for prospective elementary teachers, we investigated the impact of the use of math tools (manipulatives) in light of the experiences they provide for the teacher candidates, along with how they help to deepen prospective teachers' understanding of the mathematics they will teach in their own classrooms and how, if at all, they impact teacher candidates' dispositions towards mathematics.

Interpretations of high school students when solving a problem involving the concept of a linear function *Dinorah Méndez Huerta, Universidad de Guadalajara; Veronica Vargas-Alejo, University of Guadalajara; Luis E Montero-Moguel, The University of Texas at San Antonio*

None

Investigating Space and Place Factors in a Mathematics Classroom Discourse *Hillary Ongoyo Omoze, Purdue University (West Lafayette); Abigail Erskine, Purdue University*

In this study, we investigate the effect of space and place on mathematics classroom discourse. The teacher and the student in a mathematics classroom embody identities shaped and constrained by space and place. These inform the quality of engagement and interactions between students and mathematics, and students, teachers, and mathematics in the classroom. Mathematics educators and mathematics teacher educator conceptualization of space and place as teaching and learning contextual variables are at the core of our study. We would refer to Tate's work on geospatial factors and other social constructivists' theoretical frameworks to ground our study. We seek to situate space and place in a mathematics classroom discourse.

It's Not About the Math: Enacting Caring Instruction in a Community College Mathematics Classroom *Megan Selbach-Allen, Stanford University*

Math remains a major barrier for students interested in pursuing STEM careers even as policy makers decry the need for more graduates with these majors. One important place students from diverse backgrounds begin their studies is in community colleges even as they remain understudied. This work is an in-depth case study of one 'successful' classroom that is positioning students for future success in STEM majors. Building on prior work around the importance of care in community college classrooms, the study reveals how an instructor uses 'non-math' talk regularly in his class to connect students with the broader importance of what they are learning and express caring. This 'non-math' talk appears to be supplemented with deliberate community building and positioning students as intellectual authorities. Future work will elicit student perspectives and build a framework around this care.

Latinx Bilinguals Translangauging Within the Unofficial Space of a Mathematics Classroom *Hector Morales, Jr., Northeastern Illinois University*

This paper examines the meaning-making practices of Latinx bilingual students with a challenging mathematics task. My aim

is to draw a better understanding of how learning takes place among a group of students who participate in multiple social spaces in the classroom but who also form a unique unofficial space or "underlife" within the same classroom. Studying the collaborative efforts of Latinx bilinguals, my findings suggest these students can spontaneously and dialogically leverage communicative resources to explore mathematics via their dynamic bilingualism.

Mathematical meaning making with students through a process of double reflection *Wesley Shumar, Drexel University; Amanda Reinsburrow, Drexel University; Sienna Medina, Drexel University; Jason Silverman, Drexel University*

This paper reports on a project that produced a series of online teacher professional development workshops. Within the workshops the project utilized a web-based software application that supports teachers to look closely at student work and to make comments upon aspects of the work using the noticing and wondering framework. A goal of the workshops and related software is to support teachers' reflection on student thinking by supporting their close attention to the details of student work. The workshops also support a process of "double reflection" where teachers move from thinking about the way they solve problems to the way students solve problems. The paper is based on preliminary research looking at three types of teachers, those who have a developed sense of reflection, those who have a developing sense of reflection and those who are just starting to reflect on their own and student work.

MEME-INGFUL MATHEMATICS: Crafting Critical Conversations About Mathematics Through Student Meme Analysis *Gregory B Beaudine, University of Iowa; Gregory Benoit, Boston University/ MIT TSL; KATHERINE ELIZABETH HAMMONDS, Auburn University*

With two studies in progress, we are exploring the ways mathematical memes can help students explore societal messages surrounding mathematics and math education. In one study, we work with high school students discussing memes they chose to bring into class. In the other study, we explore instructor driven discussions with preservice teachers intended to push against popular narratives about mathematics and mathematicians. In both cases, we hope to provide students to explore societal messages and their implications and empower teachers engage their students in critical conversations about mathematics.

Models constructed in the context of reforestation *Luis Antonio Muñoz González, Universidad de Guadalajara; Veronica Vargas-Alejo, University of Guadalajara; Luis E Montero-Moguel, The University of Texas at San Antonio*

None

Multilingual International Students' Experiences: From Post Secondary Students *Jihye Hwang, Michigan State University*

I present four multilingual post-secondary international students' mathematics identities in this poster. By mathematics identity, I mean 1) one's understanding of their relationship to mathematics, 2) experiences that constructed the relationship across their time and space, and 3) one's vision for their mathematical possibilities for the future by adapting Norton's (1997) notion of identity.

One Variable, Multiple Meanings: Measuring Response Time in Those with Math Anxiety *CHRISTINE HARTMANN, Utah State University; Olivia Ewing, Utah State University; Leyla Karami Isheqlou, Utah State University; Emmett Speed, Utah State University; Kerry Jordan, Utah State University*

A common measure used in MA research is response time, which is thought to reveal implicit cognitive reactions to stimuli. Two tasks that use this variable are the arithmetic affective priming task (AAPT) and the emotional Stroop (Rubinsten & Tannock, 2010; Rubinsten et al., 2012; Pellicioni et al., 2014). The AAPT is theorized to implicitly measure a person's prior relationship with mathematics (Rubinsten & Tannock, 2010; Rubinsten et al., 2012). The emotional Stroop, a test of attentional bias, shows how a threatening stimulus captures attention (Hopko et al., 2002). These tests' goals are at odds because the AAPT posits that stimuli related to a person's prior experience makes their response time faster, while the emotional Stroop posits that related stimuli will make their response time slower. In this study, I will construct models of data from adults and children to determine which task is a better predictor of MA.

Using Virtual Reality to Explore Magnitude of Numbers *David Kirkland, University of Nevada, Reno; Teruni Lamberg, University of Nevada, Reno*

Virtual Reality was used as an activity in a summer camp to help students understand the magnitude of numbers. The findings revealed that the immersive environment helps students visualize magnitude multiplicatively and make connections between magnitude and context.

Practicing Mathematics Collaboration in STEM Careers *Daniel Heck, Horizon Research, Inc.; Jill V Hamm, UNC Chapel Hill; Jessica Dula, Horizon Research, Inc.*

This poster describes the development of simulations of collaboration on tasks involving algebra and statistics that arise in STEM careers as guided by tenets of deliberate practice. Utilizing three central features of mathematics collaboration—tasks, discourse, and social dynamics—the simulation engages players with targeted challenges. As challenges arise, players have repeated chances to choose among options reflecting varying levels of collaborative functioning; experience consequences for their choices; and receive either implicit or explicit feedback. Analysis of playtesting data from BIPOC teens in a college pathway program indicated that players appreciated receiving feedback and the experience of seeing both positive and negative consequences play out. Two additional design elements emerged and are incorporated into subsequent simulation design: explicitly encouraging players to explore choices they feel are non-productive, to observe consequences; and revealing consequences that would have resulted from non-productive choices when optimal choices are selected.

Queering the Math Gone Wrong *Katryne Dubeau, University of Saskatchewan; Sandra Hall, University of Saskatchewan; Egan J Chernoff, University of Saskatchewan*

This article describes how the integration of LGBTQIA+ culture in a mathematics classroom cannot be judged simply from its use mathematically but also from its impact socially. Through the extension of two famous probability problems, Martin Gardner's Two-Child Problem and the Monty Hall Problem, we demonstrate how each problem appears to integrate the understanding of gender identity mathematically, but only one of them works socially. The goal of this paper is to demonstrate the importance of questioning how we create a queer-inclusive curricula while considering the social issues and boundaries of the LGBTQIA+ community.

Race, Ability, and Mathematical Identity *Camille Griffin, University of Illinois at Urbana-Champaign; Erica N. Mason, University of Illinois, Urbana-Champaign*

Black middle-school students with disabilities often face barriers to developing a positive mathematical identity, an essential educational outcome that contributes to mathematics academic success. This study examines community interactions in a single classroom of mathematics students and teachers at a predominantly Black and Latiné, low-income middle school. We sought to understand what Discourses about race and ability existed in this classroom of students with and without disabilities. Data comprised twenty-four text artifacts, including notes from twelve sixty-minute field observations and analytic memos written after each visit. Preliminary findings will detail classroom community texts, actions, reactions, interactions,

Discourse patterns, and modes of meaning related to mathematical identity construction for Black middle school students with disabilities. The implications of the study results are discussed.

Redesigning Math Intervention Towards Agency and Engagement: Games and Unfinished Learning In Multiplication *Rachel Lambert, University of California Santa Barbara; Tomy Nguyen, University of California Santa Barbara*

While many students have lost opportunity in mathematics to the pandemic, those effects have been compounded for students with low-income backgrounds, multi-lingual learners, and students with disabilities. We seek math intervention that promotes mathematical agency and engagement to support student identities and equity more broadly. In collaboration with our local school district, we are currently piloting a 2-times a week Games Time where all students play non-digital mathematical games (grades 3 and 4 in 2 schools). We present analysis of the surprisingly limited research on non-digital games in math education, including emerging work on supporting multilingual learners through games. During the pilot, we will research the efficacy on math knowledge in the area of multiplication using interviews and assessments. In a collective Design Team, we will redesign based on the experiences of students and teachers.

Reimagining Parental Involvement: Using Families' Funds of Knowledge to Engage all Learners in Mathematics *Enyinnaya Nnaemeka Onyeukwu, Kennesaw State University; Belinda Edwards, Kennesaw State University*

Parental involvement in education has been traditionally defined in the literature by what schools do to attract parents into the building to assist in educating their children (Abrams & Gibbs, 2000).The current study takes a critical perspective of the deficit portrayal of parent and family engagement by listening to the stories and experiences of parents and families via a questionnaire, semi-structured interview, focus group conversations, and exploring the community in which students live; then using what is learned to design cognitive demanding mathematics learning opportunities in the mathematics classroom (Stein & Smith, 1998). This poster presents a qualitative study that examines the concept of parental involvement during their children's middle school experience by exploring parental, family, and community Funds of Knowledge (FoK) and how such knowledge can be used by a middle school mathematics teacher to promote student mathematics learning (Gonzalez et al., 2005).

Relationships Between Cognitive and Affective Factors and Number of Teaching Moves: An Exploratory Study *Sam Rhodes, Georgia Southern University; Montana Smithey, Georgia Southern University; Rick Bryck, Landmark College*

In this session, we report on an exploratory mixed-methods study aimed at developing better understandings of the relationships between various cognitive and affective factors and the number of teaching moves that preservice teachers made when engaging with 6 student work samples. Results of correlational analyses suggest filtering in working memory, subscales of anxiety, facts-first beliefs, the number of math courses PSTs have taken, and scores on learning mathematics for teaching tests, are all significant predictors of the number of teaching moves that preservice teachers make.

Role of Authentic Contexts in Proportional Reasoning *Debasmita Basu, Eugene Lang College of Liberal Arts, The New School; Hong Nguyen, The New School*

Proportional reasoning is a fundamental concept that underpins higher-level mathematical and scientific understanding. However, reasoning proportionally is not intuitive to the students. In this study we present our proportional reasoning task developed on the authentic context of added sugar to explore how the relatable context of added sugar provides students with a meaningful platform to reason proportionally?

Levels of understanding when solving a descriptive statistics problem *Abraham Emmanuel Guerra Rodríguez, Universidad de Guadalajara; Claudia Orozco, Universidad de Guadalajara; Alexander Yakhno, Universidad de Guadalajara*

Descriptive statistic sequence was designed based on Realistic Mathematics Education (RME) to engineering students, involving concepts like mean, median, range, maximum, minimum, standard deviation, and variation, dot plot and box plot. According to RME principle of re invention guidance activities are design to encourage interaction between peers. Data solution will be gather and classified by the levels of understanding based on RME.

Students' Expert-Like Attitudes in Calculus and Introductory Computer Science Courses with Active-Learning Pedagogy *Steve Balady, California State University San Bernardino; Cynthia Taylor, Oberlin College*

Student attitudes are key to retention in the Computer Science major, especially those regarding "weedout" courses such as Calculus. We use two validated instruments, the Computer Attitudes Survey (CAS) and the Mathematics Attitudes and Perceptions Survey (MAPS), to compare student attitudes in Calculus I and CS I active-learning courses with explicit real-world connections. Our analysis includes 109 students for the CAS and 73 for the MAPS. Calculus students started the course with MAPS scores in line with prior work, but unlike prior work we find that overall MAPS scores did not decline during the semester. Women's reported interest in math increased significantly during the semester. Students with prior calculus experience began Calculus with similar overall MAPS scores but much higher reported interest. Our work highlights the importance of instructors demonstrating the usefulness of Calculus.

Students' Pre-Instructional Ideas About Integer Multiplication *Lisa Lamb, San Diego State University; Jessica Pierson Bishop, Texas State University; Carlos Alejandro de Alba, San Diego State University & University of California, San Diego*

Students often learn a rule for multiplying integers. For example, some students have told us that "two negatives make a positive" when multiplying -4 x -3 = __. When asked for an explanation, one student shared, "I just learned a rule. I don't remember why." We became curious about how students, before school-based instruction, solved these types of problems. We share our preliminary findings from a pilot study about three productive ways students reasoned.

Students' Structural Reasoning About Rational Expressions *Daniel Siebert, Brigham Young University; Dana Steinhorst, Karl G Maeser Prep Academy*

Scholars suggest that students' difficulties in making sense of and meaningfully manipulating algebraic expressions is due to their lack of structural reasoning. Research studies have documented that students seldom use expert structural reasoning but give little insight into the nature of students' non-expert structural reasoning. Our study examines how six AP students identify structure, match structures to rules for manipulation, and evaluate their matches as they solve problems involving rational expressions. We found that students were engaged in structural reasoning throughout the hour-long interviews, and that successful solutions were characterized by students identifying structures by breaking expressions into smaller parts based on the highest level of operation (HLO), matching those structures to valid rules, and evaluating the correctness and progress made by the match they constructed.

The Context of TikTok and Student Learning of Mathematics *Laura Brinker Kent, University of Arkansas*

This Brief Report presents the results of a design research project in a sixth-grade mathematics class utilizing personal contexts to motivate student learning of rational number topics. Results indicate that students found success solving problems based in real-world settings by connecting to their personal experiences. One of the contexts included a story about the use of social media platforms. Given the recent controversies over whether specific platforms, such as TikTok, should be banned by various organizations, this report addresses the dilemma faced by mathematics teachers and teacher educators in terms of curricular choices, authentic practices, and political limitations. The student responses indicated the positive impact of a familiar context of TikTok in their performance on a mathematics task related to percents.

The Development of Storybooks Supporting Elementary Students' Math Identity, Executive Function, and Word Problem Solving *Caroline Byrd Hornburg, Virginia Tech; Amanda S. Mayes, Purdue University; Tamika L. McElveen, Purdue University; Sarah R Powell, The University of Texas at Austin; Gigliana Melzi, New York University; Nydia Prishker, St. Thomas Aquinas College; Ninie Asad, Virginia Tech; Isabel Valdivia, Virginia Tech; Ma Bernadette Andres-Salgarino, Santa Clara County Office of Education; Le M. Tran, The University of Texas at Austin; Michael D. Eiland, Purdue University; Sarah H. Eason, Purdue University; Sara A. Schmitt, University of Oregon; David J. Purpura, Purdue University*

One core component of the Our Mathematical World program, co-developed with 3rd-5th grade teachers and students, is a storybook series showcasing PULSE (Pause, Understand and Remember, Lay It Out, Solve, Evaluate), a novel metacognitive problem-solving approach integrating executive function and problem-solving skills. Each book features Black and Latine/x youth engaged in problem solving in community-focused contexts, with math content increasing in difficulty across the series. After initial design of the text and illustrations, books were translated to Spanish by scholars representative of different Latine/x communities. After implementation, both teacher and student feedback indicated students' engagement and enjoyment, and most students indicated that reading the books made them feel like strong math learners. Feedback from multiple implementation phases was also used to further develop and improve the books, in line with the goal to promote students' math identity, executive function, and problem-solving skills, as well as math-specific vocabulary.

The Impact of a Collaborative Intervention on a High School Math Teacher's Positioning of Emergent Bilinguals *Ji Yeong I, iowa state university of science and technology; Coskun Erden, Iowa State University; Jasmine Sourwine, Iowa State University*

This study investigated how a collaborative intervention led to a shift in a high school Algebra I teacher's positioning of Emergent Bilingual (EB) students. The change in the teacher's positioning was measured by recording, transcribing, analyzing, and coding a lesson taught only by the teacher before and after the intervention. The comparison of the pre-intervention lesson and post-intervention lesson revealed an improvement in the ways the teacher positioned her EB students. We observed that the teacher's asset-based discourse increased, and deficit-based discourse decreased between the lessons. The ways the teacher facilitated her lesson also marked improvement with increased utilization of student-led approaches, student collaboration, and richer linguistic resources. The teacher shifted her positioning of her students from followers of directions to contributors and authority figures regarding challenging mathematics tasks

The structure of first degree equations and some misconceptions that don't allow the correct solution. *María Estela Navarro Robles, Universidad Pedagógica Nacional; Adrián Hernández García, UPN*

This paper presents some results of an ongoing research work that aims to identify some misconceptions that do not allow students entering high school to solve certain first degree equations. To obtain the information, the responses of Didactic Sequences were used, which were designed using Marton's Theory of Variation and the algebrization levels proposed by Godino. What is presented here is the preliminary analysis of the results of the first sequence answered by 43 students. In the results that were obtained, it is observed that the number of terms that are on the right side of the equation increases the errors when solving it, this, apparently, is a consequence of the students not understanding the equal sign in a relational way, they only perceive it operationally.

Undergraduate Mathematics Instructors as Cultural Agents *Rachel Tremaine, Colorado State University; Jess Ellis Hagman, Colorado State University*

Faculty can play a role in enhancing equity, diversity, and inclusion (EDI) in undergraduate mathematics by acting as cultural agents who "seek to reduce the gap between students' cultures of origin and the campus culture" (Dee & Daly, 2012, p. 169). In this study, we qualitatively investigate the ways in which university mathematics instructors incorporate notions of cultural agency when asked to describe their roles. Via a detailed thematic analysis according to dimensions of cultural agenthood, we discuss how the themes manifested in six participants' descriptions of their university roles, tensions that arose between the dimensions of cultural agenthood, and introduce the notion of secondary culturally agentic actions.

Using Manipulatives to Foster Mathematical Reasoning: Didactic Variables and Affordances *Doris Jeannotte, UQAM; Claudia Corriveau, Université Laval*

The development of mathematical reasoning is present in most curricula around the world. More specifically, like other curricula around the world (OECD, 2019), Québec curriculum (Gouvernement du Québec, 2002) suggests the use of manipulatives as a way to foster mathematical reasoning in elementary classes. Yet, most research on manipulatives focuses on whether students are more successful in math when using them (e.g. Carbonneau et al (2013)). And, we still have very little information about the use itself and how different teachers' practices shape mathematical reasoning. This poster uses data from the project [anonymized], which aims to address this issue by studying how students use manipulatives to solve different tasks in relation to those practices. More specifically, we will present the analysis of students' mathematical reasoning when solving a word problem involving fractions in relation to different pedagogical choices.

Using Number Talks to Reason about Early Number Concepts in Authentic Ways *Jane M. Keiser, Miami University; Suzanne R. Harper, Miami University; Dana Christine Cox, Miami University*

In this presentation we will share our experiences with number talks in a content course on number and operation for preservice elementary mathematics teachers. We facilitated number talks within a base five number system and observed PSTs utilizing rudimentary strategies that were neither rote nor algorithmic such as skip counting, compensation, equal additions for subtraction, and doubling for multiplication. They readily deconstructed numbers into place values and flexibly utilized mathematical properties when appropriate. Translating the tasks typically used in number talks for elementary students into unfamiliar number systems has had the added benefit of establishing patterns of thinking in adult learners that more authentically match those of

their elementary counterparts.

Using Sunlight to Multiply Positive Numbers *Eric Pandiscio, University of Maine; Justin Dimmel, University of Maine*

This poster reports on the design, creation, and installation of a unique manipulative that engages learners using the natural environment. The SunRule is a dynamic, interactive sculpture that harnesses the rays of the sun to perform multiplication. The sculpture tilts and rotates, which allows beams of sunlight to shine through linear apertures of different lengths. These sunbeams are scaled in proportions that enact multiplication. We also invented a hand-held version that is suitable for classroom use. Multiple photos capture stages in its development, as well as how the device works. Challenge questions are posed relating to what the device can do. We discuss pilot data from paired interviews of preservice teachers interacting with the device. The work began with the question: How can a physical, manipulable tool realize a continuous, scaling representation of multiplication? This is an interdisciplinary collaboration with two sculptors at our university.

How Animal Mathematics Helps Human Mathematics Education Reform *Thomas Ricks, Louisiana State University*

The field of mathematics education is dominated by a human-only mathematics perspective—emphasizing symbols and precision—that disadvantages many—including neurodiverse—students. Numerous studies in animal cognition research, however, demonstrate animals' basic mathematical competence utilizing phylogenetic core systems like subitizing, the approximate magnitude system, and spontaneous simple arithmetic, all without the use of symbols or precision. Further, neurological research reveals many animals share with humans similar neuronal architecture to successfully mathematize down to the level of single number neurons, demonstrating all humans always mathematize like animals (regardless of age or professional training), meaning that below all conscious mathematical thinking, humans' brains mathematize like animals; even while professional mathematicians perform advanced human mathematics, they still manifest the very same underlying neurological signatures as animals. This study proposes concrete steps for improving mathematics education by accepting and adopting the findings about legitimate animal mathematics to augment current symbol-laden, precision-based pedagogy.

Epistemic violence as death decimals: Advancing Black logic in mathematics education research *Rolonda L. Payne, University of Maryland, College Park; Blake O'Neal Turner, University of Maryland*

Antiblack epistemic violence in theoretical interpretations creates spatial imaginaries through "discourses, images, and texts that tell a story of Blackness as a problem, non-human, and placeless" (Jenkins, 2021, p. 119). Particularly in mathematics education research, scholars have been complicit in (re)producing antiblack spatial imaginaries of Black doers and learners by using and producing research to invalidate Black students' ability to learn and do mathematics. While critical scholars have written about how research functions as an antiblack spatial imaginary, few studies have challenged how quantitative researchers engage in antiBlackness and epistemic violence in mathematics education. Thus, we ask, what antiblack spatial imaginaries about Black doers and learners are sustained within quantitative mathematics education research? This study extends scholarship problematizing gap gazing in mathematics education by providing tangible examples of the frameworks, methods, and language employed by scholars whose work is centered in or tangential to mathematics education.

Math Teachers Learning to Be Culturally Responsive *Jon Eston Brown, University of Arizona*

Although research has shown many ways teachers have successfully implemented culturally responsive math teaching (CRMT) practices, we need to know more about how teachers take up these practices or why they decide not to. Some teachers sometimes do not take up this work because they fear losing their job. However, some teachers want to see themselves and be seen by others as culturally responsive but still feel they have work to do. To understand how and why teachers engage in CRMT practice, we need to know more about how they identify with, make sense of, and own cultural responsiveness in math class. Using exploratory case study methods, I interviewed two elementary and two secondary teachers as they reflected on their culturally responsive practices. This poster presentation will report the interviews using a CRMT identity framework adapted from Wenger's (1998) social ecology of identity.

051. Geometry and Student Reasoning

Curriculum, Assessment, and Related Topics
Research Report Session
4:00 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Investigating Student's Understanding of the Area and Perimeter of Rectangles Through Problem-Solving *Kehinde Jegede, Illinois State University*

This study is an investigation of 4th Grade students' understanding of the area and perimeter of rectangles through problem-solving. Data instruments included problem-solving tasks and interview questions. Results showed that students needed help understanding the concept of the area and perimeter of rectangles.

Mental Operations for Altering Length and Preserving Angularity *Hamilton Hardison, Texas State University*

Angularity is a persistent quantity throughout K–12+ school mathematics, and many studies have shown that individuals often conflate angularity with linear attributes (e.g., the length of an angle model's sides). However, few (if any) studies have examined the productive ways in which students might reason about angularity while considering attending to linear attributes like side lengths. Leveraging data from a yearlong teaching experiment with ninth-grade students, I present four mental operations that students indicated for altering lengths while preserving angularity. Additionally, I consider implications of these mental operations for teaching and research.

052. Working Group: Critical Disability Studies in Mathematics Education

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Board Room
Participant:

Critical Disability Studies in Mathematics Education *Alison Mirin, University of Arizona; Paulo Tan, Johns Hopkins University; Cathery Yeh, Chapman University; Anette Bagger, Örebro University; Amber Grace Candela, University of Missouri - St. Louis; Jessica H. Hunt, North Carolina State University; Katherine Elizabeth Lewis, University of Washington; Alexis Padilla, University of New Mexico; Kai Rands, Independent Researecher; James Richard Sheldon, University of Arizona; Kathryn R. Westby, Michigan State University*

In continuing with past working groups on research at the intersections of disability studies and mathematics education, this working group met for PME-NA 44 centering on Disability Justice as a framework to share new developments from group members, to make new connections, and work toward future

directions. Over the course of the three days, we built community, broke up into subgroups, and planned for next steps beyond the bounds of the working group meetings.

053. Working Group: Aesthetic and Affective Dimensions of Mathematics Learning

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participant:

Aesthetic and Affective Dimensions of Mathematics Learning
Leslie Dietiker, Boston University; Meghan Riling, Vanderbilt University; V. Rani Satyam, Virginia Commonwealth University

Students' aesthetic and affective responses are interrelated and both central to mathematics learning. This working group will continue the conversation begun in 2022 to explore the connection between the affective and aesthetic dimensions of mathematics education, and how connecting these dimensions can help to understand how students experience mathematics. The goals of this working group are to evaluate the state of the field, build shared terms, and identify research questions for further inquiry.

054. Working Group: Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Emerald B
Participant:

Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning *Karen Zwanch, Oklahoma State University; Sarah Kerrigan, George Fox University; Beth L. MacDonald, Illinois State University; Steven Boyce, Portland State University; Joseph Antonides, Virginia Tech; Cody Harrington, University of Colorado Denver; Cameron Byerley, Colorado State University; Erik S Tillema, Indiana University*

Units construction and coordination is a powerful tool for modeling mathematical thinking about whole numbers and fractions. This working group will support collaboration of mathematics educators to make connections between foundational contexts for units coordination, and emerging contexts such as combinatorial reasoning, mathematical knowledge for teaching, and communicating mathematical ideas in our daily lives.

055. Working Group: Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participant:

Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices *Gil Schwarts, University of Michigan; Pat G Herbst, University of Michigan; Michelle Cirillo, University of Delaware; Alison Castro Superfine, University of Illinois at Chicago; Amy Dunning, University of Illinois Springfield; Margaret Walton, University of Maryland College Park; Hala Ghousseini, University of Wisconsin-Madison*

The goal of this new working group is to consider the subject-specific nature of mathematics teachers' practices when they anticipate and facilitate whole-class discussions. This could include, for example, how teachers' practices relate to the lesson's tasks, students' prior knowledge, or the mathematical goals of a lesson. In the inaugural meeting of this group, we aim to develop a shared language to discuss subject-specificity in mathematics education. This will be accomplished by sharing work, analyzing artifacts, and identifying important future research directions in this area. We hope to establish connections among the working group participants for future collaborations.

056. Research Colloquium: Models and Modeling Perspectives

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Emerald D
Participant:

Research Colloquium: Models and Modeling Perspectives
Corey Brady, Southern Methodist University; Hyunyi Jung, University of Florida; Angeles Dominguez, Tecnologico de Monterrey; Jeffrey McLean, University of North Carolina Chapel Hill; Aran Glancy, Purdue University

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 continue our work within the Research Colloquium format. Building upon our work in the 2021 Colloquium, we aim to continue to articulate a coherent North-American voice in the international modeling community. In particular, we aim to explore opportunities for collaboration and communication about distinctively Pan-American perspectives on the topics of Interdisciplinarity in Modeling, Modeling and Citizen Science and Culturally Sustaining approaches to Mathematical Modeling

057. Working Group:Open Science Working Group: Data Management and Sharing

Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Grand 2
Participant:

Open Science Working Group: Data Management and Sharing
Gizem Solmaz-Ratzlaff, Florida State University; Charity Buntin, Florida State University; Robert Schoen, Florida State University

2023 has been declared the "Year of Open Science" by the White House Office of Science and Technology Policy (OSTP). National Aeronautics and Space Administration (NASA) declared that 2023 will be a year to "celebrate the benefits and successes of open science and to inspire more scientists to adopt open science (OS) practices" and they introduced the Transform to Open Science (TOPS) initiative, which will take 5 years, with the goal of accelerating open science practices. So, how do these principles of open science affect mathematical education, and educational research as a whole? And what does the future of mathematical education research look like? Come spend three days with us to answer these questions and let us share some of our lessons with you. You can also bring your own data so that we can start working with you to plan your OS journey.

058. Working Group: Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Bas

Working Groups and Research Colloquia
Working Group

5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Grand 3
Participant:

Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Base *Julien Corven, Illinois State University; Joseph DiNapoli, Montclair State University; Kim Johnson, West Chester University of PA; Valerie Long, Indiana University of Pennsylvania; Dana Olanoff, Widener University; Jennifer M. Tobias, Illinois State University*

The goals of the working group on Mathematics Curriculum Recommendations for Elementary Teacher Preparation are: (1) to develop a professional knowledge base for preparing elementary teachers of mathematics through conducting and disseminating research in forums accessible to researchers and mathematics teacher educators across North America, (2) to build from prior work to propose specific, research-based recommendations for the curriculum of elementary mathematics teacher preparation (content and methods courses) that can be adopted by teacher preparation programs, accreditation bodies, and state and federal departments of education, and (3) to create a supportive community of researchers that promotes effective collaboration across institutions.

059. Working Group: Teaching and learning with data investigation: Toward a socially and environmentally just world
Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participant:

Teaching and learning with data investigation: Toward a socially and environmentally just world *Sunghwan Byun, North Carolina State University; Travis Weiland, University of Houston; Susan Cannon, University of Georgia; Anthony Fernandes, University of North Carolina - Charlotte; Emmanuel Nti-Asante, University of Massachusetts, Dartmouth; Franziska Peterson, University of Maine; Karoline Smucker, Eastern Oregon University; Kingsley Y Adamoah, Middle Tennessee State University; Christopher Engledowl, Independent Researcher*

We continue the past four years of the working group on teaching and learning data investigation by 1) sustaining the ongoing cross-institutional collaboration to develop frameworks and resources for supporting mathematics educators in facilitating data investigations and 2) advancing our discussions on designing data investigations with an eye towards taking action to promote socially and environmentally just outcomes. Based on the role of context in teaching and learning with data, we organize this working group into three themes: the context of mathematics teacher preparation, the context of cross-disciplinary work, and the context of research and collaboration.

060. Working Group: The Power of Computational Thinking in Mathematics and Data Science Education
Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Paradise A
Participant:

The Power of Computational Thinking in Mathematics and Data Science Education *Zuhal Yilmaz, Louisiana State University; Terrie Galanti, University of North Florida; Brian R Lawler, Kennesaw State University; Fernando Alegre, Louisiana State University*

With the increasing emphasis on computational thinking (CT) as a critical skill in K–12 teaching and learning, the STEM education community has an exciting opportunity to broaden its conceptualization of mathematics as a school subject. This new working group will explore the potential for CT to engage all mathematics learners by leveraging the power of computing, modeling, and simulations. Our goal is to build a collaborative community of mathematics, computer science, and data science educators to explore the potential for deeper mathematics and data science learning with CT integration. We will identify synergies across disciplines and themes for future research.

061. Working Group: Approximations of Practice and Equity: Surveying the Spaces
Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Treasures A
Participant:

Approximations of Practice and Equity: Surveying the Spaces *Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Carrie W Lee, East Carolina University; Liza Bondurant, Mississippi State University; Heather Howell, Educational Testing Service*

After three years of meeting as a working group at PME-NA, we will be editing a book on how several models of approximations of practice support or hinder the creation of equitable mathematics learning and thinking spaces. Participants and working group leaders will serve as critical friends as we use a fishbowl format and small groups to provide spaces for refinement and challenge of participants' work. Participants will leave with a network of thought partners and a draft chapter.

062. Working Group: Conceptualizing the Role of Technology in Equitable Mathematics Classrooms
Working Groups and Research Colloquia
Working Group
5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participant:

Conceptualizing the Role of Technology in Equitable Mathematics Classrooms *Nicholas Witt, Western Michigan University; Kayla Chandler, East Carolina University; Charity Cayton, East Carolina University; Jennifer M. Suh, George Mason University; Allison McCulloch, University of North Carolina at Charlotte; Karen Hollebrands, NC State; Jon D. Davis, jon.davis@wmich.edu*

This new working group will examine ways in which technology can be leveraged as a tool to support equitable opportunities to learn for every mathematics student. We plan to engage participants in discussion regarding current technology- and equity-centered frameworks that are used, develop technologically enhanced tasks to support equity, and determine a series of next steps toward furthering the goal of better understanding and bolstering existing technology-centered frameworks to be more aligned with equitable teaching. The group aims to provide the community with a welcoming space for diverse voices to generate a line of research specifically focused on bridging equity-centered frameworks with technology-centered frameworks.

063. Working Group: Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through Our Stories
Working Groups and Research Colloquia
Working Group

5:15 to 6:20 pm
Atlantis Hotel and Casino Conference Center: Treasures C
Participant:

Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through our Stories *Weverton Ataide Pinheiro, Texas Tech University; Jennifer Hall, Monash University; Katrina Piatek-Jimenez, Central Michigan University; Amanda Provost, Montclair State University; Ana DIas, Central Michigan University; Brent Jackson, WestEd*

Research on gender and sexuality continues to be of great importance to support all students in the teaching and learning of mathematics. The goal of this year's Gender and Sexuality in Mathematics Education Working Group is to build a repertoire of how its members became involved in doing gender and sexuality research, what challenges and supports we have experienced, and what stories we have told through our research. To achieve our goal, we will collect data before, during, and after the conference. During PME-NA 2023, we will collect data through focus group interviews. We aim to learn from one another about our own personal experiences and the work that has been done in gender and sexuality research. We will continue this work after PME-NA 2023 and present our findings at PME-NA 2024.

064. Graduate Student Social
PMENA
Graduate Student Event
6:30 to 8:00 pm
Atlantis Hotel and Casino Conference Center: Atlantis Sky Bridge

TUESDAY, OCTOBER, 3

065. Breakfast
PMENA
Special Event
7:00 to 8:30 am
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E

066. Social Justice and Voice
Equity and Justice
Brief Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Widening the Epistemological Window *Dana Christine Cox, Miami University; Suzanne R. Harper, Miami University; Jane M. Keiser, Miami University*

We reflect on the ways in which our methodological choices influence the diversity of voices that contribute to what we know about mathematics and mathematical learning. Our field needs more empathetic methodologies that welcome new voices and honor more diverse forms of expertise in the process of knowledge generation. Embracing new knowledge generators and methodologies would implicate our current perceptions of expertise and open the door to consider how white supremacy and power, in general, permeate status in our field.

"It was meaningful because this is now my home": Locality-identity and social justice mathematics *Stephen Caviness, Syracuse University; Nicole L. Fonger, Syracuse University; Karley Violet Voyias, Syracuse University; Emmy Wanditi Njue, Syracuse University; Brian Odiwuor, Syracuse University; Waleed Ashraf Raja, Syracuse University*

Designing for and enacting social justice mathematics tasks is one approach to supporting students' meaningful mathematics learning. We share our design conjectures that were developed out of a theoretically grounded, empirically based investigation of undergraduate students' experiences of a social justice mathematics lab. We engaged an interdisciplinary lens of historically responsive literacy and identity in both the lab design and analyses of student responses. We have conducted four cycles of action research that contribute to a broader program of design-based research. Based on thematic analyses of qualitative data, we introduce the construct of locality-identity as a main theme in the data. Attending to locality-identity in the design of this lab increased student engagement with mathematics by making mathematics relevant and authentic.

Understanding The Intersections of Student Belonging To Create Inclusive Environments: A Narrative Inquiry Approach *Darolyn A. Flaggs, Kennesaw State University; Alison Hedrick, Kennesaw State University; Wendy Sanchez, Kennesaw State University; Belinda Edwards, Kennesaw State University; Amy Hillen, Kennesaw State University*

In this qualitative research study, we used a narrative inquiry approach to reveal the unique experiences of belonging amongst preservice mathematics teachers. We explore the intersections of student belonging within and across participants from marginalized populations. We then discuss four emerging themes from our initial interviews. Reflecting on these stories, we sought to gain a deeper understanding of how mathematics teacher educators could and should cultivate inclusive environments. We conclude with recommendations for faculty to create environments supportive of student belonging and engagement.

What Comes Before a Theoretical Framework? The Aesthetic Dimension of Theorizing in Mathematics Education Research *Brady A Tyburski, Michigan State University*

There is plenty written on the roles that theoretical frameworks should play once they are already crafted; however, there is much less guidance on how scholars—especially emerging scholars—might construct a theoretical framework that serves these roles. When guidance is provided, it focuses on issues of epistemology and ontology. In this brief theoretical report, I emphasize the importance of the often-ignored aesthetic (axiological) dimension of theorizing. I first argue that aesthetics cannot be separated from our everyday behaviors and choices and therefore our research practice. I then share my own experience about how reflecting on my personal aesthetics allowed me to craft a framework that allows me to bring my whole self—worldviews and all—into my research. My hope is that by sharing my story, I can support other emerging scholars in bringing their ways of being, thinking, and feeling into their research.

067. Curriculum Decision Making
Curriculum, Assessment, and Related Topics
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

Dilating Perspectives: A Comparison of Teacher and Student Facing Texts on a Unit on Similarity *Soobin Jeon, University of Michigan; Pat G Herbst, University of Michigan*

Mathematics curricula are often the primary resource used in the teaching and learning of mathematics. Yet, there seems to be a discrepancy between the materials used by teachers and students in the mathematics curricula (e.g., more variety in the semiotic choices in text provided for teachers than for students). This paper illustrates a way to compare the curricular language written for the teacher and the student. Drawing on the social semiotic theory known as systemic functional linguistics, we examine what meaning potentials can be realized through the exchange of semiotic systems in mathematical text. Examining a Unit on Similarity in an online mathematics curriculum widely used in

the United States, the paper explores how the semiotic systems in text presented for the teacher and student may impact their learning processes and pose challenges in the instructional exchange between teacher and student.

Examining the Validity of a Generative Education Pattern Based Question *Karen Leary Duseau, University of Massachusetts, Dartmouth*

Assessment is a topic of concern to all stakeholders in our educational system. Pattern Based Questions are an assessment tool which is an alternative to the standardized assessment tool, and they are based on generative learning pedagogy, which shows promise in engaging all learners and usefulness in teaching and learning but validity has not yet been empirically established. Pattern-based questions seek to provide a qualitative expression of student understanding. It is the purpose of this research to empirically explore a correspondence between student response patterns and the students' expressed ways of thinking using a grounded theory approach and clinical interviews. Findings include rich descriptions of participants' ways of thinking about equivalent fractions as written in the PBQ. One response pattern was clearly differentiated from the others. Future research is discussed.

068. Reasoning

Curriculum, Assessment, and Related Topics
Brief Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

A modified depth of knowledge framework for word problems *Jonathan David Bostic, Bowling Green State University; Timothy Donald Folger, Bowling Green State University; Kristin Koskey, Drexel University; Gabriel Matney, Bowling Green State University; Toni Ann Sondergeld, Drexel University; Gregory Ethan Stone, MetriKs Amerique LLC*

Depth-of-knowledge (DOK) is a means to communicate the cognitive demand of tasks and is often used to categorize assessment items. Webb's (2002) framework has been applied across content areas. The aim of this two-phase iterative study was to modify Webb's DOK framework for word problems. Through work with school partners, this iterative design-research based study provides supportive evidence for a modified DOK framework reflecting levels of complexity in word problems. The resulting modified DOK framework presents an opportunity for mathematics educators to reflect on various aspects of cognitive complexity.

An International Comparison of Performance on TIMSS Elementary Mathematics Items with Potential for Covariational Reasoning *Julien Corven, Illinois State University; Teo Paoletti, University of Delaware; Allison L. Gantt, University of Delaware*

In our prior research, we identified items from the publicly released TIMSS 2011 assessments that had potential for students to employ covariational reasoning as a solution strategy. In this report, we explore the extent to which fourth-grade students' performance on such items in mathematics differed among 26 nations. Using multi-level modeling, we conclude that, in general, fourth-grade students found mathematics items for which covariational reasoning was a viable strategy to be more challenging than items for which we could not identify a possible covariational reasoning strategy. However, three countries (Finland, Sweden, and the Netherlands) did not follow this pattern.

069. Research Expectations and Reviewing for JRME

Mathematical Processes and Practices
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Emerald D
Participants:

Research Expectations for Mathematics Education Faculty in US Institutions of Higher Education *Blake E Peterson, Brigham Young University; Keith R. Leatham, Brigham Young University; Steven R. Williams, Brigham Young University*

This paper reports the results of a survey of 404 US mathematics education faculty regarding the research expectations for obtaining tenure. Survey questions asked about expected numbers of publications per year, how much different types of publications (e.g., journal articles, book chapters) and scholarly activities (e.g., giving presentations, obtaining funding) were valued. Statistical analyses were used to examine differences in these results across three demographic characteristics (institution type, research commitment, department). We found statistically significant differences related to each of these variables. Research expectations varied substantially across institution type. For example, the average expected number of yearly publications was 2.23, 1.63, and .99 papers at R1, R2, and Other institutions respectively. By contrast, research expectations seldom varied by department.

Reviewing for and submitting to the Journal for Research in Mathematics Education *Pat G Herbst, University of Michigan*

In this session I will describe the role that JRME plays in our research field and how scholars can benefit from reviewing, submitting, and publishing in the Journal. The session will serve for to answer questions from prospective authors and reviewers and also for experienced authors and reviewers to share their experiences with others.

070. Student Perspectives in Learning Math

Mathematical Knowledge for Teaching
Brief Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Considering New Measures of Children's and Parents' Math Attitudes and Their Associations with Math Performance *Caroline Byrd Hornburg, Virginia Tech; Jisun Kim, Virginia Tech; Katherine E. D'Ercole, Virginia Tech; Christine A. Berry, Virginia Tech*

Children's math anxiety is an important predictor of math performance; however, children's other math attitudes as well as parents' math attitudes have not often been considered in tandem with math anxiety. It may be that other attitudes beyond typical measures of anxiety for children and parents play a unique role. This study examined relations among children's math attitudes (i.e., math-specific anxiety, avoidance, competence, interest, and value), parents' math attitudes (i.e., math anxiety, math teaching attitudes) and children's math performance. Children (N = 59; 2nd-4th graders; 35 girls, 24 boys) and their parents completed surveys, and children solved word problems. Results highlighted correlations among most math attitudes and performance in the expected directions; however, it was a new construct of parents' math teaching attitudes that was significantly correlated with child performance rather than parents' math anxiety.

"Math is…": The musings of young adolescents pre- and post-Covid *Heidi J Higgins, University of North Carolina Wilmington; Shelby Morge, University of North Carolina Wilmington*

Posing the prompt "Math is…." to middle school students can result in a range of statements such as, "math is essential but essential isn't always fun" or "Math is fun when I understand it

but think of it as more of a chore" or " Math is the key to open your mind to all sorts of problems." This brief report will describe middle school students' perceptions of math prior to and after Covid. Data was collected as a quick write which was posed to students in their math class. We will describe trends across two data sets related to math content and feelings about math. We make suggestions for what this means for middle school mathematics teachers and how to increase student interest and motivation.

Math Their Way: Exploring Child-Initiated Mathematics *Mari Altshuler, University of Illinois at Urbana-Champaign*

This interview-based study explored early elementary students' perceptions of mathematics through the lens of the math that they opted to do. It asked, how do the mathematics activities that children initiate compare to those in which they engage in school? Results showed that when young students seized agency and engaged in math on their own terms, their activities were more expansive and creative than in school and they found these activities pleasurable.

Piquing student interests: Using voting to engage students in mathematics *Lino Guajardo, Texas State University; Holly Zolt, Texas State University; Hiroko Kawaguchi Warshauer, Texas State University; max Warshauer, 1951*

This study examines the design and implementation of a problem-solving task intended to motivate students to explore mathematics in unlikely places and investigate the students' perception of the task. The task given to 19 middle school students centered on Voting. Four voting methods provided context for determining outcomes using mathematics involving proportional reasoning, fractions, ratios, and logic. The task design provided clues for how 60 children voted for 4 choices of candy. Student work and surveys were analyzed qualitatively. Student work elicited multiple strategies using both ratios and algebraic thinking. Student perceptions were examined for mathematical, non-mathematical, and real-world perspectives. Findings indicate students see mathematics embedded in counting votes and that fairness in voting is not easily achievable. They then considered ways to optimize satisfaction among voters.

071. The role of Curriculum in Supporting Learning

Curriculum, Assessment, and Related Topics

Brief Research Report Session

8:00 to 9:15 am

Atlantis Hotel and Casino Conference Center: Grand 2

Examine the role of curriculum in supporting student learning.

Participants:

Curriculum as Story: Characterizing the Aesthetic Qualities of a Mathematics Lesson *Erin Pomponio, Montclair State University*

This work takes on an aesthetic lens to analyze one fifth-grade mathematics lesson with the intent of characterizing the text's narrative qualities using a story framework. A synthesized structure of the aesthetic qualities of the story is presented. The value of considering and prioritizing aesthetic experience in curriculum through storytelling and its potential impact on learner engagement is discussed.

Rethinking mathematics curricular coherence across elementary teachers' multiple curricular materials and multiple professional obligations *Kristin Doherty, Michigan State University; Nan Jiang, University of Arizona; Marcy B Wood, University of Arizona*

A coherent curriculum is important for supporting students' learning of mathematics. While a single teacher textbook is created with coherence in mind, teachers are now using multiple materials to plan and teach mathematics. Additionally, teachers are held accountable to multiple professional obligations that can also affect coherence. This study reports on findings from interviews with nine elementary teachers about how they are conceptualizing mathematics curricular coherence across multiple curricular materials and multiple professional obligations.

Analysis of Middle School Mathematics Textbooks to Uncover the Presence of Social Issue Contexts *Debasmita Basu, Eugene Lang College of Liberal Arts, The New School; Madhavi Vishnubhotla, Montclair State University; Annie Hua, The New School*

When mathematics is taught in the context of social issues, it provides students with mathematical skills to analyze and think critically about the world. Using the theoretical perspective of Opportunity to Learn, in this study we analyzed five middle school mathematics textbooks to investigate the extent to which school mathematics textbooks incorporate contextualized situations related to social issues. Findings of the study suggest that there are an overwhelming number of decontextualized problems in every textbook. The contextualized problems covered a range of categories, but a very few of them were on social issues that could offer students the chance to engage in critical thinking.

Lessons Learned from the Co-Design Process of a Student Centered, Middle Grades Mathematics Curriculum *Peter Karanevich, CU Boulder*

A teacher solidarity co-design framework was used to inform the co-design of a middle school math curriculum involving teachers, mathematics education researchers and graduate students. Incorporating teacher and student voice, positioning teachers as experts in their classrooms, and using feedback cycles were all methods used to create the mathematics content and context. Results showed that there can be tension around what content to emphasize in the co-design process and that students tend to engage and converse more when the context is familiar to them which can cause lessons to take longer than originally intended. Groups pursuing a co-design process should maintain open communication between members, keep the process iterative and be open to modifications so that expertise can be highlighted, ultimately culminating in experiences that are meaningful for students.

072. Supporting Pre-service Teacher Learning

Professional Development/ In-Service Teacher Education

Brief Research Report Session

8:00 to 9:15 am

Atlantis Hotel and Casino Conference Center: Grand 3

Participants:

Bridging Co-Teaching and Methods Coursework Through Site-Based Learning Collaboratives *Alyssa Sayavedra, California State University, Monterey Bay*

Nationally, there is a gap between the ambitious and equity-oriented mathematics pedagogies that pre-service teachers may learn in their university methods classes and the more traditional instruction that they typically try in their field placements (Horn & Campbell, 2015). This pilot study seeks to bridge this gap through a novel teacher learning collaborative with teacher candidates and cooperating teachers together, focused on the high-leverage practice of leading a discussion (Shaughnessy et al., 2021). Baseline findings were grim: mathematics "discussions" in teaching placements rarely included multiple student strategies or moved beyond "show and tell." However, the first learning cycle of the collaborative expanded teacher learning opportunities: one teacher candidate tried three dot talks and elicited and connected many strategies. Discussing her teaching video supported teachers' rich reflection on Agency, Ownership and Identity (Schoenfeld, 2020; 2022).

Centering Students' Assets in Early Elementary Mathematics: Teachers' Beliefs About Mathematics, Language, and Emergent Bilinguals *Brittany Caldwell, Vanderbilt University*

This study explored early grades teachers' professed beliefs about mathematics, language, and Emergent Bilinguals (EBs). The research question was: what are early grades teachers' professed beliefs about mathematics, language, student thinking, students' out-of-school experiences, and students' home and everyday language practices, in particular for EBs? The teachers in this study displayed varying degrees of asset-based responses (74%-100%) to the survey and discussed beliefs related to 1) students' backgrounds and experiences, 2) students' everyday and home languages, 3) mathematics vocabulary, and 4) supporting EBs. During interviews, teachers described their beliefs about students' assets (experiences and home/everyday language) in ways that aligned with 1) allowing students' assets in the classroom or 2) drawing on students' assets to support mathematics learning.

Project CRAFTeD: An Adapted Lesson Study For Pre-Service Mathematics Teachers *Michael S Meagher, Brooklyn College - CUNY; Asli Özgün-Koca, Wayne State University; Michael Todd Edwards, Miami University of Ohio; Christopher Nazelli, Wayne State University*

Reports on a research project designed to implement an adapted Lesson Study cycle whereby preservice mathematics teachers co-create a lesson with an experienced expert instructor and observe the instructor teach the lesson. Results show development in the preservice teachers' attention to elements of planning such as anticipation and pedagogical choices during instruction.

Prospective Elementary School Teachers' Perceptions of STEM Thinking and their Orientations for STEM Thinking *Marta T. Magiera, Marquette University; Mohammad Saleh Al-younes, Marquette University*

Drawing on a concept-map methodology, we investigated how 18 prospective elementary teachers (PSTs) conceptualize STEM thinking as habits of mind shared across STEM domains in the context of problem-solving prior to explicit classroom discussions about STEM thinking. A 28-question, 5-point Likert-scale survey was used to explore PSTs' orientations for STEM thinking in elementary school mathematics classrooms. Our results show that PSTs come to teacher education with many general ideas about STEM thinking in problem-solving contexts but do not necessarily see STEM ways of thinking as common habits of mind supporting problem-solving across STEM domains. Our data also reveals that PSTs come with positive overall STEM thinking orientations, but they tend to be hesitant to think about themselves as future teachers who foster STEM thinking in their elementary school classrooms. We discuss implications for teacher preparation.

073. Curriculum and Intersection of Social Justice

Equity and Justice
Brief Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participants:

Modules that Intersect Noticing and Equity: Passing an Inflection Point with Elementary Preservice Teachers *Molly Fisher, University of Kentucky; Walker Mask, University of Kentucky; Cindy Jong, University of Kentucky; Jonathan Norris Thomas, University of Kentucky*

Recent developments in mathematics education research seek to better incorporate knowledge of equity into teacher education, in particular practical ways that teachers can promote equity in the mathematics classroom. This paper discusses the results of using a partial versus full implementation of a set of microlearning modules designed to introduce preservice mathematics teachers to equitable noticing in elementary mathematics teaching. The results of ANCOVA analyses on the scores of a video-based assessment instrument relating to professional noticing and themes of equity in a classroom moment indicate that for these modules, there are mean gains when comparing the full to partial implementations, indicating that using more of the modules leads to a deeper understanding of the introductory equity and professional noticing frameworks used to frame the modules and this study.

Balance and Integration of Content within Early Childhood and Elementary Social Justice Mathematics Lessons *Bailey Anne Kaufman-Ridout, Fordham University; Meghan Riling, Vanderbilt University; Kayla Nguyen, Vanderbilt University*

With the push to incorporate the Teaching Mathematics for Social Justice framework (Gutstein, 2006) and Learning for Justice (2016) standards into early childhood and elementary settings, there is an increasing call for published social justice mathematics lessons (SJMLs) for our youngest learners. This study examines how mathematical and social justice content is supported within early childhood and elementary social justice mathematics lessons (SJMLs). We interpret three SJMLs designed for Pre-Kindergarten through second grade and analyze the implicit and explicit questions within them. Findings indicate that while published SJMLs are greatly needed in the early childhood and elementary classroom, there are inconsistencies with the structure, integration, and balance of mathematical and social justice content that makes up these lessons.

Deciding Between Fair and Not Fair: Emerging Models of Proportional Reasoning *Ayse Ozturk, The Ohio State University, Newark*

This study describes the applications of emerging models of proportional reasoning from students who engaged in a problem-solving process resembling a real-life context and communicated their reasoning while considering the notion of fairness. Teaching experiment methodology guided the collection of the study's data from problem-solving sessions at a math camp for secondary students. Analysis revealed that the students' referential-level model, which represented the ideal situation for any team, inspired students to develop a model based on the steepness of line segments at the formal level. The need to justify why their models made mathematical sense led the students to refine their solutions and kept all class members engaged in the activity.

Do Math Museums Provide (E)Quality STEM Experiences? *Kyunghoon Son, Boston College; Lillie R. Albert, Boston College*

The purpose of this study is to analyze the composition of STEM elements in the exhibits of mathematics museums, and to examine whether the museums are delivering a balanced and comprehensive mathematics learning experience to students. To overcome an equity issue, South Korea established twenty math museums with purpose of providing equitable access to students in rural areas. Eight mathematics museums' exhibits, including MoMath and MathAlive as representative models of math museums, were classified and compared. MoMath's exhibits overall provide a comprehensive experience to student by considering all integrated STEM elements, whereas it was revealed that the exhibits of Korean math museums are skewed towards a small number of specific elements.

074. Parents and Math Learning

Mathematical Processes and Practices
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Paradise A

075. Pre-service and In-service Teaching Practice

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Exploring Changes in Mathematics Teacher Practice from Professional Development Rooted in the TRU Framework *Victoria Bonaccorso, Montclair State University; Helene Leonard, Montclair State University; Amy L Daniel, Montclair State University; Youngjun Kim, Montclair State University; Joseph DiNapoli, Montclair State University*

Equitable and accessible classrooms should engage all learners with mathematics content in meaningful ways. However, practicing teachers need support from professional development (PD) to learn to teach with this ambitious vision. Informed by sociocultural theory, we employed an evaluative case study methodology to describe, explain, and assess the experiences of one middle school mathematics teacher's longitudinal participation in a continuous PD model focused on the Teaching for Robust Understanding (TRU) framework. Based on classroom observations and interview data, our findings show evidence of TRU-aligned changes in teaching practice as a result of years of participation in the PD model. These findings strengthen the call for PD programs focused on equity and access and suggest design elements of such PD to support effectiveness.

How Different Colors are Related to Preservice Teachers' Math Self-efficacy and Professional Identity *Ji-Won Son, The State University of New York at Buffalo; Mary DiCioccio, University at Buffalo*

This qualitative study examines 20 elementary and 13 secondary preservice teachers' reasoning for becoming a teacher as well as their math anxiety and attitudes towards math. This study also explores how elementary and secondary perservice teachers' choice of color with math is related to their professional identify and mathematics self-efficacy. Inductive content analysis was used to analyze elementary and secondary preservice teachers' reasoning and their choice of color. It was found that both elementary and secondary teachers cite altruistic reasons as the main reason for pursuing a career in teaching, although secondary teachers cite their preference for math as a reason for becoming a teacher more than elementary teachers. When asked to associate a color with math and provide a reason, the most frequent combination of color and reason was red because that was the color folder they used growing up. Despite previous research showing that red has a connotation of danger, the participants that chose red for the reason of it being the color math folder they had growing up did not share negative feelings towards mathematics.

Pre-service Elementary Teachers' Framing of Mathematical Discussion after Problem-Solving Through Mursion™ Simulation *Sezai Kocabas, Purdue University; Signe Kastberg, Purdue University; Melva R Grant, Old Dominion University; Hanan Alyami, Purdue Fort Wayne*

Research on pre-service teachers' discussion practices has focused on decompositions of practice into subskills, while acknowledging the importance of the role of context, identity, and relationships between interactive moves. We focused on 66 elementary preservice teachers' (PSTs') framing-launching moves in discussions after problem-solving in a MursionTM custom simulation. PSTs used five moves: gathering information about student processes, focusing on problem features, task and non-task oriented social interactions, and partner talk. Empirical findings of PSTs' intentions and tacit actions coupled with study findings of the diversity in PSTs' framing moves, highlight the complexity of teacher decision making involved in discussion subsills such as framing. We argue that PSTs' framing moves are motivated by an array of intentions including the mathematics aims of discussions.

Reliability and Validity of Documenting Elementary Pre-service Teachers' Performance in a Teaching Simulation *Daniel Heck, Horizon Research, Inc.; Evelyn M Gordon, Horizon Research, Inc.; Meghan Shaughnessy, Boston University; Tim Boerst, UM; Nicole Garcia, University of Michigan - Ann Arbor*

Simulations for Learning and Assessing in Teacher Education (SimulaTE) is studying teaching simulations as formative assessments of pre-service teachers' (PST) practice of eliciting and interpreting students' mathematical thinking. Training and protocols that promote reliability and validity of the simulations as formative assessments will enhance their effectiveness and generalizability. Teacher educators who use the simulations document each PST's performance to generate relevant feedback for the PST. As part of a coordinated set of validity studies, six mathematics educators were trained on the documentation protocol. Consistency of documentation within the group and with the simulation developers' judgments provided evidence supporting reliability and validity of the documentation protocol.

076. Different Approaches to Engaging Learners
Mathematical Processes and Practices
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Re/making "Engagement and Learning Needs:" Citation Mapping for Field Analysis in Mathematics Education Research *Christopher Dubbs, East Stroudsburg University; Susan Cannon, University of Georgia*

We used citation cartography to answer the question, "what research agendas should we pursue, with respect to engagement and learning needs, to ensure that all students reach their potential?" First, we found that current research studying engagement and learning needs were located on the periphery of the field with few connections between (1) these needs, (2) research related to race, gender, and social justice mathematics, and (3) research related specifically to mathematics content areas. We, thus, conclude with two recommendations for the field. First, we advise that mathematics education researchers consider how we might more fully connect distant subfields in mathematics education research. Second, we highlight the potential of making connections to fields outside of mathematics education. We believe that these two moves will help ensure all students reach their potential by having their engagement and learning needs met.

Sociomathematical Scaffolding as Students Engage in Mathematical Practices *Kristen Vroom, Michigan State University*

Instructors manage several tensions as they support students to engage in disciplinary practices such as defining, conjecturing, and proving. These tensions include honoring students' contributions while simultaneously apprenticing students to following mathematical norms. I present a case study of a teacher-researcher in a laboratory setting who was particularly skilled at this endeavor. I found that the teacher-researcher engaged pattern in which he cycled between inquiring into the students' thinking about their draft of a definition, conjecture, or proof and then engaged in scaffolding, including scaffolding of mathematical norms. I exemplify this pattern with an episode of students writing a conjecture equivalent to the Archimedean Property that served as a warrant for one of their proofs. I close the paper discussing complexities of apprenticeship into the norms of the discipline.

Student Engagement, Understanding, and STEM Interest in a

Game Based Supplemental Fraction Curriculum *Jessica H. Hunt, North Carolina State University; Michelle Taub, University of Central Florida; Matthew Marino, University of Central Florida; Kenneth Holman, University of Central Florida; Alejandra Duarte, North Carolina State University; Brianna Bentley, North Carolina State University*

We analyzed the effects of a game-based, supplemental fraction curriculum on fourth and fifth grade students' engagement, fraction knowledge, and STEM interest. Students with and without disabilities with intersecting identities (e.g., race, disability status, gender) comprised the sample. Results indicate significant differences in fraction concept knowledge as a result of the curriculum for all students' tests, but not STEM interest. Furthermore, engagement was a significant predictor of STEM post test scores, but not fraction concept post test scores. Implications of the results in the context of previous research on game-based mathematics curriculums are shared.

077. Mathematics Coaching Approaches

Mathematical Processes and Practices
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

Learning to Facilitate Reflective Conversations: Exploring Changes in the Practices of Mathematics Coaches *Ryan Gillespie, University of Idaho; Jennifer Kruger, University of Rochester; Adam Hanan, University of Idaho; Julie Amador, University of Idaho*

We examined changes in how mathematics coaches facilitated debriefing conversations after learning about a debrief conversational structure we created based on the principles of our content-focused coaching model. We compared participant coaches' first debriefing conversation, which occurred prior to learning about the debrief conversational structure to their second debriefing conversation, which occurred after learning about the debrief conversational structure. Findings indicate that in the second debriefing conversation, participant coaches participated more, prioritized different discursive moves, developed unique data collection systems to share observations from the co-taught lesson, and more frequently structured the conversation around content ideas related to the guiding principles of our content-focused coaching model.

Mathematics Coaches' Suggestions: Focus on Topic, Lesson Phase, and Clarity to Support Teachers' Instructional Practice *Julie Amador, University of Idaho; Ryan Gillespie, University of Idaho; Cynthia Carson, Warner School of Education - University of Rochester*

We examined the suggestions mathematics coaches provided to teachers as part of one-on-one coaching cycles. The purpose was to understand the object (content) of the suggestions, the lesson phase in which the suggestion would occur, and the clarity of the suggestion (how actionable the suggestion would be if the teacher followed the suggestion). Twenty-three coaching planning meetings were recorded, transcribed, and analyzed. Findings indicated that suggestions commonly focused on lesson design (how the lesson plan should be completed) or teacher questions (actual questions the teacher should ask). Almost half of the suggestions were about the explore phase (or middle) of the lesson and a majority of the suggestions were coded as medium or high clarity, meaning the coach clearly articulated what the suggestion would look like in the classroom. Implications for coaching and future coaching research are provided.

What annd How Experienced and Novice Coaches Notice: A Framework to Analyze Coach Noticing *Julie Amador, University of Idaho; Ryan Gillespie, University of Idaho; Jennifer Kruger, University of Rochester; Adam Hanan, University of Idaho*

We examined what and how experienced (mentor coaches) and novice coaches (coach participants) noticed as they analyzed a vignette of a coaching interaction between a coach and a teacher. We modified the van Es (2011) Learning to Notice Framework for a coaching context to analyze What and How coaches notice. We collected data from ten mentor coaches, who were experienced coaches and ten coach participants who were more novice coaches. We compared pre and post noticing for coach participants based on a two-year professional development model and compared the noticing to the mentor coaches. Findings indicate coach participant noticing for What and How coaches notice collectively shifted toward a greater focus on the teacher, included more interpretation, and was more specific from the beginning of the professional development to the end. The mentor coach noticing, on average, was more teacher-focused, interpretative, and specific than those of the coach participants.

078. Loving and Hating Math

Mathematical Processes and Practices
Research Report Session
8:00 to 9:15 am
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

The Dehumanization of Hearing "I Have Always Hated Math" *Becca Jarnutowski, University of Arizona; Aditya Adiredja, The University of Arizona*

We share our theorizing about a common statement regarding a math person that is often perceived as innocuous in society. More specifically, we are referring to people's responses when an individual shares that they are studying mathematics, such as "I have always hated math" and "Oh, you must be so smart." We draw on the notions of marked category, narratives, dehumanization, and microaggression. We use these theoretical constructs to argue that people's responses are an instantiation of mathematics as a marked category and that they function as microaggressions, especially for minoritized students who are multiply marked. Moreover, due to their prevalence, they can contribute to students' active choice of not doing mathematics in order to prioritize their humanity. Our report further highlights the importance of mathematical microaffirmations and the development of sub communities within mathematics.

Why am I Supposed to Love Math?: Digital Mathematics Storytelling in Asian American Communities *Theodore Chao, The Ohio State University; Angga Hidayat, the Ohio State University; Ruth Oliwe, The Ohio State University*

In this research study, we detail how Digital Mathematics Storytelling, in which youth create video stories detailing the mathematics knowledge existing within their families and communities, can actively create counter-stories to the model minority myth. Through intergenerational video storytelling in historic Asian American communities, the research team and participants used a community participatory action research and narrative inquiry framework to engage elementary and middle-school aged youth in mathematics-based storytelling that not only details the painful effects of the model minority myth but also showcases that mathematics identities within Asian American communities can be rich and joyful.

079. Mathematical Problem Solving

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Board Room
Participants:

Exploring Factors Influencing Success in Mathematical Problem Solving/ Explorando los Factores Que Influeyen en el Éxito en la Resolución de Problemas Matemáticos *Sam Rhodes, Georgia Southern University; Rick Bryck, Landmark College; Antonio Partida Gutierrez de Blume, Georgia Southern University*

Supporting students in becoming effective problem solvers is a critical component of K-12 mathematics instruction. Unfortunately, little is known about the factors that are related to problem solving proficiency in middle school students. In this session, we will report the results of a study that employed a hierarchical linear regression analysis to examine the cognitive, metacognitive, and affective factors that influenced the problem-solving scores in sixth and seventh grade students. Results and implications will be shared.

Problem-Solving at a Diverse School: Teachers Characterize Their Experiences and Their Students' Experiences *Richard Kitchen, University of Wyoming*

"Martinez Elementary" teachers participated in professional development activities during the 2021-22 school year to learn about the Discursive Mathematics Protocol (DMP), a problem-solving based instructional protocol designed specifically for use with multilingual learners (MLs). These activities included training sessions designed to help the teachers learn about the DMP's dual focus on mathematical reasoning and the mathematics register. In this paper, a socio-political framework is used to examine interview data collected from Martinez Elementary teachers to learn how they characterized their experiences and their students' experiences when they implemented the DMP during problem-solving lessons. This study contributes to the research literature by providing insights about how teachers and students at a diverse school characterized their experiences involving problem-solving based instruction.

080. Teacher Control and Curriculum

Curriculum, Assessment, and Related Topics
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Emerald A
Explore problem types in the curriculum and teacher control
Participants:

A Comparative Analysis of Fraction Problems Within the Iranian Curriculum and Go-Math Textbooks *Seyedehkhadijeh Azimi Asmaroud, Virginia State University*

Textbooks play an important role in teachers' instructional decisions (Jones & Tarr, 2007), which consequently affects students' learning. This paper reports on a comparison of the elementary mathematics textbooks used in Iran and the United States, the Go-Math textbook. I analyzed topic sequences, frequency of the tasks, and cognitive demands of the fraction task in second and third-grade textbooks, employing the framework developed by Smith and Stein (1998) regarding the Levels of Cognitive Demands (LCD). Findings showed that Iran's textbooks devoted more percentage of pages to fractions in second grade than Go-Math textbooks. LCD of the tasks in second grade in both courtiers were in lower levels. Also, the presentation of the fraction concepts varied in different countries and Go-Math covered more fraction concepts in third grade. Recommendations for future research were offered.

Elementary Mathematics Curriculum: State Policy, COVID-19, and Teachers' Control *Mona Baniahmadi, University of Texas Austin; Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Amy Olson, Duquesne University*

In the U.S., state guidance to schools in response to the COVID-19 pandemic was politicized. We used state-level political affiliation to explore whether access to curricular resources differed pre-pandemic or during pandemic remote teaching and teachers' reported control over curricular resources during pandemic teaching. We found that pre-pandemic the percentage of teachers in Republican states reported higher levels of resources overall, and use of core and teacher-created curricular resources in particular. They also reported having greater control over their curricular decision-making during the pandemic. There were no state-level differences in teachers' level of preparation for pandemic teaching, but teachers in Democrat states reported a greater proportion of their students had sufficient resources for online learning. We discuss the implications of these findings in terms of teacher control and state policies.

081. Student thinking and Math Identities in Problem Solving

Mathematical Processes and Practices
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

How a Teaching Practice That Builds on Student Thinking Helps Teachers Draw Out Conceptual Connections *Joshua M. Ruk, University of Wisconsin-Whitewater; Laura R. Van Zoest, Western Michigan University*

Past research has identified factors that help maintain the cognitive demand of tasks, including drawing conceptual connections. We investigated whether teachers who were engaging in the teaching practice of building—and thus focusing the class on collaboratively making sense of their peers' high-leverage mathematical contributions—drew conceptual connections at a higher rate than has been found in previous work. The rate was notably higher (54% compared to 14%). By comparing multiple enactments of the same task, we found that this higher rate of drawing conceptual connections seemed to be supported by (1) eliciting student utterances that delve more deeply into the underlying mathematics, (2) giving students more time to explore the underlying math, and (3) using previously learned abstractions to help move the class toward understanding the new abstract concepts underlying a task.

Mathematics Learner and Mathematics Educator Identities in a Problem-Solving Focused Mathematics Content Course *Stephen Caviness, Syracuse University; Joanna Masingila, Syracuse University*

In this study, we sought to understand what might be learned about preservice teachers' mathematics learner and mathematics educator identities in the context of a problem-solving focused mathematics content course. Twenty-two preservice teachers participated in this study as part of their undergraduate teacher preparation program. We implemented a narrative identity lens which operationalized stories as identity with a sociocultural understanding of learning. In our findings we emphasize the importance of the way that preservice teachers define mathematics and how this influences mathematics identities. In addition, we discuss examples of how mathematics learner identity influenced mathematics educator identity, and vice versa.

082. Examining Variation in Problems

Curriculum, Assessment, and Related Topics
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

An Examination of Japanese Curricula Through Quantitative And (Co)Variational Reasoning: The Treatment of Linear Functions *Nurdan Turan, New York University; Gulseren Karagoz Akar, Bogazici University*

This is an empirical research report investigating how Japanese curricula represent functional relationships through the lenses of

quantitative and covariational reasoning. We examined the tasks, questions, and representations in the Japanese elementary and lower secondary course of study, teachers' guide, and textbooks. Findings showed that, starting from the 4th grade by the end of 8th grade, Japanese curricula focus on iteratively improving learners' quantitative and covariational reasoning gradually raising up to continuous covariation level. This pointed out that Japanese curricula have a spiral nature in the learning of functional relationships involved in proportional and linear situations. We discuss the implications of findings for teaching, learning, and teacher education.

Opportunities for Learning: Thin Slicing Content with Variation *Leah Michelle Frazee, Central Connecticut State University; Fabiana Cardetti, University of Connecticut; Jillian M Cavanna, University of Hartford; Megan Staples, University of Connecticut*

Building Thinking Classrooms (Liljedahl, 2021) provides teachers with a new method of designing and sequencing tasks called "thin slicing", which emerged from variation theory. The results of the present study indicate that an analysis of the dimensions and ranges of variation within such a task offers insights into learning opportunities available. Specifically, identifying instances where variation has not been adequately positioned against a background of sameness can highlight potentially limited opportunities for students to notice the intended mathematics. The results of this analysis can inform design decisions and modifications to the task before implementation increasing the potential of the task to support student learning.

083. Teaching Geometry and Reasoning

Mathematical Processes and Practices
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Emerald D
Participants:

Linear or Nonlinear? Students' Graph Reasoning and Selection on an Online Assessment *Robert Knurek, University of Colorado Denver; Heather Lynn Johnson, University of Colorado Denver*

We conducted a collective case study investigating two college algebra students' graph reasoning and selection on an online assessment. Students completed the assessment during individual, semi-structured interviews, as part of a broader validation study. The assessment contained six items; students selected Cartesian graphs to represent relationships between attributes in dynamic situations and explained their reasoning. Each student spontaneously wondered whether to select a piecewise-linear or nonlinear graph. Our qualitative analysis revealed that students' expectations about whether a graph "should" be linear or nonlinear impacted their graph selection. These expectations also influenced how they narrowed down between two graph choices that both represented the same gross covariation in attributes. We conclude with implications for course textbooks to promote students' covariational reasoning.

What does it mean for geometry teachers to improve a lesson? A multimodal analysis *Gil Schwarts, University of Michigan; Pat G Herbst, University of Michigan; Soobin Jeon, University of Michigan; Amanda Marie Brown, University of Michigan*

A central goal of lesson-centered professional development programs (PD) for mathematics teachers is to learn by constructing an artifact, for example, by designing and improving a lesson plan together. That leads to the questions, what does it mean, for mathematics teachers, to improve a lesson? And how can improvements be accounted for in the analysis of the resulting artifacts, especially when these are multimodal? This paper lays the groundwork for answering such questions by drawing on empirical data from a lesson-centered PD program for secondary geometry teachers. We show how semiotic choices were made to convey that the teacher would need to support students when geometry instruction moves from a construction task to a proof, by (1) addressing students' confusion; and (2) creating a shared language to discuss diagrams. We relate these findings to teachers' professional growth and the conference theme.

084. Technology and Math Learning

Mathematical Processes and Practices
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Coordinated Multi-Hand Inscriptions with Collaborative Immersive Spatial Displays *Camden Glenn Bock, The University of Maine; Justin Dimmel, University of Maine; Brooke Howlett, The University of Maine; Joshua Bohm, The University of Maine*

Immersive spatial diagrams (three-dimensional diagrams rendered with immersive stereoscopic displays) offer learners the opportunity to extend practices of diagramming in school geometry into a human-scale, spatial context. With digital spatial painting tools, learners can use two or more hands to inscribe simultaneously, a spatial analog of the input affordances of multi-touch tablets. In this study, we describe how learners coordinate their use of multi-hand spatial painting tools to inscribe diagrams. In particular, with human-scale spatial diagrams, learners embodied inscriptions can center them within the diagram (e.g., with one's torso as an axis) and realize mathematical relationships (e.g., an arm sweeping a circle as a radius). Our analysis suggests that the design of spatial diagramming environments should consider the opportunities for embodied connections afforded by large-scale, collaborative, and multi-handed interactions.

Opportunities for Instrumental Genesis in Mathematics Lessons *Catherine Dennis, University of New Hampshire; Orly Buchbinder, University of New Hampshire*

Digital technologies have become ubiquitous in mathematics classrooms. However, there are still many aspects of technology use and integration that are not well understood. One such topic is instrumental orchestration, which is the process by which teachers support students' learning of mathematics with and through technological tools. This exploratory study extends prior research on instrumental orchestration by analyzing a sample of videos found on teacher professional development websites. In addition to identifying six literature-based categories of instrumental orchestration, the analysis revealed five new categories; extended by teachers as well as peers to support student learning. We discuss implications of this analysis for research and teacher education.

085. Belonging and Boundary Crossing

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Grand 2
Participants:

Establishing a Mathematical Belongingness Construct: Exploratory Factor Analysis of NCES's High School Longitudinal Study 2009 *Lybrya Kebreab, Saint Louis University; Sarah B. Bush, University of Central Florida; Debbie Hahs-Vaughn, University of Central Florida-Orlando; Farshid Safi, University of Central Florida; Janet Andreasen, University of Central Florida; Christa Jackson,*

Saint Louis University

This investigation utilized publicly available data from the High School Longitudinal Study 2009 (HSLS:09) by the National Center for Educational Statistics (NCES) to examine any latent structures among variables which may empirically support the validity and reliability of a mathematical sense of belonging (MSB) construct. Using the nationally representative survey data in the HSLS:09, the proposed study performed exploratory factor analyses (EFA) to parsimoniously explain the shared variance among a plethora of variables related to create a complex construct of MSB or mathematical belongingness. A complex, weighted sample size of over 13,000 high school students was used to conduct an EFA which was then mapped onto four of Mahar and colleagues' (2012) transdisciplinary themes of belonging. Implications for preservice teacher, professional development for practicing teachers, as well as future research directions are discussed.

Humanizing Mathematics through Boundary Crossing Collaboration *Lili zhou, California State University, Los Angeles*

What mathematics is and how to teach it are questions that mathematics educators constantly confront. A challenge identified in mathematics education is supporting students to see mathematics as normal human activity. Mathematics educators' viewpoints of mathematics determine whether they can recognize and exploit learning opportunities for student. This study presents the boundary crossing collaboration between two female educators within informal learning settings. Drawing on a boundary crossing learning perspective, I explored two female educators' mathematics experiences and interrogated their boundary crossing experiences as sites for humanizing mathematics. Based on this exploration, I address the possibilities for humanizing mathematics by facilitating boundary crossing between mathematics education and informal education.

086. Challenges of Being a Math Coach

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Grand 3
Participants:

Exhausted, drained, and apatehtic: An emerging coach's emotional trajectory during her first year *pavneet Kaur Bharaj, University of Massachusettes Boston; Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Kathryn Habib, University of North Carolina; ANNA HINDEN, UNC; Anna Gustaveson, University of North Carolina*

While instructional coaching can support teacher improvement and student learning, their effectiveness and longevity in the role may be influenced by teachers' emotions, the quality of the teacher-coach relationship, as well as the cognitive and emotional climate of the school. In this study, we analyze the emotional experiences of a novice mathematics instructional coach at multiple time points over one school year, through 14 reflective interviews. We categorize the coach's descriptions of her emotions as positive, negative, and neutral and describe themes that explain why she felt the way she did in her experiences. Our analysis points to three major reasons underlying her emotional trajectory which ultimately led to her decision to discontinue her role as a coach: (a) unmet expectations (b) student learning, and (c) teacher engagement.

Exploring the enactment of a coaching stance: A case of dissonance from one coach-teacher dyad *Evthokia Stephanie Saclarides, University of Cincinnati; Ryan Gillespie, University of Idaho*

Drawing on data collected from one coaching cycle for one coach-teacher dyad, this study explores one instructional coach's discursive enactment of their coaching stance. Qualitative analyses indicate that there was dissonance between the coach's stance for coaching and their discursive enactment of coaching, and that the coach's disciplinary expertise seemed to influence the enactment of her coaching stance. Implications for research and practice are discussed.

087. Epistemic Tensions of STEAM and Collaborative Problem Solving

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Paradise A
Participants:

Epistemic Rekeying: Epistemic Tensions Across Disciplines as Opportunities for Artistic Response *Corey Brady, Southern Methodist University; Lauren Vogelstein, Vanderbilt University*

There are strong motivations to implement integrated STEAM activities that engage with key ideas in mathematics. In integrating mathematics with other STEM disciplines, however, epistemic tensions can emerge. Rather than attempting to suppress, avoid, or adjudicate these tensions, we propose a strategy of "epistemic rekeying," in which epistemic tensions are offered as provocations for students to create playful and artistic responses. This approach takes epistemic tensions seriously and makes them accessible to young learners. We give the rationale for this approach and describe settings where students' creativity suggested its potential to us

Model Eliciting Activities as a Powerful Tool to Expand Collaborative Work Opportunities for Undergraduate Students *Luis E Montero-Moguel, The University of Texas at San Antonio; Veronica Vargas-Alejo, University of Guadalajara; Guadalupe Carmona, University of Texas at San Antonio; Dinorah Méndez Huerta, Universidad de Guadalajara*

This research contributes to the need to identify and expand learning environments that encourage undergraduate students to develop collaborative work skills and apply their classroom knowledge to solve real-world problems. Using qualitative methods, we examine the effects of the interaction between two teams of students when solving a Model-eliciting activity, based on theoretical framework of the Models and Modeling Perspective. Our analysis shows that the students had two opportunities for interaction, within the team and between the modeling teams. Through these interactions, the students refined their models in three directions: mathematical knowledge, interpretation, and modeling of the phenomenon, and mathematical representations. The findings of this study emphasize the significant value of model-eliciting activities in enhancing students' collaboration and modeling abilities.

088. Mathematical Proofs

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Epistemological Obstacles Related to Treating Logical Implications as Actions *Anderson Norton, Virginia Tech; Rachel Arnold, Virginia Tech; Joseph Antonides, Virginia Tech; Vladislav Kokushkin, Virginia Tech*

Understanding how students reason with logical implication is essential for supporting students' construction of increasingly

powerful ways of reasoning in proofs-based mathematics courses. We report on the results of an NSF-funded case study with a mathematics major enrolled in an introductory proofs course. We investigate the epistemological obstacles that she experienced and how they might relate to her treatment of logical implications as actions. Evidence shows that an action conception may pose challenges when students transform or quantify implications and may contribute to erroneous assumptions of biconditionality. Our report on available ways of operating with logical implications as actions is a first step in designing instructional tasks that leverage students' existing reasoning skills to support their continued development.

Proof Without Claim: A Novel Tool for Exploring Students' Conceptions of Proofs *Alison Mirin, University of Arizona; Dov Zazkis, Arizona State University; Andre Rouhani, Arizona State University*

In order to learn more about student understanding of the structure of proofs, we generated a novel genre of tasks called "Proof Without Claim" (PWC). Our work can be viewed as an extension of Selden and Selden's (1995) construct of "proof framework"; while Selden and Selden discuss how the structure of a proof can be discerned by the claim it proves, we leverage the consideration that one can discern a claim by the structure of its proof. In these PWC tasks, the student is presented with a proof with any explicit mention of its claim being proven removed and is instructed to discern the proof's claim. We introduce the construct of Personal Proof Framework (PPF) to describe the varied ways in which students relate the claim being proven to the content of the proof.

089. Sense Making

Policy, Instructional Leadership, Teacher Educators
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Exploring the Association between Upper Elementary Students' Mature Number Sense and Grade-Level Mathematics Achievement *Patrick Kirkland, University of Norte Dame; Claire Guang, University of Notre Dame*

Students with mature number sense make sense of numbers and operations, use reasoning to notice patterns, and flexibly select the most effective and efficient problem-solving strategies (McIntosh et al., 1997; Yang, 2005). Despite being highlighted in national standards and policy documents (CCSS, 2010; NCTM, 2000), the association between students' mature number sense and other important outcomes is not well specified. For example, how does students' mature number sense relate to their grade-level mathematics achievement? We analyzed 153 upper elementary school students' scores on measures of mature number sense, fraction and decimal knowledge, multiplication fluency, and grade-level mathematics achievement. We found mature number sense to be measurably distinct from their fraction and decimal knowledge and uniquely associated with students' grade-level mathematics achievement.

First and Third Graders' Interpretations of an Equality Incorrect Worked Example *Laura Bofferding, Purdue University; Mahtob Aqazade, Rice University*

Interpreting the equal sign as an indication that both sides of the equation need to be equal is often difficult for students. We engaged first and third graders in an analysis task of an equality worked example that showed a common incorrect answer. Students had the opportunity to agree or disagree with the hypothetical student and explain why. Results indicate that first graders were more focused on equality than third graders, although many students at both levels demonstrated an operational view of the equal sign. Some responses suggested students were transitioning in their thinking. Given the variety in students' explanations, using an incorrect worked example as part of a group discussion may be fruitful for helping students develop their reasoning around equality problems.

090. Learning Strategies in High School and College Math Class

Mathematical Processes and Practices
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

Guided Reinvention as Teaching Practices That Aim to Promote Student Learning to Define *Jungeun Park, University of Delaware; Jason Martin, University of Central Arkansas; Michael Oehrtman, Oklahoma State University; Douglas Rizzolo, University of Delaware*

Our study explores teaching practices that aim to promote students' learning to define an analytical object. A Calculus II instructor conducted a teaching experiment (TE) in which 11 students reinvented a formal definition of a limit over five class periods with the instructor's guidance. During the TE, the instructor's teaching practices were based on what principles of definitions from the literature inform about defining discourse. Our analysis of the instructor's teaching practices and students' follow-up work revealed several teaching practices that seem to promote development of students' narratives towards a formal definition of an analytical object: Providing testing methods to check if students' narratives can be considered as a completion of the defining task, asking students to place components of their definitions on graphs with related quantities, and asking them to reflect their illustration of the definition in their written definition.

Various Procedures for Finding Numbers in an Interval: a Study with High School Students *Mayra Zulay Suárez, Centro de Investigación y de Estudios Avanzados del IPN; Ana Isabel Sacristán, Cinvestav-IPN*

In this report we present a study on how high-school students learn strategies to find intermediate numbers in an interval to understand the property of numerical density. Research has shown how some high-school students have difficulty understanding this property. To address this difficulty, we proposed a Hypothetical Learning Trajectory for promoting the learning of numerical density, through various school mathematics. The research showed that some high-school students recognize that there is an infinite quantity of intermediate numbers in an interval; however, all the participants had difficulty understanding that there is no successor in a set that is not the natural or integer numbers one.

091. Mathematical Tasks and Curriculum

Mathematical Processes and Practices
Research Report Session
9:30 to 10:30 am
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Fascinated, Surprised, Curious: The Engagement of Elementary Preservice Teachers In Open Mathematics Tasks *Emily Mainzer, Penn State University*

Whole-class discussion of open mathematics tasks is an instructional practice K-12 mathematics educators report has the potential to engage all learners. Because this practice has not been extensively and systematically researched, this study aims to describe and analyze the engagement and experience of learners in open mathematics tasks. Drawing on a holistic conceptualization of engagement with behavioral, cognitive, affective, and aesthetic dimensions, the study specifically analyzes the engagement of three elementary preservice teachers

as they participated in tasks and accompanying discussions in their elementary mathematics methods course. The three preservice teachers were selected because of their varied mathematical identities. While the engagement of the three focus preservice teachers varied, results suggest the openness of the tasks was an important factor in making their engagement possible.

First Impressions Matter: An Analysis of Prospective Teachers' Noticing of Curriculum Materials *Scott Block, University of Nebraska-Lincoln; Kelsey Isla Quaisley, University of Nebraska-Lincoln; Lorraine M Males, University of Nebraska-Lincoln*

Given the ubiquity of curriculum materials and complexity of their usage, it is imperative that teacher education programs prepare prospective teachers (PSTs) to use curriculum materials. In this paper, we focus on what PSTs notice when they are interacting with curriculum materials, and how their initial impressions of curriculum materials influence their later understandings of curriculum materials. We found that PSTs' 20-second impressions may be indicative of their longer impressions of curriculum materials, which can include their preferences, values, beliefs, and approaches to using curriculum materials.

092. Coffee Break

PMENA
Special Event
10:30 to 11:00 am
Atlantis Hotel and Casino Conference Center: Foyer

093. Working Group: Critical Disability Studies in Mathematics Education

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Board Room
Participant:

Critical Disability Studies in Mathematics Education *Alison Mirin, University of Arizona; Paulo Tan, Johns Hopkins University; Cathery Yeh, Chapman University; Anette Bagger, Örebro University; Amber Grace Candela, University of Missouri - St. Louis; Jessica H. Hunt, North Carolina State University; Katherine Elizabeth Lewis, University of Washington; Alexis Padilla, University of New Mexico; Kai Rands, Independent Researecher; James Richard Sheldon, University of Arizona; Kathryn R. Westby, Michigan State University*

In continuing with past working groups on research at the intersections of disability studies and mathematics education, this working group met for PME-NA 44 centering on Disability Justice as a framework to share new developments from group members, to make new connections, and work toward future directions. Over the course of the three days, we built community, broke up into subgroups, and planned for next steps beyond the bounds of the working group meetings.

094. Working Group: Aesthetic and Affective Dimensions of Mathematics Learning

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participant:

Aesthetic and Affective Dimensions of Mathematics Learning *Leslie Dietiker, Boston University; Meghan Riling, Vanderbilt University; V. Rani Satyam, Virginia Commonwealth University*

Students' aesthetic and affective responses are interrelated and both central to mathematics learning. This working group will continue the conversation begun in 2022 to explore the connection between the affective and aesthetic dimensions of mathematics education, and how connecting these dimensions can help to understand how students experience mathematics. The goals of this working group are to evaluate the state of the field, build shared terms, and identify research questions for further inquiry.

095. Working Group: Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald B
Participant:

Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning *Karen Zwanch, Oklahoma State University; Sarah Kerrigan, George Fox University; Beth L. MacDonald, Illinois State University; Steven Boyce, Portland State University; Joseph Antonides, Virginia Tech; Cody Harrington, University of Colorado Denver; Cameron Byerley, Colorado State University; Erik S Tillema, Indiana University*

Units construction and coordination is a powerful tool for modeling mathematical thinking about whole numbers and fractions. This working group will support collaboration of mathematics educators to make connections between foundational contexts for units coordination, and emerging contexts such as combinatorial reasoning, mathematical knowledge for teaching, and communicating mathematical ideas in our daily lives.

096. Working Group: Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participant:

Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices *Gil Schwarts, University of Michigan; Pat G Herbst, University of Michigan; Michelle Cirillo, University of Delaware; Alison Castro Superfine, University of Illinois at Chicago; Amy Dunning, University of Illinois Springfield; Margaret Walton, University of Maryland College Park; Hala Ghousseini, University of Wisconsin-Madison*

The goal of this new working group is to consider the subject-specific nature of mathematics teachers' practices when they anticipate and facilitate whole-class discussions. This could include, for example, how teachers' practices relate to the lesson's tasks, students' prior knowledge, or the mathematical goals of a lesson. In the inaugural meeting of this group, we aim to develop a shared language to discuss subject-specificity in mathematics education. This will be accomplished by sharing work, analyzing artifacts, and identifying important future research directions in this area. We hope to establish connections among the working group participants for future collaborations.

097. Research Colloquium: Models and Modeling Perspectives

Working Groups and Research Colloquia
Working Group

11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald D
Participant:

Research Colloquium: Models and Modeling Perspectives *Corey Brady, Southern Methodist University; Hyunyi Jung, University of Florida; Angeles Dominguez, Tecnologico de Monterrey; Jeffrey McLean, University of North Carolina Chapel Hill; Aran Glancy, Purdue University*

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 continue our work within the Research Colloquium format. Building upon our work in the 2021 Colloquium, we aim to continue to articulate a coherent North-American voice in the international modeling community. In particular, we aim to explore opportunities for collaboration and communication about distinctively Pan-American perspectives on the topics of Interdisciplinarity in Modeling, Modeling and Citizen Science and Culturally Sustaining approaches to Mathematical Modeling

098. Working Group: Innovations To Support Elementary Mathematics Teachers Navigating Digital Curricula
Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 1
Participant:

Innovations To Support Elementary Mathematics Teachers Navigating Digital Curricula *Steve Rhine, Pacific University; Shannon O. S. Driskell, University of Dayton; Ann Wheeler, Texas Women's University; Rachel Harrington, Western Oregon University*

Digital curricula (DC) are gaining ubiquity in elementary mathematics classrooms and dramatically impacting the nature of mathematics teaching. Teacher educators and professional development providers are not keeping pace with the changing learning environments.This Working Group will examine video case studies of teachers implementing DC in varied ways, identify unique features of instruction with DC, brainstorm innovations to teacher education and professional development, and determine a research agenda. Pepin et al.'s (2017) theoretical framework of Learning Spaces will guide our discussion as well as four thematic questions addressing students' procedural fluency versus conceptual understanding, Common Core Mathematical Practices, affordances and constraints of DC, and teachers' use of DC generated data to inform their instruction.

099. Working Group: Teaching and learning with data investigation: Toward a socially and environmentally just world
Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 2
Participant:

Teaching and learning with data investigation: Toward a socially and environmentally just world *Sunghwan Byun, North Carolina State University; Travis Weiland, University of Houston; Susan Cannon, University of Georgia; Anthony Fernandes, University of North Carolina - Charlotte; Emmanuel Nti-Asante, University of Massachusetts, Dartmouth; Franziska Peterson, University of Maine; Karoline Smucker, Eastern Oregon University; Kingsley Y Adamoah, Middle Tennessee State University; Christopher Engledowl, Independent Researcher*

We continue the past four years of the working group on teaching and learning data investigation by 1) sustaining the ongoing cross-institutional collaboration to develop frameworks and resources for supporting mathematics educators in facilitating data investigations and 2) advancing our discussions on designing data investigations with an eye towards taking action to promote socially and environmentally just outcomes. Based on the role of context in teaching and learning with data, we organize this working group into three themes: the context of mathematics teacher preparation, the context of cross-disciplinary work, and the context of research and collaboration.

100. Working Group: Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Bas
Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 3
Participant:

Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Base *Julien Corven, Illinois State University; Joseph DiNapoli, Montclair State University; Kim Johnson, West Chester University of PA; Valerie Long, Indiana University of Pennsylvania; Dana Olanoff, Widener University; Jennifer M. Tobias, Illinois State University*

The goals of the working group on Mathematics Curriculum Recommendations for Elementary Teacher Preparation are: (1) to develop a professional knowledge base for preparing elementary teachers of mathematics through conducting and disseminating research in forums accessible to researchers and mathematics teacher educators across North America, (2) to build from prior work to propose specific, research-based recommendations for the curriculum of elementary mathematics teacher preparation (content and methods courses) that can be adopted by teacher preparation programs, accreditation bodies, and state and federal departments of education, and (3) to create a supportive community of researchers that promotes effective collaboration across institutions.

101. Research Colloquium: Embodied Mathematical Imagination and Cognition (EMIC)
Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participant:

Research Colloquium Embodied Mathematical Imagination and Cognition (EMIC) / COLOQUIO DE INVESTIGACIÓN: COGNICIÓN E IMAGINACIÓN MATEMATICA INCORPORADA / COLLOQUE DE RECHERCHE : IMAGINATION ET COGNITION MATHÉMATIQUES INTÉGRÉES *Mitchell J. Nathan, University of Wisconsin - Madison; Candace Walkington, Southern Methodist University; Dor Abrahamson, Univ. of California, Berkeley; Erin Ottmar, Worcester Polytechnic Institute; Martha W Alibali, University of Wisconsin-Madison; Michael I. Swart, University of Wisconsin - Madison*

Embodied approaches to mathematics learning, instruction, design, and assessment offer natural inroads for engaging all learners. Since 2015, the Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium has organized hands-on, collaborative, and generative activities for experiencing the contributions that embodied mathematics has to offer. During this 3-part research colloquium, participants are

invited to explore notions of engagement and design activities intended to transform teaching, learning, and assessments. This experience can lead to a deeper understanding of the value of embodiment for math education, its theoretical foundations, and its potential to transform education.

102. Working Group: The Power of Computational Thinking in Mathematics and Data Science Education

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Paradise A
Participant:

The Power of Computational Thinking in Mathematics and Data Science Education *Zuhal Yilmaz, Louisiana State University; Terrie Galanti, University of North Florida; Brian R Lawler, Kennesaw State University; Fernando Alegre, Louisiana State University*

With the increasing emphasis on computational thinking (CT) as a critical skill in K–12 teaching and learning, the STEM education community has an exciting opportunity to broaden its conceptualization of mathematics as a school subject. This new working group will explore the potential for CT to engage all mathematics learners by leveraging the power of computing, modeling, and simulations. Our goal is to build a collaborative community of mathematics, computer science, and data science educators to explore the potential for deeper mathematics and data science learning with CT integration. We will identify synergies across disciplines and themes for future research.

103. Working Group: Approximations of Practice and Equity: Surveying the Spaces

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures A
Participant:

Approximations of Practice and Equity: Surveying the Spaces *Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Carrie W Lee, East Carolina University; Liza Bondurant, Mississippi State University; Heather Howell, Educational Testing Service*

After three years of meeting as a working group at PME-NA, we will be editing a book on how several models of approximations of practice support or hinder the creation of equitable mathematics learning and thinking spaces. Participants and working group leaders will serve as critical friends as we use a fishbowl format and small groups to provide spaces for refinement and challenge of participants' work. Participants will leave with a network of thought partners and a draft chapter.

104. Working Group: Conceptualizing the Role of Technology in Equitable Mathematics Classrooms

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participant:

Conceptualizing the Role of Technology in Equitable Mathematics Classrooms *Nicholas Witt, Western Michigan University; Kayla Chandler, East Carolina University; Charity Cayton, East Carolina University; Jennifer M. Suh, George Mason University; Allison McCulloch, University of North Carolina at Charlotte; Karen Hollebrands, NC State; Jon D. Davis, jon.davis@wmich.edu*

This new working group will examine ways in which technology can be leveraged as a tool to support equitable opportunities to learn for every mathematics student. We plan to engage participants in discussion regarding current technology- and equity-centered frameworks that are used, develop technologically enhanced tasks to support equity, and determine a series of next steps toward furthering the goal of better understanding and bolstering existing technology-centered frameworks to be more aligned with equitable teaching. The group aims to provide the community with a welcoming space for diverse voices to generate a line of research specifically focused on bridging equity-centered frameworks with technology-centered frameworks.

105. Working Group: Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through Our Stories

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures C
Participant:

Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through our Stories *Weverton Ataide Pinheiro, Texas Tech University; Jennifer Hall, Monash University; Katrina Piatek-Jimenez, Central Michigan University; Amanda Provost, Montclair State University; Ana DIas, Central Michigan University; Brent Jackson, WestEd*

Research on gender and sexuality continues to be of great importance to support all students in the teaching and learning of mathematics. The goal of this year's Gender and Sexuality in Mathematics Education Working Group is to build a repertoire of how its members became involved in doing gender and sexuality research, what challenges and supports we have experienced, and what stories we have told through our research. To achieve our goal, we will collect data before, during, and after the conference. During PME-NA 2023, we will collect data through focus group interviews. We aim to learn from one another about our own personal experiences and the work that has been done in gender and sexuality research. We will continue this work after PME-NA 2023 and present our findings at PME-NA 2024.

106. Working Group:Open Science Working Group: Data Management and Sharing

Working Groups and Research Colloquia
Working Group
11:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures D
Participant:

Open Science Working Group: Data Management and Sharing *Gizem Solmaz-Ratzlaff, Florida State University; Charity Buntin, Florida State University; Robert Schoen, Florida State University*

2023 has been declared the "Year of Open Science" by the White House Office of Science and Technology Policy (OSTP). National Aeronautics and Space Administration (NASA) declared that 2023 will be a year to "celebrate the benefits and successes of open science and to inspire more scientists to adopt open science (OS) practices" and they introduced the Transform to Open Science (TOPS) initiative, which will take 5 years, with the goal of accelerating open science practices. So, how do these principles of open science affect mathematical education, and educational research as a whole? And what does the future of mathematical education research look like? Come spend three days with us to answer these questions and let us share some of our lessons with you. You can also bring your own data so that we can start working with you to plan your OS journey.

107. Lunch

PMENA
Special Event
12:00 to 1:45 pm
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E

108. Noticing and Fractions

Policy, Instructional Leadership, Teacher Educators
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

Exploring Preservice Teacher's Embodied Noticing of Students' Fraction Division *Karl Wesley Kosko, Kent State University; Temitope Egbedeyi, Kent State University; Enrico Gandolfi, Kent State University*

There is emerging evidence that professional noticing is embodied. Yet, there is still a need to better under embodied noticing at a fundamental level, especially from the preservice teachers. This study used traditional and holographic video, along with eye-tracking technology, to examine how preservice teachers' physical act of looking interacts with their professional noticing. The findings revealed that many participants focused on less sophisticated forms of mathematical noticing of students' reasoning. Additionally, results from eye-tracking data suggest that the more participants described students' conceptual reasoning, the more likely they were to focus on how recorded students used their hands to engage in the mathematics.

Exploring Preservice Teachers' Understanding of Fractions From a Commognitive Lens *Jinqing Liu, University of California, Irvine; Merav Weingarden, University of New-Hampshire*

Fraction is one of the most challenging mathematical topics to learn and teach. Teachers often lack a profound understanding of fractions, leading to students working with fractions procedurally. In this paper, by drawing upon the commognitive framework, we offer an in-depth examination of two prospective teachers' (PSTs') fraction understanding. We show how two PSTs who solve the same comparing fraction task, follow similar steps, and get the same correct answer, participate differently in the discourse about fractions. This different participation was identified by the extent to which the PSTs individualized the standard routine of comparing fractions, which we conceptualize in this paper. We discuss the affordances of the commognitive discursive lens on PSTs' understanding of fractions and highlight the study's contribution to teacher educators and teacher preparation programs.

109. Unit Coordination and Fractions

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Emerald D
Participants:

Fraction addition through the music *Maria Teresa Sanz, Cepartamento Didáctica de la Matemática. Universidad de Valencia; Carlos Valenzuela, Universidad de Guadalajara; Emilia López-Iñesta, Departamento Didáctica de la Matemátia. Universidad de Valencia; Guillermo Luengo, Departamento Didáctica de la Matemática. Universidad de Valencia*

This study examined the effects of an academic intervention, associated with music, on the conceptual understanding of musical notation and arithmetic of fractions of first-year students of Middle Secondary Education from a Spanish public school. The students (N = 12) had previous concepts about musical instruction, as well as arithmetic with fractions, particularly addition. This is an observational study in which a battery of four tasks was administered before and after an instruction based on a musical environment, music being a semiotic function. The instruction included 9 sessions of 50 minutes each. The results prior to the intervention show deficiencies in a concept that was not new to the students, however, after the intervention the students were competent in addition with fractions.

What is a Unit? Broadening Units Coordination *Karen Zwanch, Oklahoma State University; Sarah Kerrigan, George Fox University*

Units coordination, defined by Steffe (1992) as the mental distribution of one composite unit (i.e., a unit of units) "over the elements of another composite unit" (p. 264) is a powerful tool for modeling students' mathematical thinking in the context of whole number and fractional reasoning. This paper proposes extending the idea of a numerical unit to an algebraic unit and a covariational unit. Evidence to support this extension is taken from two qualitative studies conducted with middle-grades students. Results suggest the coordination of two unknowns in algebraic contexts is limited for students who assimilate with composite units. Additionally, in the context of covariational reasoning, results describe a new partitioned unit that students who assimilate with composite units may apply. Implications for engaging all learners are discussed.

110. Simulations and Data Visualizations

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Grand 2
Participant:

Shape Thinking and Students' Activity with Simulations and Tables *Toni York, Montclair State University; Nicole Panorkou, Montclair State University*

The construct of static and emergent shape thinking (Moore & Thompson, 2015) characterizes differences in students' reasoning about graphs. In our previous work with middle school students, we found that this construct may also be useful in characterizing students' reasoning about other representations such as simulations and tables. In this paper, we present data from six students' reasoning to initiate a discussion around the possible nature of static and emergent shape thinking in the context of simulations and tables that would contribute to an expansion of the current framework to include these representations.

111. POSTER SESSION: Teacher Education

PMENA
Poster Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Paradise Terrace
Participants:

A comparison of elementary and secondary level preservice teachers' beliefs about learning mathematics *Pingping Zhang, Winona State University; Manjula Joseph, Fresno Pacific University*

Teachers' beliefs about mathematics, about students, and about learning greatly impact how they teach (Pajares,1992). Beliefs of preservice teachers (PSTs) tend to be adaptable, and crucial for creating focused experiences in teacher preparation programs. Participants for this study are elementary and secondary PSTs and we set out to find out how their beliefs about mathematics differed, with the purpose of making informed decisions in the respective courses. Data came from their responses to the question: In your opinion, why is mathematics important for students to learn? Data were analyzed using thematic coding. Results showed that while both groups discussed the same four

reasons with similar emphasis, secondary PSTs tended to include multiple reasons in their responses.

A Framework for Pedagogical Content Knowledge in Teaching Measures of Central Tendency *Dhimitraq Duni, Eastern New Mexico University*

In analyzing teacher knowledge, when introducing measures of central tendency, it became apparent that existing frameworks were too general and overarching to be able to analyze work from in-service teachers. Therefore, a framework was devised to look at teachers' pedagogical content knowledge more precisely. The components of this new framework are situated in research as well as curriculum documents. In this report I will introduce the framework as well as results derived in analyzed in-service teachers' pedagogical content knowledge.

Aligning Teachers' Movements and Identities *Maria Eloisa Nuguid, Purdue University*

To address the need of making mathematics meaningful to all learners, I explore the research question: How do teachers' identities align with their movements in a small group mathematics station? Through two case studies of experienced elementary teachers/teacher educators, this study uses lenses of embodied cognition and identity as performance to understand bodily action and gestures in the mathematics stations. Using qualitative methods, I found through transcription, coding, and thematic analysis of video and interview data that participants made both conscious and subconscious choices with actions. The most salient identities so far include being a teacher and teacher educator. Conscious actions include gesturing such as pointing and forming shapes with their hands. Unconscious gestures include folding their hands in their laps. These actions mostly aligned with my participants' previous teaching experiences. For continuing work, my goal is to extract meaning from their subconscious movements.

An Examination of Two Approaches to Facilitating Tecnologically Enhanced Inquiry-Based Calculus Lessons / Una Examinacion de Dos Lecciones de Calculo Basadas en el uso de Technologia *Nicholas Witt, Western Michigan University; Offir Neil Romero Castro, Western Michigan University; Elisha Hall, Western Michigan University*

This poster presentation will highlight the ways in which two Calculus instructors' implementation of a technologically enhanced lesson on conceptually understanding the definition of the derivative of a function at a point. The study aims to initiate conversations regarding how we might characterize the nature of Inquiry-Based Learning environments that aim to develop conceptual understanding through the use of dynamic technology tools. Our initial findings indicate that the two instructors' implementation of nearly identical content varied among three components: small vs whole group, teacher vs student control of technology, and student vs teacher control of discussions.

Artificial Intelligence as Teaching Aid: Polyphonic Lessons from the "Great Calculator Debate" in Mathematics Education *Christopher Dubbs, East Stroudsburg University*

Technological conservatists worry that the use of artificial intelligence (AI) in teaching and learning will develop a generation of individuals reliant upon AI tools. By combining a systems approach to teaching with computer literacy and computational thinking, I recast AI, not as a threat but as an instructional aid: an object to be used to enhance the learning of mathematics. I use the Foucauldian method of using historical mirrors as contemporary levers to draw on the research from the wake of the The Great Calculator Debate to disrupt our present situation of anti-AI panic. Through this retelling, I argue for an AI-infused mathematics (teacher) education: a mathematics (teacher) education that uses AI—in its various forms—to the fullest extent possible in service of accomplishing the mathematics (teacher) educator's other simultaneous goals (e.g., social justice, cultural relevance, mathematical rigor, etc.).

Cognitive Complexity of Elementary Math Textbook Language in Low - and High-Income School Districts *Mike Pacheco, University of Nevada, Reno; Lynda R. Wiest, University of Nevada - Reno*

Fifth-grade mathematics textbooks from the five highest- and five lowest-income school districts in the United States were analyzed for cognitive demand in terms of level of verbs used according to Bloom's Revised Taxonomy. Verbs that appeared most often were the three lowest levels of the six verb categories. The results are encouraging from an equity standpoint but discouraging in terms of cognitive expectations placed on students in school mathematics.

Conceptualizing Prospective Mathematics Teachers' Technologically Enhanced Curriculum Design Knowledge *Nicholas Witt, Western Michigan University*

This poster presents a framework for conceptualizing Prospective Mathematics Teachers'(PMT) process of designing conceptually oriented technologically enhanced tasks developed in Desmos Activity Builder. The poster highlights one PMT's knowledge resources that were activated during her Moments of Repurposing and Envisioning while she designed a task focused on developing a conceptual understanding of Vertical Transformations of Functions. Implications with respect to task design, teacher knowledge, and learning theory will be discussed.

Coordination of Geometry Representations in a Textbook *Waldemar Stepnowski, Temple University*

The study describes how the common representations are coordinated. I analyzed a popular geometry textbook using semiotics and a pragmatic approach to capture the variety of representations into categories and to use descriptive statistics to narrow the focus to the most common representations and coordinations. The major findings are: (1) exposing which representations are most often coordinated like written language; (2) some of the mechanisms in coordination use numbers, point names, and textbook gestures, which include color, arrows, font changes, etc.

Critique as Support in Japanese Instructional Circles *Matthew Melville, Purdue University Fort Wayne; Douglas Corey, Brigham Young University; Bryant Jensen, Brigham Young University*

A closer look at how teachers participating do not have to combine critique as support because they use both giving and receiving critique as support. We engaged in discourse analysis to discover the methods that teachers utilize this method of support.

Cultivating positive mathematics identities in preservice teachers *Glenn Waddell, Jr., University of Nevada, Reno*

Aligned with the AMTE Standards for Preparing Teachers of Mathematics, Bay-Williams et. al. constructed an Identity Survey and research team to composed of several institutions ranging from R1 to private teaching universities. The team implemented the common Identity Survey and research design in 2021, and has initial results to share. Participants will learn about the design and explore the initial quantitative and qualitative data outcomes. The author hopes that attendees will consider participating in what we hope is an expanding effort to address teacher development and shifting preservice teacher identities from 'learner of mathematics' to 'teachers of mathematics.'

Designing an Education Abroad Program for Preservice Mathematics Teachers *Blair Izard, SUNY Empire State College*

We describe an education abroad program designed specifically for preservice mathematics teachers. Data suggest that this program, and more broadly education abroad programming, has potential for developing mathematics teachers who are prepared

to work across cultures. We share details of the program (i.e., semester schedule, course requirements, stakeholders, key features of the program, and other important logistics) as a means of considering the possibilities of implementing this type of work (or components of this work) elsewhere.

Developing Learners' Algebraic Manipulation Ability: A Mathematics Teacher Educator Reflects on Preservice Teachers' Initial Thoughts *Barbara Kinach, Arizona State University*

This design research study applies the cognitive strategy IACTS (Identify Assess Challenge Transform Sustain) previously developed for integer subtraction and multiple meanings of the "–" symbol to the context of symbolic transformation of algebraic expressions involving the "–" symbol. Qualitative data for this exploratory study conducted during Fall 2022 in the author's secondary mathematics methods course include preservice teachers' written explanations for how to teach $–(x+y)$, $2 – (x + 3)$, and $2 – (x – 5)$ from scratch and their post-course reflections on this experience. Preliminary results reported by the mathematics teacher educator indicate understanding of subtraction as adding the opposite did not transfer from the integer arithmetic to the algebraic context and need for PCK related to algebraic manipulation.

Dilemmas as a Site for Mathematics Teacher Educator Learning *Michael Jarry-Shore, Boise State University*

For this self-study, I examine the following question: how might unpacking the dilemmas that mathematics teacher educators (MTEs) encounter support MTE learning? I root the study in a dilemma that arose as I was modeling a Number Talk for a class of pre-service elementary teachers (PSTs). I share how unpacking this dilemma with another MTE developed my pedagogical content knowledge and better prepared me to respond to similar such dilemmas in the future. I propose conducting future research, in which MTEs would bring their various dilemmas to gatherings with other MTEs, thus allowing me to develop criteria for identifying such dilemmas and further study the MTE learning that arises from unpacking these dilemmas collectively.

Elementary Preservice Teachers Suggested Instructional Strategies For Equipartitioning *Maryam Zolfaghari, Kent State University; Hanan Alyami, Purdue Fort Wayne*

This poster explores elementary preservice teachers' [PSTs] suggestions to help children with partitioning circles into odd number of parts.

Elementary Teachers' Use of Mathematics Curricular Materials: Focus on Teachers Pay Teachers and Pinterest *Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Kristin Doherty, Michigan State University; Marcy B Wood, University of Arizona; Jill Newton, Purdue University*

In this poster, we report findings from a study of elementary teachers' use of teacher-created online curriculum materials. The teachers shared their rationale, autonomy, and strategies related to selecting and implementing mathematics activities.

Embodied teacher actions to promote students' generalization in a visual pattern task *Lizhen Chen, Western Washington University; Allyson Hallman-Thrasher, Ohio University*

In this study, we investigate how a mathematics teacher candidate coordinated gestures and speech to enact generalizing promoting actions. We examined the teacher candidate's teaching video of a visual pattern task. We found that the teacher candidate's gestures changed in concert with the complexity and accuracy of students' generalization explanations. By varying his gesture use, the teacher candidate successfully negotiated mathematical meanings with students in an embodied way that promoted students' better clarification and justification of their generalizing thinking.

Exploring Prospective Teachers' Interpretations of Mathematics and Equity-based Teaching Practices *Kathleen Nitta, Assistant Professor, Gonzaga University*

This poster session reports on an exploratory inquiry project that seeks to better understand how prospective teachers in elementary methods courses and associated clinical field experiences construct meaning of the research-based mathematics teaching practices and equity-based teaching practices. Concurrently, the inquiry explores prospective teachers emerging commitment to principles of ambitious mathematics teaching. The project uses end-of-semester narrative reflections as a primary data source to uncover connections prospective teachers made between pedagogical practices presented in the methods course to instructional practices observed and enacted in the clinical experience. The reflections also provide data to trace prospective teachers' perceptions of what a commitment to ambitious teaching resembles in their future practice. In the poster session emerging themes from the data will be shared as well as implications that point to research questions for future study. The session will also discuss PTs' interpretations of ambitious mathematics teaching.

Impact of Embedded Mental Models on Modeling Process *Sarah Gilchrist, The Ohio State University; Azita Manouchehri, The Ohio State University*

In this study, we considered how preservice teachers' knowledge of the problem context and interest in the setting influence their choices when engaged in mathematical modeling. We observed that the participants' personal experiences with the context enforced particular conditions on the models they produced and used. These particularities are what we call embedded mental models. In this report, we examine both the affordances and the constraints that our participants experienced as a result of their embedded mental models.

Implementing Co-Planning to Integrate Academic and Practitioner Knowledge *Emily Deal, Illinois State University; David Barker, Illinois State University; Oscar Chavez, Illinois State University*

The purpose of this study is to further understand how preservice teachers (PST), university instructors (UI), and mentor teachers (MT) draw upon and integrate academic and practitioner knowledge while co-planning secondary mathematics instruction in a third space. This case study was conducted with two PSTs, two UIs, and one MT. The data presented was collected from initial background and post co-planning questionnaires. Analysis of questionnaire data suggests that current definitions of each knowledge type are either not clear enough, are a misrepresentation of the body of knowledge they seek to describe, or may need further elaboration. We conclude that the notion of identifying and integrating academic and practitioner knowledge is not so clean cut and provides fruitful opportunities for further discussion.

Investigating Preservice Teachers' Desire to Emphasize Fun in the Mathematics Classroom *Jordan Allred, University of Central Arkansas; Lisa Skultety, University of Central Arkansas*

This study investigates EPSTs' desire and reasoning for introducing "fun" into their mathematics classrooms in hopes of fostering student engagement and avoiding negative mathematics experiences. It examines the different perceptions EPSTs have of their future students; it also explores the various techniques and methods they plan to use to address those perceptions. When their considering future teaching goals, 54% of the observed EPSTs planned to emphasize "fun" activities, 54% hands-on activities such as manipulatives, and 43% classroom collaboration in their classrooms, among other methods.

Mathematics and visual impairments: Study of teachers' of students with visual impairments mathematical pedagogical

content knowledge *Tasnim Alshuli, University of Arizona*

This poster will investigate teachers' of students with visual impairments (TSVIs) role in students' with visual impairments (SVIs) mathematical education, including TSVIs' mathematics teaching practices and their perspective regarding SVIs' learning and experiences in mathematics education. This poster will also include findings and implications from an interview targeted to a TSVI using the mathematical pedagogical content knowledge framework.

Mathematics Teachers' Conceptions of the Theory of Multiple Intelligences in Ghana *Sumaila Yakubu, Montana State University Bozeman; Michael Johnson Nabie, University of Education Winneba; Fenqjen Luo, Montana State University*

The study investigated the Ghanaian mathematics teachers' conceptions of the theory of multiple intelligences (MIs) using a basic qualitative method design. Participants included (12) senior high school mathematics teachers in one municipality of Ghana. Questionnaires and semi-structured interviews including field notes provided information on mathematics teachers' conceptions of the theory. Qualitative data obtained were analyzed thematically. The results indicated that mathematics teachers conceived the theory of MIs as a theory of abilities for learning, multiple teaching strategies, and theory for diverse needs

Modelación Matemática: Estrategia para estudiar la Combinación Lineal de Matrices analizando el parámetro altura *Carlos Oropeza Legorreta, Facultad de Estudios Superiores Cuautitlán UNAM; Liliana Suarez Tellez, Instituto Politecnico Nacional; José Isaac Sánchez Guerra, Facultad de Estudios Superiores Cuautitlán UNAM*

Una dificultad en la enseñanza y aprendizaje del álgebra lineal es que los estudiantes frecuentemente no encuentran un sentido de utilidad de los conceptos estudiados. Nuestro proyecto integra un modelo de corte geométrico bajo un enfoque visual para estudiar el concepto de combinación lineal con matrices, que ofrece una oportunidad robusta de estabilizar el entendimiento del concepto referido. En este trabajo reportamos una explicación detallada de la manera de modelar el estudio de la combinación lineal de matrices tomando como parámetro de análisis el valor de los elementos a(i,j) como una estrategia alternativa. El constructo teórico en el que basamos nuestro estudio es la modelación en matemática educativa. La propuesta de ejecución de la actividad didáctica contempla tres etapas: primero la solución analítica del problema, después la elaboración de la gráfica con lápiz y papel, y por último el uso de software para verificar los resultados tanto analíticos como gráficos.

Niveles de comprensión que emergen al resolver una secuencia didáctica para estadística descriptiva *Jose Luis Pineda, Universidad de Guadalajara; Claudia Orozco, Universidad de Guadalajara; Humberto Gutierréz-Pulido, Universidad de Guadalajara*

A didactic sequence is developed and implemented, which is composed of three stages, under the approach of Realistic Mathematics Education (RME) with the objective of learning descriptive statistics for university students.

Picking and Adapting a Preexisting Teaching Math for Social Justice Lesson *Kathryn E. Roman, Portland State University; Christopher Orlando Roman, Portland State University; Manqing Gao, Portland State*

There are more resources available now with preexisting teaching math for social justice lessons (TMSJLs) for teachers to choose and implement in their classes. Yet, there has not been much research emphasizing how to pick and adapt these lessons. To this end, this poster will present one example from an online, synchronous class for mathematics majors on how to pick a preexisting TMSJL and adapt it. The data included instructional notes from each author and student work from the 12 undergraduate mathematics majors. Preliminary findings showed that teachers can pick and adapt preexisting TMSJLs by investigating (1) students' interests, (2) students' math interests/knowledge, and (3) the available preexisting TMSJLs.

Preservice Teachers Learning to Teach with Online Technologies During an Initial Methods of Teaching Course *Maria L. Fernandez, Florida International University*

Thirty-four PSTs' learning to teach with online technologies and development of TPACK during a technology-focused, initial methods of teaching mathematics and science course will be discussed. Data sources for the investigation included microteaching lesson study projects consisting of lesson plans, self-analysis reports of own teaching video and instructor/peer feedback, and lesson plan revisions, as well as PSTs' self-report surveys about their learning. The results highlight that one methods course can facilitate substantive growth in PSTs' preparedness to teach mathematics and science with online technologies.

Professional noticing: the interrelated skills of attending to and interpreting student mathematical thinking *John Matt Switzer, Texas Christian University; Dawn Teuscher, Brigham Young University*

We seek to extend the understanding and application of the interrelatedness of professional noticing (Jacobs et al., 2010) by identifying the student mathematical thinking to which (STs') ability to attend to and interpret student mathematical thinking while student teaching and the ways they interpret the student mathematical thinking that was available to them. We report findings from STs' individual professional noticing skills of attending to and interpreting students' mathematical thinking. We then compare these findings to the combination of the two professional noticing skills (i.e. interrelated skills). In this poster, we answer the following research questions, How do STs' individual skills of attending to and interpreting student mathematical thinking differ from their interrelated professional noticing?

Reconceptualizing mathematical problem solving for middle and secondary preservice teachers *Pingping Zhang, Winona State University; Brooke Krejci, Winona State University*

Developing an understanding of mathematical problem solving with preservice teachers is warranted as Son and Lee (2021) suggest a need for teacher educators to focus on developing preservice teachers' conception of problem solving to assign with the current strand. This paper shares the results of a pilot study for a four-year research project on documenting the reconceptualization of mathematical problem solving for middle/secondary (grade 5-12) preservice teachers. It aims to investigate the following two questions: (1) What does mathematical problem solving mean to grade 5-12 preservice teachers? (2) How does the selected problem-solving activity challenge their conceptions of mathematical problem solving?

Returning to Disrupting Deficit Narratives: Funds of Knowledge Beyond Curriculum *Aditya Adiredja, The University of Arizona; Marta Civil, University of Arizona*

In this brief research report, we share a professional development activity that helped instructor participants disrupt deficit narratives about minoritized students. Our year-long professional development program includes an instructor-conducted interview with one of their students. The focus of the interview is to learn how race and gender might have contributed to students' learning experience in STEM. This activity is inspired by Funds of Knowledge work wherein teachers conduct home visits to learn about the students' home lives and their families' resources and experiences. These home visits were done as part of the process to disrupt deficit narratives about minoritized communities. Using data from the first cohort of participants we argue that the

instructor-conducted interview in our project served similar purpose of disrupting deficit narratives. We discuss implications to undergraduate mathematics education.

Situating Preservice Teachers' Emerging Professional Identities in the Geospatial Framework *Hillary Ongoyo Omoze, Purdue University (West Lafayette); Rose Mbewe, PURDUE UNIVERSITY*

In this study, we investigate the challenges novice teachers face in new teaching and learning environments at their first postings. Research has shown that often times they face a daunting task adjusting to new learning institutional environments, student beliefs and actions, and mentor pressure has been daunting for novice teachers. In some instances, novice teachers have reported contradictions between their theoretical knowledge from educator programs and the reality in the field. We leverage different theoretical frameworks- geospatial lenses, social justice, and equity, culturally relevant mathematics, and mathematics teacher knowledge to conceptualize pedagogical approaches to mathematics educator development that would productively position them in different spaces and places. We believe that by providing first-hand practitioner and researcher experiences and deliberately involving in the evolution of novice teachers' professional identities they would be prepared to face the challenges.

Supporting Preservice Secondary Mathematics Teachers in Having Critical Data Talk Discussions *Nina Gabrielle Bailey, University of North Carolina Charlotte; Allison McCulloch, University of North Carolina at Charlotte*

This study aims to describe how an introduction to the Critical Statistical Literacy Habits of Mind Framework supported preservice secondary mathematics teachers' facilitation of a social justice centered data talk. Specifically, we present findings on the following research questions: (a) What types of data representations do preservice secondary mathematics teachers select for a data talk? (b) Which CSLHM do preservice secondary mathematics teachers enact as they think through (i.e., plan) their selected data representation? And how robustly? (c) When enacting their data talks, in what ways do preservice secondary mathematics teachers support student development of CSLHM?

Taking Structure Seriously: What do Teachers Notice About Invariance in Fractions *Chandra Hawley Orrill, ReThink Learning Labs; Rachael Eriksen Brown, Penn State Abington; Kun Wang, University of Massachusetts Dartmouth*

In this exploratory study, we considered five teachers' interpretations of two representations of the relationship 2/3 is equal to 8/12. Our goal was to understand what aspects of fractions the teachers saw as invariant and what they saw as changing. This is part of a larger effort to think about the role of making sense of structures in solving math tasks. Our analysis showed that teachers were able to make sense of the drawings, but that their interpretation of the referent unit varied. Further, we found that these teachers did not attend to the relationship between the numerator and denominator in the fraction situation as they considered what stays invariant.

The Impact of Operation Strategies on the Conviction of Preservice Teachers' Beliefs about "Learning Styles" *Lisa Skultety, University of Central Arkansas; Jordan Allred, University of Central Arkansas; Bernard Ronald Smith, University of Central Arkansas*

In this poster, we investigate how elementary preservice teachers experiences with integer operation strategies unintentionally reinforced the myth of "learning styles". While participants felt that learning styles were important to students' success in mathematics at the start and end of the semester, after learning integer operations with models and manipulatives, the preservice teachers were even more convinced that matching instruction to learning styles was critically important for students.

The Variety and Complexity of Teachers' Descriptions Regarding Elementary Math Block Structure *Eric Partridge, University of Missouri*

This paper explores how five elementary teachers utilize their instructional minutes for math (i.e., math block structure), with a particular focus on instructional format. Four instructional formats were identified across the teachers, though the teachers selected, combined, and implemented these instructional formats in different ways. These findings have implications for student learning, teacher practice, professional development, and coaching.

To Use or Not to Use? Teachers' Considerations in a Crowded Curricular Landscape *Doris Fulwider, Purdue University; Amy Olson, Duquesne University*

The number of online curricular resources has proliferated and there is evidence that teachers are making use of these resources to plan their lessons (Pepin, et al., 2013; Sawyer, et al., 2020). Silver (2020) characterizes teacher curriculum supplementation (TCS) as a widespread phenomenon spawned initially by the adoption of Common Core standards and accelerated by the COVID-19 pandemic. In his systematic literature review on the topic, he acknowledges TCS as underrepresented in scholarly literature due to the complexities surrounding ambiguous definitions of supplementation, the vast number and types of supplemental materials available, and the countless reasons teachers decide to source these alternative materials. This poster session explores three teachers' decision making around why and how they choose to use supplemental curricular resources in the elementary mathematics classroom.

Understanding Elementary Preservice Teachers' Dispositional Shifts and Perceptions of Mathematics Pedagogy *Kristin Doherty, Michigan State University*

This study examines preservice teachers' mathematics experiences with and perceptions of traditional- and reform-oriented mathematics pedagogy. Preservice teachers were surveyed at the beginning and end of their first elementary mathematics methods course. The surveys asked about their perceptions and experiences with mathematics pedagogy (1) over time as a student and (2) observing and learning to teach mathematics in their methods course and field placement. By the end of the methods course, all participants exhibited shifts toward reform-oriented pedagogy, to differing degrees. Examining the nature of equity within these reform-oriented views at the end of the course helped illuminate connections between reform pedagogy and equity.

Understanding mathematics coaches' opportunities to engage with equity during their own professional development *Evthokia Stephanie Saclarides, University of Cincinnati; Juan M Gerardo, University of Cincinnati*

The overarching purpose of this investigation is to better understand what opportunities mathematics coaches have to engage with equity during their own district-sponsored professional development. Ultimately, our analysis showed that coaches primarily had opportunities to engage with the equity dimensions of access and achievement, while they had fewer opportunities to engage with the equity dimensions of identity and power.

Using Cultural Immersion Experiences in Teacher Education to Inform Culturally-Responsive Mathematics Instruction *Alesia Mickle Moldavan, Georgia Southern University*

Cultural immersion experiences can be used to study mathematics as a cultural practice and develop mathematical identities to build cultural competence. This study reports on a

cultural immersion field experience assigned to preservice teachers in an elementary mathematics methods course to develop skills to recognize, interact with, and support the learning of mathematics as a cultural practice. Findings indicate that the preservice teachers had opportunities to visit various places, including construction sites, lumber facilities, and restaurants relevant to their students, and speak with various community members to learn how mathematics is used. The preservice teachers associated state standards to the concepts and made suggestions of how to make mathematics relevant to students by recognizing mathematics from their communities. Implications indicate that preservice teachers must have learning opportunities to develop cultural awareness and relate it to their instruction.

Using design-based research to explore a model of professional development *Rachael Eriksen Brown, Penn State Abington; Chandra Hawley Orrill, ReThink Learning Labs; Kun Wang, University of Massachusetts Dartmouth*

This poster will highlight the evolution of a professional development model that intends to engage teachers playfully in content and practice through iterations of design-based research. This will include the current model, where it came from, and how we are using design-based research to further develop it.

ADHD Learners, Collaborative Learning and Mathematics: A Critical Literature Review *Matthew Hertel, The University of Texas, at Austin; Emma Carene Gargroetzi, University of Texas at Austin*

This poster presents findings from a literature review conducted to examine access and participation, and challenge deficit framing of ADHD learners in collaborative mathematics. Exceedingly little research exists investigating the participation of ADHD learners in collaborative mathematics. Thus, we examine literature at the intersection of collaborative learning, mathematics education, and ADHD learners. We ask of this literature: 1) How is the learner framed? 2) What theories of learning are employed? 3) What methods are used? 4) What is understood as the purpose of collaborative learning? 5) Where is relevant literature located?

A framework for designing graphing tasks from the ground up *Hwa Young Lee, Texas State University; Teo Paoletti, University of Delaware; Holly Zolt, Texas State University; Mai Bui, Texas State University; Hamilton Hardison, Texas State University; Allison L. Gantt, University of Delaware; Brandi Rygaard Gaspard, Texas State University*

In this poster, we present a novel design framework we used to design graphing tasks for middle-grades students, with attention to students' understandings of three layers constituting a graphical representation: frames of reference, coordinate system, and graph. We exemplify tasks we designed using this framework and discuss the role the framework played when analyzing students' engagement with the tasks.

Developing a Qualitative Data Analysis Process with a Multi-Researcher Team *Tara Heikila, Washington State University- Vancouver; Nicole Grace Bonge, University of Arkansas; Catherine Davis, Brigham Young University; Kate Webster, Brigham Young University; Dawn Teuscher, Brigham Young University; Amy Roth McDuffie, Washington State University*

This poster presents a multi-researcher team's process of engaging in qualitative data analysis. Three subgroups, each including an experienced researcher and a graduate student, applied iterative approaches to code and identify data patterns regarding ways middle school mathematics teachers use curricular reasoning (CR) to engage learners. Teachers use CR as they design and enact instruction with their students, curriculum materials, and standards in mind. This poster will present ways each subgroup of researchers analyzed the following CR aspects: analyzing curricular materials, viewing mathematics from the learner perspective, and considering mathematical meaning. The poster will illustrate how we created space for dialogue about data analysis, wove seven researchers' perspectives together, and discussed different approaches to analyzing data. Our process has implications for other researchers as they consider data analysis approaches in their contexts, especially when analyzing complex data sets focused on teaching and learning.

Embracing Student Language as Scaffolding During Mathematical Model *Abigail Lois Quansah, Texas State University; Jennifer A Czocher, Texas State University*

This study demonstrates how an interviewer embraced a bilingual student's language choice, enabling her to mathematically model real-world problems. The study synthesized 3 theoretical approaches to plan scaffolding moves and trace how adopting the student's mathematical language aided their mathematical reasoning during mathematical modeling. We present the case of Navani, who sorted word-problem prompts into two groups, "independent" and "dependent," which the interviewer interpreted as corresponding to linear and exponential growth, respectively. Findings revealed that the interviewer's uptake of Navani's language served as a pathway to support her as she completed increasingly difficult modeling tasks.

Exploring the Validity of a Measure of Instructional Vision *Cathy Holl-Cross, UNC Charlotte; P. Holt Wilson, UNCG; Olanrewaju Oriowo, University of North Carolina at Charlotte; Christine Fisher, UNC Greensboro; Olu Adefope, East Carolina University*

This study investigates the validity of the VHQMI survey instrument as an approximation to Munter's (2014)VHQMI rubric scores and identify factors that may be significant predictors of VHQMI survey scores through examining two questions: (1) Is there a significant positive correlation between VHQMI survey and interview rubric scores? and (2) What factors are significant predictors of educators' vision score?

Measured Speed And Accuracy of Inferred Intelligence Through Implicit Association Tests *STEPHANIE Ann SADOWNIK, University of Toronto*

This study asked the question, does the presence of corrected vision (glasses) influence the congruent trial reaction time and accuracy reading on an Implicit Association Test (IAT) at the same rate as the incongruent trial? The theoretical construct explored in the study was the perception of intelligence. A within-subjects one factor research design (n = 26) considered both Reaction Time (ms) and Accuracy (%). A one-tailed, Wilcoxon's signed-rank test indicated that the median reaction time for congruent trials (Mdn = 1255.20) was (not) significantly lower compared to the median reaction time for incongruent trials (Mdn = 1261.05), W = 208, p = .211, rB = 0.185. Implications point to the potential for implicit bias in the mathematics classroom while practical applications of the study reside in the potential for use and the potential curricular value of the TELLab software and analysis utility of JASP in the classroom.

Quantitative Instrument Repository for Mathematics Education Research with Validity Evidence *Erin E. Krupa, North Carolina State University; Jonathan David Bostic, Bowling Green State University; Timothy Donald Folger, Bowling Green State University; Brianna Bentley, North Carolina State University; Katie Burkett, North Carolina State University*

The paper reports on the developments of a repository of quantitative assessments used in mathematics education contexts. This repository centralizes assessments and the associated

validity evidence. The repository is public and freely available and has potential to inform future quantitative mathematics education scholarship.

Raising Critical Mathematics: Going Beyond Numbers *Courtney Harris, The Ohio State University*

This poster presentation analyzes students initial thinking as it relates to the social justice issue of nourishment. Students were presented with graphical and tabular data from various regions across the globe. All participants were able to identify inequalities regarding human nourishment in various regions across the world based on numerical data. They highlighted lack of access to resources and technology as factors contributing to undernourishment and delineated consequences to include demise of life and increase in rate of crime (people stealing food). Drawing from their knowledge of conditions in their own local communities, they offered that preventative measures could include planting vegetable gardens for family sustenance. These sheltered perspectives were routed in an absence of cultural and political life conditions beyond their own surrounding. Hence, we argue that while mathematics serves a viable tool for highlighting inequities, it may not be sufficient in engaging learners in deep analysis of consequences of data.

Student Access to Mathematical Learning Opportunities in Co-Taught Elementary Mathematics *Laurel Dias, Utah Valley University*

This study investigated how one teacher pair used five different co-teaching models during mathematics instruction in a second-grade classroom, through the lens of accessibility. Mathematical learning opportunities were analyzed through ethnographic lesson observations, artifact analysis, and teacher reflections. Qualitative analysis revealed considerations for all five co-teaching models. These findings support teachers to design and enact co-taught mathematics instruction more intentionally to meet all students' needs and provide guidance for teacher educators to prepare pre-service teachers for co-teaching.

Technology in Mathematics Education Research: Analysis of the Past Four Decades *Eunhye Flavin, Stonehill College; Ji-Eun Lee, Oakland University; Sunghwan Hwang, Seoul Gaju Elementary School*

This study performed a scoping review of the literature concerning the use of technology in mathematics education published in the last four decades between 1981–2022 to explore research trends. This study synthesized relevant studies by analyzing 2,433 articles retrieved from three research engines. We employed Latent Dirichlet Allocation (LDA) topic modeling to extract key terms and topics from the selected articles. The findings revealed a steady increase in research interest, and the combination of frequently used words in the article abstracts suggests popular research topics that have been studied during the set period. The results of LDA identified seven research topics that were not precisely aligned with those identified in prior studies on mathematics education or educational technology. Over time, the seven topics showed different research trends (stable, fluctuating, increasing, and decreasing). This study provided plausible reasons for these varied patterns.

Urban girls' visuospatial reasoning: Maps as eco-cultural tools to leverage lived experiences and spatial reasoning *Elizabeth Suazo-Flores, Purdue University; Maria Eloisa Nuguid, Purdue University; Signe Kastberg, Purdue University*

Visuospatial reasoning is malleable (e.g., Sinclair et al., 2016), could be developed before attending school (Sinclair et al., 2013), and is conducive to STEM careers (Chen & Mix, 2013). Owens (2020) described visuospatial reasoning as involving space and place, recognizing shapes, combinations, and their properties, symmetry thinking, comparing quantities and using ratios, spatial capabilities, locating, intention, attention, and noticing. As part of an afterschool club led by researchers from a Midwestern research-intensive university in an urban elementary school, we invited 14 typically marginalized girls to draw maps from their homes to the school. Maps have been used to gain insight into spatial thinking (Cohrssen & Pearn, 2021). Using Owen's (2020) work as a lens, we learned that girls' maps went beyond spatial representation, showing links across time, perspectives, and relationships.

Using BIPOC STEM Professionals' Career Stories to Promote Engagement and Equity *Jill V Hamm, UNC Chapel Hill; Robert Martinez, UNC Chapel Hill; Daniel Heck, Horizon Research, Inc.*

This poster describes the inclusion of career-relevant feedback and guidance grounded in dimensions of Community Cultural Wealth, from BIPOC STEM professionals, into simulations set in STEM careers for BIPOC teens to practice mathematics processes of communication and problem solving in collaboration with virtual partners. Teens experience feedback and guidance as they play the simulation, as they try mathematics collaborative skills and experience consequences of their choices. Focus group data from BIPOC teens in a college pathway program provide evidence that BIPOC STEM professionals' stories of using mathematics and navigating their career enhance engagement and other aspects of motivation in practicing collaborative skills. Analyses of data from simulation playtesting with BIPOC teens in college pathway programs are in process to assess contributions of BIPOC STEM professionals' stories to teens' mathematics career interest and efficacy.

Exploring Dynamic Aspects of Teaching in Early Career Teachers' Classrooms *Annika Perlander, University of South-Eastern Norway; Annica Andersson, University of Southeastern Norway*

This classroom study takes a dialogic research approach to investigate how early-career mathematics teachers engage students in conversations about mathematics

Mathematics Teacher Education in Changing Times: Master Students Storylines *Annica Andersson, University of Southeastern Norway; Trine Foyn, University of South Eastern Norway; Anita Movik Simensen, The Artic University of Norway*

This research is part of the Norwegian Research Council's FINNUT-granted project MIM: Mathematics Education in Indigenous and Migrational Contexts: Storylines, Cultures and Strength-Based Pedagogies, a research collaboration with researchers in the US and Canada.

Mathematics Achievement in the Culturally Sustaining Classroom: How School Principals Support Diverse Learning Environments *Kellie J. Pop, University of Nevada, Reno; Lynda R. Wiest, University of Nevada - Reno*

The purpose of the study is to investigate how school principals support their mathematics teachers and what resources they provide to create culturally sustaining classrooms. It is a qualitative study using semi-structured interviews of US K-12 school principals in traditional school settings who practice culturally sustaining leadership (CSL). This study seeks to investigate the perspectives of school principals on how they navigate mathematics education in their schools toward cultural sustainability by ensuring all students gain access to grade-level mathematics knowledge.

Elementary School Teacher's Mindset in Mathematics Education *Christy Sutton, University at Buffalo; Ji-Won Son, The State University of New York at Buffalo*

The purpose of this exploratory case study is to understand how an elementary math teacher's mindset (fixed or growth) is reflected in teaching practices. While there is a growing body of research of student and teacher mindset and productive struggle in learning (Haimovitz & Dweck, 2017), there is little research

that use classroom observations to explore the relationship between teacher mindset and verbalizations (de Ruiter et al., 2020). In this study, a second-grade teacher and her students were observed over two lessons. Transcripts of the observations were coded for both verbalizations and teacher practices. The results show that in general, a teacher's personal mindset was not reflected in her teaching, but the mindset of her speech was reflected in her students' responses. In addition, her actions at times contradicted her words and made the classroom culture one that participated in predominantly fixed practices.

112. How Math Identity and Anxiety Shapes Learning

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Role of Grit and Other Factors in Mitigating Math Anxiety in College Math Students *Marjorie Anne Darrah, West Virginia University; Monica Leppma, West Virginia University; Lori Ogden, West Virginia University*

Math anxiety refers to feelings people get when facing computational challenges. The fear of failure often causes people to avoid activities, like taking challenging mathematics courses or choosing majors that require mathematics. Grit describes how people persist or persevere in the wake of failure. This article looks at factors that contribute to a person having grit and the interaction of grit and math anxiety. Students (N = 258) enrolled in college math classes at a large university completed a set of surveys that indicated their levels of self-compassion, mindfulness, self-efficacy, math anxiety, and grit. The analyses of the data found that grit predicted math anxiety, and that self-compassion, mindfulness, and self-efficacy predicted grit. The results of this study suggest that promoting factors that help students develop grit can in turn affect their math anxiety and thus their persistence in mathematics courses and STEM majors.

Students' Mathematics Identity and Mathematical Agency from 5th through 11th Grade *Jennifer Cribbs, Oklahoma State University; Juliana Utley, Oklahoma State University*

We explored 5th through 11th grade students' mathematics identity and mathematical agency through a cross-sectional analysis. Results indicate changes in these measures with significant decreases in mathematics identity from 5th to 6th grade as well as 8th to 10th and 11th grade. However, a significant increase in mathematics identity was found from 6th to 8th and 9th grade. Mathematical agency also significantly shifted between grade levels, particularly with the sub-constructs collective and disciplinary/conceptual agency, which had a similar trend as mathematics identity. This study highlights the potential for meaningful changes in mathematics identity and mathematical agency across students' schooling.

113. Teaching Undergraduate Mathematics Courses

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Formas de razonar y argumentar en actividades de resolución de problemas de estudiantes de primer año de universidad / First year university students ways of reasoning and argumentation in problem-solving activities *Tania Azucena Chicalote Jiménez, CINVESTAV-IPN; Daniel Ortiz, CINVESTAV-IPN*

The objective of this study is to characterize the ways of reasoning and argumentation that undergraduate mathematics students show in problem-solving activities from a course that highlights the importance of formulating conjectures and the search for different ways to support or validate them. The use of a Dynamic Geometry System in the representation of the problems and in the formulation of conjectures or relationships that are important in the solution processes is highlighted. In this context, students have the opportunity to implement several mathematical skills and look for various ways to argue and support the relevance and validity of conjectures. The results indicate that students extend their ways of reasoning, which allows them to move from empirical arguments to formal arguments in presenting solutions to problems.

How instructors of undergraduate mathematics courses manage tensions related to teaching courses for teachers? *Amanda Brown, University of Michigan; Pat G Herbst, University of Michigan; Michael Ion, University of Michigan*

For centuries, there has been a debate about the role of undergraduate education in society. Some have argued that universities should focus on practical skills and knowledge to prepare students for the workforce, while others have supported the idea that universities should prioritize providing a broad understanding of disciplinary knowledge and practices. In this paper, we leverage collected from 32 interviews to explore how instructors of the undergraduate geometry course for teachers (GeT) talk about the various tensions they experience in their work and the way those ways of talking about those tensions relate to these two perspectives. Three distinct ways of talking about tensions emerged from the data, as a dilemma that needs to be managed, as a place to take sides, as an opportunity to reframe aspects of the work.

114. Learning Through Activity

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

The Learning Through Activity Design Framework: The Framework in Action *Martin Simon, New York University*

In this theoretical paper, I use an empirically based example to illustrate particular design features of the Learning Through Activity (LTA) design framework and examine the impact of particular design principles. The LTA design framework is based on our elaboration of Piaget's construct of reflective abstraction. The example discussed here, involving the learning of a fraction concept, contains both an unsuccessful attempt, not based on the LTA framework, and a subsequent successful attempt, based on the framework. I use this contrast to make theoretical distinctions with regards to designing for the learning of mathematical concepts.

Simulating a Pedagogy of Enactment May Work for Some Early Numeracy Teachers but Not Others *Arielle Orsini, Concordia University; Jenna Rice, Carleton University; Helena P. Osana, Concordia University; Julie Houle, Lester B. Pearson School Board; Anne Lafay, Concordia University*

The Numeracy Kit for Kindergarten 5-Year-Olds (NyKK-5) is a tool to support kindergarten teachers' numeracy practices. Based on a pedagogy of enactment, the NyKK-5 was designed to simulate the types of in-class supports that have been identified as critical elements of effective mathematics professional development (PD). Two groups of teachers received PD on children's early numeracy: The NyKK-5 condition was provided the NyKK-5 and the theory condition was not provided any pedagogical tools. Students in the NyKK-5 and theory classrooms demonstrated greater numeracy growth relative to students in a comparison condition. Teacher logs and classroom observations suggested that the amount of time spent engaging students in mathematics was more predictive of student learning

than the NyKK-5 by itself, but the amount of teaching experience may define one condition under which use of the tool is optimized.

115. Focusing on Conceptual Understanding and Writing

Mathematical Processes and Practices
Research Report Session
2:00 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Successful Implementation of Explicit Attention to Concepts (EAC) in Middle School Mathematics Classrooms *Emily Leckie, Boise State; Angela R Crawford, Boise State University*

This study addresses the need to better describe instructional strategies used by middle grades mathematics teachers. After coding 177 videos of grades 6-8 mathematics instruction for indications of effective instructional practices, we further analyzed 8 of the highly scored videos with specific attention to teachers' implementation of strategies associated with Explicit Attention to Concepts (EAC) (Author et al., 2020). We found that these effective teachers of mathematics tended to enact EAC by using a preferred strategy more predominantly than others, though all teachers used at least two EAC strategies during a lesson. Additionally, most participants in our study used an Initiate, Response, Evaluate (IRE) format (Mehan, 1979) when enacting EAC. We illustrate examples of their instruction with vignettes.

Teachers' Orientation Towards and Interactions with Students' Writing in High School Mathematics *Ethan P. Smith, Washington State University Tri-Cities*

This report details a case study focused on different manifestations of teachers' orientations towards students' writing in high school mathematics. I make use of teacher interviews to unpack teachers' described orientations towards writing in mathematics, as well as their interpretations of interactions observed during recorded observations. These observations also illustrate the types of writing embedded in tasks enacted by these teachers and the nature of their interactions with students' writing during such tasks. Findings indicate participants' distinct understandings of "writing in math," show their flexibility in employing both teacher- and student-oriented interactions with student writing, and suggest their desire to pursue more student-oriented interactions. Avenues for future research related to such findings are discussed.

116. Responsive Mathematical Teaching

Curriculum, Assessment, and Related Topics
Research Report Session
2:15 to 3:00 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Interpretations on modeling, connecting professional development with classroom learning *Veronica Vargas-Alejo, University of Guadalajara; Luis E Montero-Moguel, The University of Texas at San Antonio; Luis Antonio Muñoz González, Universidad de Guadalajara*

This article presents the results of a research whose objective was to study the evolution of teachers' interpretations when participating in a professional development process focused on mathematical modeling. The research was qualitative, case study type. The theoretical framework was the Models and modeling perspective. The analysis of the collected data permitted us to identify the teacher's interpretations and their evolution. As a result, it was identified that the teacher recognized that modeling can be a vehicle for teaching and learning mathematics beyond just the application of learned mathematical knowledge.

Teacher Practices for Culturally Responsive Mathematical Modeling in Grades K-2 *Erin Turner, University of Arizona; Mary Carlson, Montana State University; Julia Aguirre, University of Washington Tacoma; Jennifer M. Suh, George Mason University; Jon E Brown, University of Arizona; Mary Philomena Greene, Montana State University; Elzena McVicar, University of Washington-Seattle*

There is growing recognition that mathematical modeling can be a lever for equity in elementary mathematics classrooms. This study focuses on the impact of a professional development program focused on culturally responsive mathematical modeling on 8 kindergarten through 2nd grade teachers' practices in modeling lessons. We use a project developed observation tool to evaluate two video recorded modeling lessons from each teacher (16 total). Findings focus on patterns in the strengths and challenges in primary grade teachers' practices for teaching modeling, including how teachers' practices align with culturally responsive teaching. We discuss implications of our findings for the design and refinement of professional development.

117. Coffee Break

PMENA
Special Event
3:00 to 3:20 pm
Atlantis Hotel and Casino Conference Center: Foyer

118. Mathematical Play and Preparing Teachers to Engage Students

PMENA
Plenary Session
3:30 to 5:00 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7

As part of a longitudinal study focused on mathematical play, we (Melissa, Amy, and Anita) are often faced with questions about what counts as play and what mathematics (and other learning) we see in play, and whose play is most likely to be seen or dismissed. Rather than discuss our findings from classroom videos of kindergarten children engaged in mathematical play, we asked scholars who bring different lenses to research on play, young children, and teaching and learning mathematics to look at some of our data and provide their perspectives. In this session, we will share a video and discuss with our panel (Nathaniel, Naomi, and Tran) various ways to interpret that video. This paper provides background on the potential of mathematical play and the details of the study that generated data for analysis. We conclude with a copy of a transcript that is associated with a video we will watch during the plenary with the hopes that participants will watch it prior to the session and come up with their own questions/perspectives.

Participants:

What do you see in mathematical play *Melissa Gresalfi, Vanderbilt University; Wager Anita, Vanderbilt University; Amy Noelle Parks, Michigan State; Nathaniel Bryan, Miami of Ohio; Naomi Jessup, Georgia State University; Tran Templeton, Columbia University*

As part of a longitudinal study focused on mathematical play, we (Melissa, Amy, and Anita) are often faced with questions about what counts as play and what mathematics (and other learning) we see in play, and whose play is most likely to be seen or dismissed. Rather than discuss our findings from classroom videos of kindergarten children engaged in mathematical play, we asked scholars who bring different lenses to research on play, young children, and teaching and learning mathematics to look at some of our data and provide their perspectives. In this session, we will share a video and discuss with our panel (Nathaniel, Naomi, and Tran) various ways to interpret that video. This paper provides background on the potential of mathematical play and the details of the study that generated data for analysis. We conclude with a copy of a transcript that is associated with a

video we will watch during the plenary with the hopes that participants will watch it prior to the session and come up with their own questions/perspectives.

Preparing teachers to engage students for equitable mathematics education *Robert Berry III, University of Arizona*

Preparing teachers to teach mathematics is at the intersection of the three areas where cultural and racial knowledge intersects with content and pedagogical content knowledge. Consequently, preparing teachers to teach mathematics must consider all peoples' practices. This highlights two Black girls marginalized by their teacher, which provides the space for discussing teacher discretion and systemic violence. A significant takeaway when preparing teachers is to get them to think about how they can lead with mathematics rather than violence.

119. Dinner Event

PMENA
Special Event
6:30 to 10:00 pm
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E
An Elegant Dinner and Dance. Join us for a evening of fun!

WEDNESDAY, OCTOBER, 4

120. Steering Committee Board Meeting

PMENA
Meeting
7:00 to 8:30 am
Atlantis Hotel and Casino Conference Center: Board Room

121. Breakfast

PMENA
Special Event
7:00 to 8:30 am
Atlantis Hotel and Casino Conference Center: Paradise B,C,D,E

122. Early Career and Math Learning

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Emerald A
Participants:

Learning Assistants and Legitimate Peripheral Participation *Brinley Poulsen Stringer, San Diego State University*

Near-peer mentors are being increasingly used in college mathematics classrooms to support student learning initiatives. Studies have found improved student performance as a result of such initiatives; however, little qualitative research has been used to investigate the impact of near-peer mentors. This post-hoc analysis examines pilot study data from a College Algebra course at Crossroads State University, which utilizes Learning Assistants (LAs) in some mathematics classrooms. Data are analyzed using Lave and Wenger's (1991) Legitimate Peripheral Participation. By looking at structures, power, discourse, motivation, and contradictions, I investigate how students engage in mathematics classrooms where LAs are present.

Learning Assistant- Student Interaction in Calculus: A Critical Discourse Analysis *Rebecca Butler, University of New Hampshire; Orly Buchbinder, University of New Hampshire*

Learning Assistants (LAs) are undergraduate peer-tutors who, having successfully passed a particular course, return to assist with teaching that course. Through their work across many STEM courses, LAs have been shown to have positive effects on several student outcomes, but little is known about why LAs' presence in classrooms is positively associated with these outcomes. This study provides a novel perspective on this issue by critically analyzing a portion of classroom dialog between an LA and a student in a Calculus I course. The language used by these interlocutors was analyzed with attention to the social and informational aspects of the dialog, examining both the relationship between the student and the LA, and the ways they frame mathematical content. These findings have implications for the future study of LAs' practice and bear relevance to the improvement of LA educational programs.

Staff Perceptions of Their Role at a Summer STEM Program for Middle School Girls *Lynda R. Wiest, University of Nevada - Reno; Jessica L. Koltz, Utah State University*

This interview research was designed to understand the perceptions of instructors and volunteers who worked at a one-week residential math and technology program for middle school girls regarding their experiences working with the program. Instructors and volunteers described their potential professional and/or personal growth, their challenges with the program, and suggested program improvements. The data indicate that personal benefits accrued from involvement in the program, in particular, enhanced knowledge and skills. Instructors and volunteers also reported professional growth in skills and dispositions. Instructor challenges included working with an especially broad ability range and insufficient collaboration with other instructors, and volunteers described uncertainty about their expected role. Some staff also suggested updates to technology used in the program. This study contributes to research on out-of-school-time STEM programs.

Successes and Challenges from Early Career Mathematics Teachers *J Vince Kirwan, Kennesaw State University; Belinda Edwards, Kennesaw State University*

Despite working towards a common vision for teacher preparation, newer teachers experience successes and challenges in their teaching. This study investigated the experiences of three third year teachers to identify what they found successful or challenging in their teaching. Findings indicated that successes or challenges were contextually dependent upon the individual, though common themes across experiences existed.

123. Pre-service Teacher Learning Approaches

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Emerald B
Participants:

Teachers' Perceptions and Beliefs about the Construct of Math Anxiety of 3rd and 4th-Grade Students: A Case Study in Mexico *Beatriz Ruiz, Universidad Iberoamericana*

Math anxiety is a multifactorial construct, the complexity of which has not been fully understood (Mammarella et al., 2019). It generates blockages and negative attitudes toward learning mathematics from the first years of primary education (Guzmán et al., 2021; Harari et al., 2013; Szczygieł, 2020), and its presence affects academic performance, produces demotivation, and in the long run, it leads to avoidance of learning tasks or topics that involve mathematics (Ashcraft, 2002; Dowker et al., 2016). In Mexico, it is a phenomenon little studied and understood. The objective of the present case study is to investigate the perceptions of value and beliefs about learning math that 3rd and 4th-grade teachers have in a school in Mexico City.

The story of VCAST-SIG: Collaborative approaches that enhance MTE professional knowledge and teacher learning *Nirmala Naresh, University of North Texas; KANITA DUCLOUX, Western Kentucky University; Theresa Hopkins, University of Tennessee; Laurie Overman Cavey, Boise State University; Marta T. Magiera, Marquette University; Lee*

Roberson, Colorado State University

Like K-12 mathematics teachers, for whom effective instruction requires a full suite of pedagogical and mathematical knowledge and skills, Mathematics Teacher Educators (MTEs) also need a professional knowledge base to facilitate the development of future educators capable of supporting K-12 students' mathematical learning. In this paper, we theorize about contributors to the development of a Community of Practice (CoP) who were engaged with developing and implementing a common set of instructional materials. We discuss how using the materials in various contexts and interacting with the user community provided a much-needed network of MTEs focused on enhancing their students' mathematical learning experiences as well as their own professional development in terms of teaching, research, and curriculum development.

When Whole-Class Discourse Predicts Poor Learning Outcomes: An Examination of 47 Secondary Algebra Classes *Samuel Otten, University of Missouri at Columbia; Zandra de Araujo, University of Florida; Ze Wang, University of Missouri at Columbia; Ruby Ellis, North Carolina State University*

We observed lessons and collected student pre- and post-test data from 47 algebra classes in a variety of school districts. To our surprise, we found that time spent in whole-class discourse was negatively correlated with students' learning gains, both on a procedural knowledge measure and a conceptual measure. In looking more closely at some of the quality indicators of the whole-class discourse, such as the presence of mathematical justifications and the integration of multiple representations, analysis still revealed no positive relationship with student learning gains. We discuss whether these results may be related to the lack of ambitious instruction in the data set, the tendency of students to disengage when whole-class discourse is occurring, or the possibility that the whole-class discourse is happening too early in the lesson.

Engaging Preservice Teachers' Learning Through Integrated STEM Inquiry in a Mathematics Content Course *Su Liang, University of Texas, San Anotonio; Sasha Wang, Boise State University*

This paper reports a sub-study of a National Science Foundation-funded project to investigate preservice elementary teachers' (PSETs) mathematics learning through an integrated STEM inquiry in a mathematics content course. In particular, PSETs participated in a 3D printing STEM module to explore and visualize the symmetry of a variety of crystal lattice structure solids. The results show that the PSETs perceived the STEM module to be engaging. Their learning increased in TSEM teaching and learning.

124. Pre-service Teachers Exploring Mathematical Content

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Emerald C
Participants:

Pre-Service Teachers' Algebraic Thinking Strategies to Support the Meaning of the Equal Sign *Alysia Goyer, University of Nevada, Reno; Teruni Lamberg, University of Nevada, Reno*

Pre-service teachers often rely on their formalized algebra skills to make sense of early algebraic concepts, including the meaning of the equal sign. This study documents pre-service students' conceptions of early algebra as it relates to the equal sign. Specifically, we document how pre-service teachers thought about the meaning of the equal sign and the strategies they used to solve arithmetic problems that can be solved using relational thinking.

Pre-service teachers' conceptions of openness as reflected in task design *Ji-Eun Lee, Oakland University*

This study explored 56 pre-service elementary teachers' (PSTs') conceptions and the development of open tasks. The data included survey results and the open tasks PSTs designed. Findings revealed the following ideas: (a) PSTs' initial conceptions of open tasks address many aspects identified in the literature and (b) PSTs' open task development showed a much narrower spectrum of features of open tasks than the ones shown in their initial conceptions. While this study contributes to our understanding of future teachers' awareness and competency regarding open tasks, the findings generate further questions about the issues and challenges teacher education needs to consider.

Preservice Teachers' Understanding of Fraction Division and their Preference for Problem Sequence *Ji-Won Son, The State University of New York at Buffalo; Seoyeon Lee, University at Buffalo-SUNY*

Notwithstanding the effort to enhance pre-service teachers and teachers' content knowledge of division involving fractions, the current literature reveals the same concerns about teachers' conceptual understanding of fraction division. We examined 24 pre-assessments completed by pre-service teachers (PSTs) to learn about their initial content knowledge by using three ways to demonstrate the understanding of fraction division: 1) Solving numerically, 2) Posing word problems using two different contexts, 3) Model by using visual pictorial such as diagrams. We also explore how they make a decision on sequencing two given options: 'a whole number divided by a proper fraction' vs. 'a proper fraction divided by a whole number.' PSTs' epistemological obstacles are generalized inductively and studied closely to see how they are related to their decision-making process.

125. Fostering Creativity and Engagement in Math Classrooms

Curriculum, Assessment, and Related Topics
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Emerald D
Participants:

A Utility Value Intervention to Support Undergraduate Student Interest, Engagement, and Achievement in Calculus and Calculus-Based Physics *Viviane Seyranian, California State Polytechnic University, Pomona; Ian Thacker, University of Texas at San Antonio; Nina Abramzon, California State Polytechnic University, Pomona; Alex Madva, California State Polytechnic University, Pomona; Paul Beardsley, California State Polytechnic University, Pomona*

The purpose of this study was to help undergraduate STEM students at a Hispanic-serving institution make connections between calculus and physics content and their lives using a utility-value intervention. As part of either a Calculus II or a calculus-based Newtonian Physics course, 471 undergraduate students were randomly assigned to either read essays written by peers emphasizing the usefulness of their coursework in their daily life or to a control group. We found that students in the intervention condition reported significantly higher levels of utility value, midterm grades, and earned higher course grades. A path analysis revealed that utility value indirectly improved achievement through interest and engagement factors. Findings support predictions stemming from Expectancy-Value theory and offer practitioners with principles for leveraging perceived utility value, interest, engagement, and achievement.

Embodiment as Evidence for Student Engagement in an Inquiry-Oriented Mathematics Classroom *Kaylee Fantin-Hardesty, Colorado State University; Rachel Tremaine, Colorado State University; Jocelyn Rios, Colorado State*

University; Hortensia Soto, Colorado State University

Student engagement is an impactful component of student experience in mathematics classrooms, and can shape academic and affective outcomes. The measurement of engagement in classroom settings has been limited to self-report measures or observational frameworks which privilege verbal participation. By conducting a microanalysis of two students' engagement with a meaningful mathematics task in an inquiry-oriented discrete mathematics classroom, we provide evidence for embodiment as a lens through which to effectively observe behavioral, affective, and cognitive engagement. We emphasize embodiment's potential to (a) illuminate engagement which may have gone unnoticed under observational scales which privilege verbalization, (b) account for the multimodal nature of utterances, and (c) consider the broader classroom context in which students engage with mathematical tasks.

The Teacher's Role in Fostering Collective Creativity in Elementary Classroom Settings *Ayman Aljarrah, Acadia University; Jo Towers, University of Calgary*

In a research study designed to investigate the emergence of collective creativity in elementary classroom settings, and in which teachers' decision-making practices were analyzed alongside both the teachers' observed teaching practices in their classrooms and their students' problem-solving actions, the first author developed four metaphors for collective mathematical creativity and linked the entailments of these metaphors to teachers' actions. In this paper, we discuss in detail these entailments and teacher actions and reflect on the implications for practice and further research.

126. Teaching Proofs and Functions

Professional Development/ In-Service Teacher Education
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Grand 1
Participants:

Examining Mathematics Teacher Educators' Rationales When Implementing a Common Functions Task *Jonathan D Watkins, Ball State University; Alees Lee, Weber State University; Nicholas Kochmanski, UNC Greensboro; Terrie Galanti, University of North Florida*

In this study, we examine the knowledge, purposes, and rationales of four mathematics teacher educators (MTEs) as they implemented a common mathematical task in content and methods courses for prospective secondary teachers. When implementing the common task, the MTEs made decisions to foreground the learning of mathematics or the learning of pedagogy that were situated in their knowledge of their respective university programs, their knowledge of prospective teachers and their needs, as well as the MTEs' beliefs and backgrounds.

An Exploration of Integrating Mathematical Modeling Ideas in Teaching Application of Functions *LI SIQING, Law Ting Pong Secondary School; Lili zhou, California State University, Los Angeles*

In the paper, we proposed an instructional design that incorporates mathematical modeling ideas for the teaching of application of functions. With more exploratory teaching materials and more real-world scenarios, the design is promising in helping students master function related concepts, enhancing their engagements in class, and improving their problem-solving and self-exploratory skills. We interviewed students and teachers who had applied the design and analyzed the transcripts using thematic analysis in order to verify the effectiveness of the design. The results demonstrated that the design could improve students' performance from several perspectives, while some challenges would also be posed.

Inservice Secondary Teachers' Beliefs About Deductive Discourse for Equation Solving *Elizabeth Wrightsman, Texas State University; Cody L Patterson, Texas State University*

We investigate teacher beliefs about discourses for equation solving and the challenges these beliefs might pose for the implementation of instructional practices that promote deductive reasoning in algebra. To uncover these beliefs, we recorded three video explanations of solutions to the same linear equation with distinct discursive characteristics, and analyzed seven secondary mathematics teachers' small-group critical discussions of these explanations. Three prevalent themes surfaced in our thematic analysis. Teacher beliefs about discourse for equation solving specified different roles and potential benefits of deductive explanations, estimated students' capacity to understand deductive explanations, and hypothesized differences between teachers' and students' potential to understand deductive reasoning. We discuss implications of these beliefs for opportunities to engage all learners in conceptual thinking about equations.

Teachers' Reactions to Routine and Alternative Practices for Presenting Proofs: A Survey Experiment *Bukola Ake, University of Maine; Justin Dimmel, University of Maine; Pat G Herbst, University of Michigan*

We conducted a multimedia survey experiment with a nationally representative sample (n = 405) of secondary geometry teachers. Participants were shown storyboard depictions of instructional episodes and asked to rate the appropriateness of the (hypothetical) teacher's actions using a Likert-like response format. We analyzed participants responses using ANOVA. The purpose of the experiment was to investigate how secondary geometry teachers expect students to communicate when presenting proofs during class. Our results (1) replicated findings from a prior investigation of what teachers expect when students present proofs and (2) investigated how geometry teachers reacted to instructional practices that attempted to steer student presentations of proofs toward disciplinary communication practices.

127. Mathematics Language Routines

Mathematical Processes and Practices
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Grand 2
Participants:

Mathematics Teacher Questioning: Interventions to Promote Equity and Link to Students' Ways of Knowing Mathematics *Ana-Maria Haiduc, Purdue University; Elizabeth Suazo-Flores, Purdue University; Signe Kastberg, Purdue University*

This study aims to reveal one high school mathematics teacher questioning, the intentions of his questions, and ways questioning supported equitably students' identity forming. We aimed to answer the question: How does teacher questioning offer insights about equitable teaching practices that promote students' mathematical identity formation?

Gestures and Blends of Mathematical Proof *Laurie D. Edwards, Saint Mary's College of California*

128. Productive Struggle, Socio political Awareness and Language

Mathematical Knowledge for Teaching
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Grand 3
Participants:

Integer Comparisons: Language and Context *Mahtob Aqazade, Rice University*

In this paper, I explored how 39 fifth-grade students responded to 28 integer comparison questions compromising of different compound phrasing (e.g., most hot) and number types (e.g., positive numbers only) as well as having temperature context or no context (e.g., most negative). Students' highest average percent correct were on most cold and most negative compound phrasing questions and their challenges were with questions starting with the least. They performed better when all numbers were positive except for the least cold and least negative compound phrasing questions, they did better for negative numbers only. This paper highlights the role of language, number type, and context in students' interpretations of integer comparisons. The results of this paper have implications for designing integer learning opportunities that engage all learners and build on their mathematical thinking.

Real World Critical mathematics lesson: A Way to Leverage Students' Conceptual Understanding and Sociopolitical Awareness *Autumn Pham, Portland State University; Eva Thanheiser, Portland State University; Molly L Robinson, Portland State University; Kathryn E. Roman, Portland State University*

We investigated the development of students' sociopolitical consciousness via engagement in a mathematical activity purposefully designed around understanding the unemployment rate in the US. Qualitative data was collected from 12 university seniors participating in an online capstone class. Results showed that students: (1) further developed interpreting data visualizations, (2) understood the nature of the unemployment rate in the United States (i.e. how data is collected, how it is calculated, and how it behaves over time), (3) developed an understanding of the inequality in the US social and political structure, and (4) developed a more critical lens or more critical consciousness by questioning and critiquing the status quo. This study shows that the Unemployment Rate task can be implemented to bridge the disconnect between the mathematics classroom and real world applications, and may eventually affect a "liberatory social change".

Prospective Mathematics Teachers' Experiences Engaging in an Opportunity for Productive Struggle *Nitchada Kamlue, Western Michigan University; Laura R. Van Zoest, Western Michigan University; Yaronn James Arciaga, Western Michigan University*

This study investigated what 12 prospective mathematics teachers (PTs) in a middle school mathematics method course reported during a video-stimulated recall interview about their experiences when they were engaged in a doing math task that yielded an Opportunity for Productive Struggle (OPS). We investigated their reported feelings during the OPS, what mathematics they made sense of as a result of it, and the relationships between their feelings and sense making. We found that PTs' feelings did not predict the nature of their sense making and that regardless of how they felt during the OPS, the majority of them (66.67%) reported that engaging in the OPS resulted in mathematical sense making. Other PTs reported pedagogical sense making. We suggest future research to expand on our findings.

129. Emotional Intelligence and Positioning in the Math Class

Mathematical Knowledge for Teaching
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participants:

Emotional Intelligence and Mathematics Anxiety's Impact on Mathematics Performance of Students with and without MLD *Qingli Lei, University of Illinois Chicago; Di Liu, East China Normal University; Xiuhan Chen, University of Missouri, Columbia; Megan Hirni, University of Missouri, Columbia; Heba Abdelnaby, University of Missouri, Columbia*

This study investigated the relationship between non-cognitive factors (mathematics anxiety, Trait Emotional Intelligence, and mathematics self-concept) and mathematics performance in students with and without Mathematics Learning Disability (MLD). Participants were 340 3rd, 4th, and 5th grade students from a public elementary school. Results showed that students with MLD had significantly lower mathematics performance compared to their peers. Mathematics anxiety was found to have a negative impact on mathematics performance among students without MLD. While low TEI scores were significant predictors of lower math performance for students with and without MLD. Additionally, mathematics self-concept mediated the relationship between math anxiety and math performance. These findings have important implications for educators who work with students with and without MLD.

Exploring Intellectual Authority in Work-sharing Interactions in One Sixth-grade Mathematics Classroom *Miriam S Leshin, Stanford University*

Opportunities for students to share their thinking with the class—which I refer to as "work-sharing practices—require a profound shift in who is positioned with intellectual authority in mathematics classrooms. This study explores work-sharing practices in one sixth grade mathematics classroom through an interactional lens. Video analysis revealed three types of work-sharing interactions along a continuum of distributions of intellectual authority, ranging from the presenting student holding authority to the teacher holding authority. Notably, in the center of the continuum were instances in which the student was initially positioned with authority, but that authority shifted to the teacher in the next moment, largely based on correctness of the student's work. Findings suggest the need to deepen our understanding of authority dynamics in work-sharing interactions, as the field works to center students' thinking.

130. Tasks and Student Reasoning in High School and College Math Courses

Mathematical Processes and Practices
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Paradise A
Participants:

Framing Instructional Tasks for Interaction with Content: Introducing Derivatives Graphically with Inquiry *Saba Gerami, University of Michigan*

In this study, I present how eight U.S. college calculus instructors with different patterns of inquiry practices used instructional situation to frame instructional tasks for introducing derivatives graphically to students. During four interviews, the instructors proposed up to eight tasks for introducing derivatives physically, graphically, verbally, and symbolically (Zandieh, 2000). The findings focus on the two tasks proposed by each instructor that centered the graphical representation of the derivative: derivative at a point as the slope of a tangent line, and derivative as a function presented by its graph. While no two instructors proposed the same tasks with the same instructional situations for teaching these concepts, they relied on graphing, conjecturing, and calculating situations to frame their tasks.

Implications of Faster/Slower Language on Undergraduate Precalculus Students' Graphing *Irma Stevens, University of Rhode Island*

Researchers have recommended using tasks that support students in reasoning covariationally to build productive meanings for

graphs, rates of change, exponential growth, and more. However, not many recent studies have been done to identify how students reason when engaging in covariational reasoning tasks in undergraduate precalculus courses. In this study, I analyze submitted classwork, including video submissions of that work, in an applied precalculus undergraduate course. In comparing current literature on students' covariational reasoning with these students' responses, there is some overlap that this study provides additional insights to, and there are also unique ways of reasoning these students exhibited tied to understanding the steepness of slope as being associated with ideas of speed. This study contributes to knowledge about how students develop covariational reasoning.

131. Big Ideas Related to Modeling and Measurement

Mathematical Processes and Practices
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Treasures A
Participants:

Quantitative Operators in Mathematical Modeling *Sindura Subanemy Kandasamy Kularajan, Texas State University; Elizabeth Roan, Texas State University; Jennifer A Czocher, Texas State University*

In this report, we present cases where students constructed new quantities through operating on quantities that do not fit the definitions of existing theories on quantitative operations. As a result, we identified five quantitative operators — operators that can be used on single qualities in order to transform the quantity to a new quantity — students used while constructing mathematical models for real-world scenarios.

Using Big Ideas of Measurement as a Framework to Explore Professional Noticing of Students' Thinking *Mai Bui, Texas State University*

This paper presents Big Ideas of Measurement as a framework of students' thinking about measurement. Drawn upon research-based evidence, the framework is a collection of key concepts that students must develop for a robust understanding of measurement. These are also key aspects of students' thinking that teachers should notice. In a case study with four mathematics teacher educators, this framework was utilized to design an instrument to measure their professional noticing and to analyze the results. Findings provided snapshots of professional noticing of participants with varied expertise in content knowledge and student thinking. Additionally, the choice of artifacts showed influences on their noticing

132. The Role of Modeling and Mathematical Learning

Mathematical Processes and Practices
Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Treasures B
Participants:

Unpacking Equity Oriented Teaching Dilemmas in Elementary Mathematical Modeling Lessons *Mary Carlson, Montana State University; Erin Turner, University of Arizona; Jennifer M. Suh, George Mason University; Julia Aguirre, University of Washington Tacoma*

Our paper details the ways teachers understand and navigate equity-oriented dilemmas (Berlak & Berlak, 1981) when teaching mathematical modeling and how mathematics teacher educators can support teachers' learning of culturally responsive mathematics teaching. Using Author's (2021a) framework for culturally responsive mathematics teaching, we explored the ways teachers describe and frame their choices when faced with dilemmas. Findings revealed that teachers identified dilemmas with Rigor and Support most often, followed by Knowledges and Identities. Dilemmas related to Power and Participation occurred far less frequently. Implications for teacher professional development are discussed.

Using Dynagraphs to Investigate Understanding of Slope *Courtney Nagle, Larson Texts, Big Ideas Learning and Penn State Behrend; Deborah Moore-Russo, University of Oklahoma*

This paper provides a case study account of a preservice secondary mathematics teacher's thinking while engaging in slope tasks using dynagraphs. The data included audio recordings and screen captures of a small group of preservice teachers engaging with these tasks, with our analysis focusing on the case of Robin. Despite familiarity using slope to measure steepness and determine relationships in a Cartesian plane setting, results indicate Robin struggled to reason about these same uses of slope when presented with a dynagraph. Using the APOS-Slope framework as a lens, the analysis suggests that Robin is limited to thinking of slope as an Action when using slope to measure steepness and determine relationships, relying heavily on shape thinking in the Cartesian plane. Implications for teaching and further research are provided.

133. Fractions, Statistics and Rate of Change

Pre-Service Teacher Education
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Treasures C
Participants:

A Local Causal Explanation for Why Students Might Conflate Rates of Change and Amounts of Change *Elizabeth Roan, Texas State University; Jennifer A Czocher, Texas State University*

Previous research on differential equations notes that students tend to conflate rate of change and amounts of change. In this study, we create a local causal explanation (Maxwell, 2004) for why one participant did distinguish between the rate of change in a population and change in a population, while the other did not. We conjecture that students may only be able to construct (or talk about) rates of change if they have the appropriate quantities available to them in which to coordinate.

Beyond the Statistics: Joy in Mathematics *Nicole Marie Wessman-Enzinger, George Fox University; Laura Bofferding, Purdue University*

In this research report, we share about specific tenets of joy in mathematics and conditions for supporting joy. A pair of students, Julia and Javier, young Latinx mathematicians in Grades 3 and 4 respectively, participated in a study that involved addition and subtraction with negative integers within game play. Drawing on descriptions of joy and supporting joy, we describe specific instances of joy from Julia and Javier and the conditions that supported their joy. Julia and Javier's joy with mathematics above grade level provides a story of empowerment that counters a narrative that they are in an afterschool program where students are not meeting grade level expectations. Further, this qualitative analysis provides explicit instances of joy in mathematics and the conditions supported in a structured mathematical game, which is useful to both teachers and researchers.

Recognizing referent unit in fraction multiplication problems: is the whole always the same? *Kun Wang, University of Massachusetts Dartmouth; Chandra Hawley Orrill, ReThink Learning Labs; Rachael Eriksen Brown, Penn State Abington*

Teachers' attention to and flexibility with referent units is important to better understand fractions and fraction operations, though it is documented that teachers struggle with it. In this study, we explored teachers' different approaches to identifying

referent unit in a fraction multiplication problem involving a drawn representation. By analyzing data from pilot interviews with five middle school mathematics teachers, we found that teachers attended referent unit differently. Moreover, their different mastering referent unit related to what they view as a whole through their thinking.

134. Supporting Teachers and Students through Curriculum and Online learning

Mathematical Processes and Practices
Brief Research Report Session
8:00 to 9:30 am
Atlantis Hotel and Casino Conference Center: Treasures D
Participants:

Implementation of a new mathematics curriculum: the case of inquiry and mathematics teachersS *Suela Kacerja, University of South-Eastern Norway; Trond Stølen Gustavsen, University of South-Eastern Norway*

Teachers are important actors in implementing a new curriculum as being the ones who interpret and enact it in the classrooms. In our study, we focus on mathematics teachers' interpretation and enacting of inquiry in mathematics lessons (grades 1-7) as a highlighted element in the new Norwegian curriculum. In a preliminary analysis of data from interviews with teachers and observation of their teaching, we found that some elements of inquiry have become prominent in the teacher intended and enacted curriculum. There is a focus on different solution strategies, mathematics talk, collaboration, and active students. However, in the observed lessons there were also examples of closed tasks or group work not being used for collective collaboration. Challenges the teachers pointed out are connected to the students not being used or willing to engage with inquiry, and missing materials. We did not have any examples of students posing their own questions.

Asynchronous Google Classroom Mathematics and Synchronous L2 Oral Performance *STEPHANIE Ann SADOWNIK, University of Toronto*

In this meta-analysis, reading comprehension and mathematics are considered for elementary students between grade three and five, the age group where most reading comprehension strategies are introduced and practiced (Ness, 2011). Results indicate that (1) reading comprehension is linked to cognitive processing ability, the more students' struggle with comprehending text, the less cognitive processing they have available to solve the mathematical problem; (2) mathematical language is precise; and (3) often above the grade level of the student who is solving the word problem. Asynchronous learning management systems or other online platform, such as Google Classroom, may help educators to meet federal obligations for supporting English Language Learners conceptual development in mathematics, developing language proficiency and providing equitable access for content area learning.

"Oh! That's Interesting!": Captivating Students Who Hate Mathematics With Mathematical Ideas *Brit Claiborne, Boston University; Alexandra Videlock Barstow, Boston University; Leslie Dietiker, Boston University*

The positive relationship between students' attitudes toward mathematics and mathematics achievement is well documented. Yet there is a worsening problem of low appeal of mathematics especially at the secondary level. Therefore, in this study we focus on three high school students who report a strong dislike of mathematics. By analyzing student surveys, interviews, and lesson observation data, we examined how some mathematical lessons improved these students' experiences (i.e., their aesthetic dimensions). We found that while student preferences varied, each student was interested in lessons that centered them as sense-makers and in which the content unfolded with suspense. Such lessons led to positive aesthetic responses such as surprise, curiosity, and satisfaction. Thus, lessons can be designed in which even students with the most negative views of mathematics can find mathematical concepts interesting.

Holistic Individualized Coaching: Foregrounding Teachers' Psychological and Affective Attributes to Support Teacher Learning *Dionne Cross Cross Francis, University of North Carolina at Chapel Hill; Kathryn Habib, University of North Carolina; Anna Gustaveson, University of North Carolina; pavneet Kaur Bharaj, University of Massachusettes Boston; ANNA HINDEN, UNC*

Coaching has been shown to be an effective professional development approach to improving teachers' mathematics instruction. However, research on existing coaching models foregrounds teachers' knowledge and instructional practices and tends to overlook the psychological and affective aspects of teaching. In this study, we explored if and how two elementary teachers' participation in Holistic Individualized Coaching (HIC), designed to attend to the psychological and affective aspects of teaching, supported instructional change and teachers' well-being. Results show that while both teachers mathematics instruction improved, changes to the beliefs, teaching efficacy, and emotions were different. Findings suggest that teachers navigate different psychological and affective pathways towards change and the importance of attending to these attributes during coaching interactions.

135. Coffee Break

PMENA
Special Event
9:30 to 10:00 am
Atlantis Hotel and Casino Conference Center: Foyer

136. Working Group: Critical Disability Studies in Mathematics Education

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Board Room
Participant:

Critical Disability Studies in Mathematics Education *Alison Mirin, University of Arizona; Paulo Tan, Johns Hopkins University; Cathery Yeh, Chapman University; Anette Bagger, Örebro University; Amber Grace Candela, University of Missouri - St. Louis; Jessica H. Hunt, North Carolina State University; Katherine Elizabeth Lewis, University of Washington; Alexis Padilla, University of New Mexico; Kai Rands, Independent Researecher; James Richard Sheldon, University of Arizona; Kathryn R. Westby, Michigan State University*

In continuing with past working groups on research at the intersections of disability studies and mathematics education, this working group met for PME-NA 44 centering on Disability Justice as a framework to share new developments from group members, to make new connections, and work toward future directions. Over the course of the three days, we built community, broke up into subgroups, and planned for next steps beyond the bounds of the working group meetings.

137. Working Group: Aesthetic and Affective Dimensions of Mathematics Learning

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald A
Participant:

Aesthetic and Affective Dimensions of Mathematics Learning
Leslie Dietiker, Boston University; Meghan Riling, Vanderbilt University; V. Rani Satyam, Virginia Commonwealth University

Students' aesthetic and affective responses are interrelated and both central to mathematics learning. This working group will continue the conversation begun in 2022 to explore the connection between the affective and aesthetic dimensions of mathematics education, and how connecting these dimensions can help to understand how students experience mathematics. The goals of this working group are to evaluate the state of the field, build shared terms, and identify research questions for further inquiry.

138. Working Group: Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald B
Participant:

Complex Connections: Reimagining Units Construction and Coordination for MKT and Combinatorial Reasoning *Karen Zwanch, Oklahoma State University; Sarah Kerrigan, George Fox University; Beth L. MacDonald, Illinois State University; Steven Boyce, Portland State University; Joseph Antonides, Virginia Tech; Cody Harrington, University of Colorado Denver; Cameron Byerley, Colorado State University; Erik S Tillema, Indiana University*

Units construction and coordination is a powerful tool for modeling mathematical thinking about whole numbers and fractions. This working group will support collaboration of mathematics educators to make connections between foundational contexts for units coordination, and emerging contexts such as combinatorial reasoning, mathematical knowledge for teaching, and communicating mathematical ideas in our daily lives.

139. Working Group: Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald C
Participant:

Describing the work of managing classroom discussions: Attending to the subject-specific aspects of teachers' practices *Gil Schwarts, University of Michigan; Pat G Herbst, University of Michigan; Michelle Cirillo, University of Delaware; Alison Castro Superfine, University of Illinois at Chicago; Amy Dunning, University of Illinois Springfield; Margaret Walton, University of Maryland College Park; Hala Ghousseini, University of Wisconsin-Madison*

The goal of this new working group is to consider the subject-specific nature of mathematics teachers' practices when they anticipate and facilitate whole-class discussions. This could include, for example, how teachers' practices relate to the lesson's tasks, students' prior knowledge, or the mathematical goals of a lesson. In the inaugural meeting of this group, we aim to develop a shared language to discuss subject-specificity in mathematics education. This will be accomplished by sharing work, analyzing artifacts, and identifying important future research directions in this area. We hope to establish connections among the working group participants for future collaborations.

140. Research Colloquium: Models and Modeling Perspectives

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Emerald D
Participant:

Research Colloquium: Models and Modeling Perspectives
Corey Brady, Southern Methodist University; Hyunyi Jung, University of Florida; Angeles Dominguez, Tecnologico de Monterrey; Jeffrey McLean, University of North Carolina Chapel Hill; Aran Glancy, Purdue University

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 continue our work within the Research Colloquium format. Building upon our work in the 2021 Colloquium, we aim to continue to articulate a coherent North-American voice in the international modeling community. In particular, we aim to explore opportunities for collaboration and communication about distinctively Pan-American perspectives on the topics of Interdisciplinarity in Modeling, Modeling and Citizen Science and Culturally Sustaining approaches to Mathematical Modeling

141. Working Group: Innovations To Support Elementary Mathematics Teachers Navigating Digital Curricula

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 1
Participant:

Innovations To Support Elementary Mathematics Teachers Navigating Digital Curricula *Steve Rhine, Pacific University; Shannon O. S. Driskell, University of Dayton; Ann Wheeler, Texas Women's University; Rachel Harrington, Western Oregon University*

Digital curricula (DC) are gaining ubiquity in elementary mathematics classrooms and dramatically impacting the nature of mathematics teaching. Teacher educators and professional development providers are not keeping pace with the changing learning environments.This Working Group will examine video case studies of teachers implementing DC in varied ways, identify unique features of instruction with DC, brainstorm innovations to teacher education and professional development, and determine a research agenda. Pepin et al.'s (2017) theoretical framework of Learning Spaces will guide our discussion as well as four thematic questions addressing students' procedural fluency versus conceptual understanding, Common Core Mathematical Practices, affordances and constraints of DC, and teachers' use of DC generated data to inform their instruction.

142. Working Group:Open Science Working Group: Data Management and Sharing

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 2
Participant:

Open Science Working Group: Data Management and Sharing
Gizem Solmaz-Ratzlaff, Florida State University; Charity Buntin, Florida State University; Robert Schoen, Florida State University

2023 has been declared the "Year of Open Science" by the White House Office of Science and Technology Policy (OSTP). National Aeronautics and Space Administration (NASA) declared that 2023 will be a year to "celebrate the benefits and

successes of open science and to inspire more scientists to adopt open science (OS) practices" and they introduced the Transform to Open Science (TOPS) initiative, which will take 5 years, with the goal of accelerating open science practices. So, how do these principles of open science affect mathematical education, and educational research as a whole? And what does the future of mathematical education research look like? Come spend three days with us to answer these questions and let us share some of our lessons with you. You can also bring your own data so that we can start working with you to plan your OS journey.

143. Working Group: Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Bas

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 3
Participant:

Mathematics Curriculum Recommendations for Elementary Teacher Preparation: Establishing a Research Base *Julien Corven, Illinois State University; Joseph DiNapoli, Montclair State University; Kim Johnson, West Chester University of PA; Valerie Long, Indiana University of Pennsylvania; Dana Olanoff, Widener University; Jennifer M. Tobias, Illinois State University*

The goals of the working group on Mathematics Curriculum Recommendations for Elementary Teacher Preparation are: (1) to develop a professional knowledge base for preparing elementary teachers of mathematics through conducting and disseminating research in forums accessible to researchers and mathematics teacher educators across North America, (2) to build from prior work to propose specific, research-based recommendations for the curriculum of elementary mathematics teacher preparation (content and methods courses) that can be adopted by teacher preparation programs, accreditation bodies, and state and federal departments of education, and (3) to create a supportive community of researchers that promotes effective collaboration across institutions.

144. Research Colloquium: Embodied Mathematical Imagination and Cognition (EMIC)

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Grand 4,5,6,7
Participant:

Research Colloquium Embodied Mathematical Imagination and Cognition (EMIC) / COLOQUIO DE INVESTIGACIÓN: COGNICIÓN E IMAGINACIÓN MATEMATICA INCORPORADA / COLLOQUE DE RECHERCHE : IMAGINATION ET COGNITION MATHÉMATIQUES INTÉGRÉES *Mitchell J. Nathan, University of Wisconsin - Madison; Candace Walkington, Southern Methodist University; Dor Abrahamson, Univ. of California, Berkeley; Erin Ottmar, Worcester Polytechnic Institute; Martha W Alibali, University of Wisconsin-Madison; Michael I. Swart, University of Wisconsin - Madison*

Embodied approaches to mathematics learning, instruction, design, and assessment offer natural inroads for engaging all learners. Since 2015, the Embodied Mathematical Imagination and Cognition (EMIC) Research Colloquium has organized hands-on, collaborative, and generative activities for experiencing the contributions that embodied mathematics has to offer. During this 3-part research colloquium, participants are invited to explore notions of engagement and design activities intended to transform teaching, learning, and assessments. This experience can lead to a deeper understanding of the value of embodiment for math education, its theoretical foundations, and its potential to transform education.

145. Working Group: The Power of Computational Thinking in Mathematics and Data Science Education

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Paradise A
Participant:

The Power of Computational Thinking in Mathematics and Data Science Education *Zuhal Yilmaz, Louisiana State University; Terrie Galanti, University of North Florida; Brian R Lawler, Kennesaw State University; Fernando Alegre, Louisiana State University*

With the increasing emphasis on computational thinking (CT) as a critical skill in K–12 teaching and learning, the STEM education community has an exciting opportunity to broaden its conceptualization of mathematics as a school subject. This new working group will explore the potential for CT to engage all mathematics learners by leveraging the power of computing, modeling, and simulations. Our goal is to build a collaborative community of mathematics, computer science, and data science educators to explore the potential for deeper mathematics and data science learning with CT integration. We will identify synergies across disciplines and themes for future research.

146. Working Group: Approximations of Practice and Equity: Surveying the Spaces

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures A
Participant:

Approximations of Practice and Equity: Surveying the Spaces *Bima Kumari Sapkota, The University of Texas Rio Grande Valley; Carrie W Lee, East Carolina University; Liza Bondurant, Mississippi State University; Heather Howell, Educational Testing Service*

After three years of meeting as a working group at PME-NA, we will be editing a book on how several models of approximations of practice support or hinder the creation of equitable mathematics learning and thinking spaces. Participants and working group leaders will serve as critical friends as we use a fishbowl format and small groups to provide spaces for refinement and challenge of participants' work. Participants will leave with a network of thought partners and a draft chapter.

147. Working Group: Conceptualizing the Role of Technology in Equitable Mathematics Classrooms

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures B
Participant:

Conceptualizing the Role of Technology in Equitable Mathematics Classrooms *Nicholas Witt, Western Michigan University; Kayla Chandler, East Carolina University; Charity Cayton, East Carolina University; Jennifer M. Suh, George Mason University; Allison McCulloch, University of North Carolina at Charlotte; Karen Hollebrands, NC State; Jon D. Davis, jon.davis@wmich.edu*

This new working group will examine ways in which technology can be leveraged as a tool to support equitable opportunities to

learn for every mathematics student. We plan to engage participants in discussion regarding current technology- and equity-centered frameworks that are used, develop technologically enhanced tasks to support equity, and determine a series of next steps toward furthering the goal of better understanding and bolstering existing technology-centered frameworks to be more aligned with equitable teaching. The group aims to provide the community with a welcoming space for diverse voices to generate a line of research specifically focused on bridging equity-centered frameworks with technology-centered frameworks.

148. Working Group: Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through Our Stories

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures C
Participant:

Gender and Sexuality in Mathematics Education Working Group: Supporting Learners and Scholars Through our Stories *Weverton Ataide Pinheiro, Texas Tech University; Jennifer Hall, Monash University; Katrina Piatek-Jimenez, Central Michigan University; Amanda Provost, Montclair State University; Ana DIas, Central Michigan University; Brent Jackson, WestEd*

Research on gender and sexuality continues to be of great importance to support all students in the teaching and learning of mathematics. The goal of this year's Gender and Sexuality in Mathematics Education Working Group is to build a repertoire of how its members became involved in doing gender and sexuality research, what challenges and supports we have experienced, and what stories we have told through our research. To achieve our goal, we will collect data before, during, and after the conference. During PME-NA 2023, we will collect data through focus group interviews. We aim to learn from one another about our own personal experiences and the work that has been done in gender and sexuality research. We will continue this work after PME-NA 2023 and present our findings at PME-NA 2024.

149. Working Group: Teaching and learning with data investigation: Toward a socially and environmentally just world

Working Groups and Research Colloquia
Working Group
10:00 to 12:00 pm
Atlantis Hotel and Casino Conference Center: Treasures D
Participant:

Teaching and learning with data investigation: Toward a socially and environmentally just world *Sunghwan Byun, North Carolina State University; Travis Weiland, University of Houston; Susan Cannon, University of Georgia; Anthony Fernandes, University of North Carolina - Charlotte; Emmanuel Nti-Asante, University of Massachusetts, Dartmouth; Franziska Peterson, University of Maine; Karoline Smucker, Eastern Oregon University; Kingsley Y Adamoah, Middle Tennessee State University; Christopher Engledowl, Independent Researcher*

We continue the past four years of the working group on teaching and learning data investigation by 1) sustaining the ongoing cross-institutional collaboration to develop frameworks and resources for supporting mathematics educators in facilitating data investigations and 2) advancing our discussions on designing data investigations with an eye towards taking action to promote socially and environmentally just outcomes. Based on the role of context in teaching and learning with data, we organize this working group into three themes: the context of mathematics teacher preparation, the context of cross-disciplinary work, and the context of research and collaboration.

PARTICIPANT INDEX

CONFERENCE PRESENTERS

Abbaspour Tazehkand, Shahabeddin, University of Central Florida, shaha8@knights.ucf.edu

Abdelnaby, Heba, University of Missouri, Columbia, hzadmb@mail.missouri.edu

Abramzon, Nina, California State Polytechnic University, Pomona, nabramzon@cpp.edu

Acevedo, Carlos Ivan, Texas State University, cia24@txstate.edu

Acharya, Srujana, University of Delaware, srujana@udel.edu

Adefope, Olu, East Carolina University, adefopeo@ecu.edu

Ader, Engin, Boğaziçi University, ader@boun.edu.tr

Adiredja, Aditya, The University of Arizona, adiredja@math.arizona.edu

Aguirre, Julia, University of Washington Tacoma, jaguirre@uw.edu

Aguirre Ortega, Brenda A, University of Colorado Boulder, brag2087@colorado.edu

Ake, Bukola, University of Maine, bukola.ake@maine.edu

Akuom, Denish Ogweno, Montclair State University, akuomd1@montclair.edu

Alapala, Burcu, UW Madison, alapala@wisc.edu

Albert, Lillie R., Boston College, albertli@bc.edu

Alegre, Fernando, Louisiana State University, falegre@lsu.edu

Aljarrah, Ayman, Acadia University, ayman.aljarrah@acadiau.ca

Alli-Balogun, Kudirat, University at Buffalo, kudiratt@aol.com

Allred, Jordan, University of Central Arkansas, jordanallred54@gmail.com

Alshuli, Tasnim, University of Arizona, talshuli@arizona.edu

Altshuler, Mari, University of Illinois at Urbana-Champaign, mshuler@illinois.edu

Alyami, Hanan, Purdue Fort Wayne, alyamih@pfw.edu

Al-younes, Mohammad Saleh, Marquette University, mohammad.al-younes@marquette.edu

Alzaga Elizondo, Tenchita, Portland State University, halzaga@pdx.edu

Amador, Julie, University of Idaho, jamador@uidaho.edu

Andersson, Annica, University of Southeastern Norway, annica.andersson@usn.no

Andreasen, Janet, University of Central Florida, janet.andreasen@ucf.edu

Andres-Salgarino, Ma Bernadette, Santa Clara County Office of Education, bernadette_salgarino@sccoe.org

Anita, Wager, Vanderbilt University, anita.wager@vanderbilt.edu

Anthonypillai, Serena, University of Connecticut, Serena.anthonypillai@uconn.edu

Antonides, Joseph, Virginia Tech, jantonides@vt.edu

Aqazade, Mahtob, Rice University, mahtob.aqazade@tamucc.edu

Arciaga, Yaronn James, Western Michigan University, yaronnjames.arciaga@wmich.edu

Arnold, Rachel, Virginia Tech, rlongley@vt.edu

Arrivillaga, Fabiola, Instituto Politécnico Nacional, México, farrivillaga.hurtado@gmail.com

Asad, Ninie, Virginia Tech, ninie@vt.edu

Ataide Pinheiro, Weverton, Texas Tech University, wataidep@ttu.edu

Austin, Christine Kathryn, Kent State University, causti17@kent.edu

Azimi Asmaroud, Seyedehkhadijeh, Virginia State University, sazimi@vsu.edu

Baas, Andrew, Texas State University, andrew.baas@txstate.edu

Bailey, Nina Gabrielle, University of North Carolina Charlotte, nbaile15@uncc.edu

Bajwa, Neet Priya, Illinois State University, nbajwa@ilstu.edu

Balady, Steve, California State University San Bernardino, steve.balady@csusb.edu

Bang, Hee Jin, Age of Learning, Inc.,

heejin.bang@aofl.com
Baniahmadi, Mona, University of Texas Austin, mbaniahmadi@tacc.utexas.edu
Barabe, Genevieve, Université de Montréal, genevieve.barabe@umontreal.ca
Barker, David, Illinois State University, dbarker@ilstu.edu
Barno, Erin, Boston University, ebarno@bu.edu
Basu, Debasmita, Eugene Lang College of Liberal Arts, The New School, basud1@newschool.edu
Bayyurt, Izge, University of Maine, Izge.bayyurt@maine.edu
Beardsley, Paul, California State Polytechnic University, Pomona, pmbeardsley@cpp.edu
Beaudine, Gregory B, University of Iowa, Gregory-Beaudine@uiowa.edu
Bender, Stacy, Peacemaker Resources, stacy@peacemakerresources.org
Bennett, Amy Been, University of Nebraska-Lincoln, abennett14@unl.edu
Benoit, Gregory, Boston University/ MIT TSL, gbenoit1@bu.edu
Bentley, Brianna, North Carolina State University, blbentle@ncsu.edu
Bermudez, Hillary, Syracuse University, hbermude@syr.edu
Berry, Christine A., Virginia Tech, christineb43@vt.edu
Berry III, Robert, University of Arizona, rqberry@arizona.edu
Bertolone-Smith, Claudia Marie, California State University Chico, cmbertolone-smith@csuchico.edu
Betten, Kasie, Sunnyside Unified School District, kasieb@susd12.org
Betts, Anastasia, University of Buffalo SUNY, albetts@buffalo.edu
Bieda, Kristen N, Michigan State University, kbieda@msu.edu
Bishop, Jessica Pierson, Texas State University, jbishop01@txstate.edu
Blanton, Maria, TERC, Maria_Blanton@terc.edu
Block, Scott, University of Nebraska-Lincoln, scott.block@huskers.unl.edu
Bock, Camden Glenn, The University of Maine, camden.bock@maine.edu
Boerst, Tim, UM, tboerst@umich.edu
Bofferding, Laura, Purdue University, LBofferd@purdue.edu
Bohm, Joshua, The University of Maine, joshua.bohm@maine.edu
Bonaccorso, Victoria, Montclair State University, bonaccorsov@montclair.edu
Boncoddo, Rebecca, Central Connecticut University, Boncoddo@ccsu.edu
Bondurant, Liza, Mississippi State University, lb2206@msstate.edu
Bonge, Nicole Grace, University of Arkansas, ngbonge@uark.edu
Bostic, Jonathan David, Bowling Green State University, bosticj@bgsu.edu
Boyce, Steven, Portland State University, sboyce@pdx.edu
Brady, Corey, Southern Methodist University, corey.brady@vanderbilt.edu
Brass, Amy, Pennsylvania State University, aqb6161@psu.edu
Braun, Benjamin, University of Kentucky, benjamin.braun@uky.edu
Brown, Amanda Marie, University of Michigan, milewsk4@gmail.com
Brown, Amanda, University of Michigan, amilewsk@umich.edu
Brown, Jon E, University of Arizona, jebrown@email.arizona.edu
Brown, Jon Eston, University of Arizona, jebrown@arizona.edu
Brown, Rachael Eriksen, Penn State Abington, reb37@psu.edu
Brown, Yuriko Hoshiya, Pennsylvania State University, yhb100@psu.edu
Brownell, Christopher S., Fresno Pacific University, chris.brownell@fresno.edu
Bryan, Nathaniel, Miami of Ohio, bryann@MiamiOH.edu
Bryck, Rick, Landmark College, rickbryck@landmark.edu
Buchbinder, Orly, University of New Hampshire, orly.buchbinder@unh.edu
Bui, Mai, Texas State University, mtb104@txstate.edu

Burkett, Katie, North Carolina State University, keburket@ncsu.edu
Burnett, Camille S., Prairie View A&M University, csburnett@pvamu.edu
Bush, Sarah B., University of Central Florida, Sarah.Bush@ucf.edu
Busi, Rich, James Madison University, busirp@jmu.edu
Butler, Rebecca, University of New Hampshire, rlb1053@wildcats.unh.edu
Caldwell, Brittany, University of California- Santa Cruz, bbettner@ucsc.edu
Caldwell, Brittany, Vanderbilt University, brittany.caldwell@vanderbilt.edu
Campbell, Tye, Utah State University, tgcamp22@gmail.com
Cannon, Susan, University of Georgia, cannonso@uga.edu
Cardetti, Fabiana, University of Connecticut, fabiana.cardetti@uconn.edu
Carll, Erin, University of Washington, ecarll@uw.edu
Carlson, Mary, Montana State University, mary.carlson5@montana.edu
Carmona, Guadalupe, University of Texas at San Antonio, guadalupe.carmona@utsa.edu
Caro-Rora, Domonique, Florida State University, dr11e@my.fsu.edu
Carson, Cynthia, Warner School of Education - University of Rochester, cynthiacarson17@gmail.com
Cavanna, Jillian M, University of Hartford, cavanna@hartford.edu
Cavey, Laurie Overman, Boise State University, lauriecavey@boisestate.edu
Caviness, Stephen, Syracuse University, scavines@syr.edu
Chao, Theodore, The Ohio State University, chao.160@osu.edu
Chavez, Oscar, Illinois State University, ochave2@ilstu.edu
Chavez, Rosa, Texas Tech University, rosa.d.chavez@ttu.edu
Chen, Lizhen, Western Washington University, chenl24@wwu.edu
Chen, Xiuhan, University of Missouri, Columbia, xcthc@missouri.edu
Chernoff, Egan J, University of Saskatchewan, egan.chernoff@usask.ca
Chicalote Jiménez, Tania Azucena, CINVESTAV-IPN, tania.chicalote@cinvestav.mx
Cirillo, Michelle, University of Delaware, mcirillo@udel.edu
Civil, Marta, University of Arizona, civil@math.arizona.edu
Claiborne, Brit, Boston University, bcn@bu.edu
Corey, Douglas, Brigham Young University, corey@mathed.byu.edu
Corriveau, Claudia, Université Laval, claudia.corriveau@fse.ulaval.ca
Cortina, José Luis, Universidad Pedagógica Nacional, México, jcortina@upn.mx
Corven, Julien, Illinois State University, jccorve@ilstu.edu
Cox, Dana Christine, Miami University, Dana.Cox@MiamiOH.edu
Crawford, Angela R, Boise State University, angelacrawford1@boisestate.edu
Cribbs, Jennifer, Oklahoma State University, jennifer.cribbs@okstate.edu
Cullen, Amanda L, Illinois State University, almille@ilstu.edu
Czocher, Jennifer A, Texas State University, czocher.1@txstate.edu
Daniel, Amy L, Montclair State University, daniela4@montclair.edu
Darrah, Marjorie Anne, West Virginia University, marjorie.darrah@mail.wvu.edu
Davis, Catherine, Brigham Young University, catherine.davis@byu.edu
Davis, Jon D., jon.davis@wmich.edu, jon.davis@wmich.edu
Deal, Emily, Illinois State University, eedeal@ilstu.edu
de Alba, Carlos Alejandro, San Diego State University & University of California, San Diego, cdealba3923@sdsu.edu
de Araujo, Zandra, University of Florida, zdearaujo@coe.ufl.edu
Dennis, Catherine, University of New Hampshire, catherine.dennis@unh.edu
D'Ercole, Katherine E., Virginia Tech, katherinedercole@vt.edu

Dias, Laurel, Utah Valley University, laurel.dias@uvu.edu
DiCioccio, Mary, University at Buffalo, marydici@buffalo.edu
Dietiker, Leslie, Boston University, dietiker@bu.edu
Dimmel, Justin, University of Maine, justin.dimmel@maine.edu
DiNapoli, Joseph, Montclair State University, dinapolij@montclair.edu
Dingman, Shannon, University of Arkansas, sdingman@uark.edu
Dirdak, Abigayle, University of Arizona, adirdak@math.arizona.edu
Dobie, Tracy Elyse, University of Utah, tracy.dobie@utah.edu
Doherty, Kristin, Michigan State University, kdoherty@msu.edu
Donoghue, Tarah Michelle, University of Colorado - Boulder, tarah.donoghue@colorado.edu
Duarte, Alejandra, North Carolina State University, aduarte2@ncsu.edu
Dubbs, Christopher, East Stroudsburg University, cdubbs@esu.edu
Dubeau, Katryne, University of Saskatchewan, katryne.dubeau@usask.ca
DUCLOUX, KANITA, Western Kentucky University, kanita.ducloux@wku.edu
Dula, Jessica, Horizon Research, Inc., j.dula@horizon-research.com
Duni, Dhimitraq, Eastern New Mexico University, dhimitraq.duni@enmu.edu
Duseau, Karen Leary, University of Massachusetts, Dartmouth, kduseau@umassd.edu
Eason, Sarah H., Purdue University, season@purdue.edu
Edwards, Belinda, Kennesaw State University, bedwards@kennesaw.edu
Edwards, Laurie D., Saint Mary's College of California, ledwards@stmarys-ca.edu
Edwards, Michael Todd, Miami University of Ohio, edwardm2@miamioh.edu
Egbedeyi, Temitope, Kent State University, tegbedey@kent.edu
Eiland, Michael D., Purdue University, meiland@purdue.edu
Elizondo, Dr. Andrea M, Del Mar College, aelizondo43@delmar.edu
Ellis, Brittney, Texas State University, b_e107@txstate.edu
Ellis, Ruby, North Carolina State University, rellis7@ncsu.edu
Ellis Hagman, Jess, Colorado State University, jess.ellis@colostate.edu
Erden, Coskun, Iowa State University, cerden@giastate.edu
Erskine, Abigail, Purdue University, aerskin@purdue.edu
Erwin, Alicia, Illinois State University, amerwi2@ilstu.edu
Ester Mariñoso, Pilar, Universidad Camilo Jose Cela, pester@ucjc.edu
Ewing, Olivia, Utah State University, olivia.ewing@usu.edu
Falley, Brandi, Texas Woman's University, bfalley@twu.edu
Fantin-Hardesty, Kaylee, Colorado State University, kaylee.fantinhardesty@colostate.edu
Feikes, David, Purdue University Northwest, feikesd@pnw.edu
Fernandez, Luis Miguel, The University of Texas Rio Grande Valley, lmfg1992@gmail.com
Fernandez, Maria L., Florida International University, mfernan@fiu.edu
Ferragud, Carlos Bernardo Gómez, Departamento Didáctica de las Ciencias Experimentales y Sociales. Universidad de Valencia, carlos.b.gomez@uv.es
Fink, Heather, Portland State University, hfink@pdx.edu
Fisher, Christine, UNC Greensboro, cakierna@uncg.edu
Fisher, Molly, University of Kentucky, molly.fisher@uky.edu
Flaggs, Darolyn A., Kennesaw State University, dflaggs@kennesaw.edu
Flavin, Eunhye, Stonehill College, eflavin@stonehill.edu
Folger, Timothy Donald, Bowling Green State University, tdfolge@bgsu.edu
Fonger, Nicole L., Syracuse University,

nfonger@syr.edu
Forte, Frank, Montclair State University, fortef@montclair.edu
Foyn, Trine, University of South Eastern Norway, trine.m.foyn@usn.no
Francis, Dionne Cross Cross, University of North Carolina at Chapel Hill, dicross@unc.edu
Franklin, Jeffery, Indianapolis University Purdue University Indiana, frankljj22@gmail.com
Frauenholtz, Todd, Bemidji State University, TFrauenholtz@bemidjistate.edu
Frazee, Leah Michelle, Central Connecticut State University, frazee@ccsu.edu
Fulwider, Doris, Purdue University, dfulwide@purdue.edu
Galanti, Terrie, University of North Florida, terrie.galanti@unf.edu
Galindo, Claudia, University of Maryland, galindo@umd.edu
Galindo, Enrique, Indiana University, egalindo@indiana.edu
Gandolfi, Enrico, Kent State University, egandol1@kent.edu
Gantt, Allison L., University of Delaware, agantt@udel.edu
Gao, Manqing, Portland State, manqgao@pdx.edu
Garcia, Nicole, University of Michigan - Ann Arbor, nmgarcia@umich.edu
García-Rodríguez, Martha Leticia, Instituto Politécnico Nacional, martha.garcia@gmail.com
Gardiner, Angela Murphy, TERC, angela_gardiner@terc.edu
Gargroetzi, Emma Carene, University of Texas at Austin, egroetzinger@gmail.com
Gartland, Sara, National University of Ireland Galway, sara.gartland@nuigalway.ie
Gatza, Andrew M, Ball State University, amgatza@bsu.edu
Geller-McKee, Ricki Lauren, Purdue, rickilauren28@gmail.com
Gerami, Saba, University of Michigan, sgerami@umich.edu
Gerardo, Juan M, University of Cincinnati, proforgs@mrg9605.com
Ghousseini, Hala, University of Wisconsin-Madison, Ghousseini@wisc.edu
Gibson, Jennifer, James Madison University, gibso2js@jmu.edu
Gilchrist, Sarah, The Ohio State University, gilchrist.42@osu.edu
Gillander, Lorianne, Texas Woman's University, lgillander@twu.edu
Gillespie, Ryan, University of Idaho, rgillespie@uidaho.edu
Goffney, Imani, University of Maryland-College Park, igoffney@umd.edu
Gonzalez, Dario Andres, Universidad Autónoma de Chile, dario.gonzalez@fulbrighmail.org
Goodwin, Connor, Indiana State University, Connor.Goodwin@indstate.edu
Gordon, Evelyn M, Horizon Research, Inc., egordon@horizon-research.com
Goyer, Alysia, University of Nevada, Reno, agoyer@nevada.unr.edu
Graham, Bruce Michael, North Carolina State University, bmgraha2@ncsu.edu
Grande, Nicholas, The Pennsylvania State University, npg5053@psu.edu
Grant, Melva R, Old Dominion University, mgrant@odu.edu
Graysay, Duane, Syracuse University, dtgraysa@syr.edu
Green, Mindy, Revere Jr./Sr. High School, mindy.green@reverescool.com
Greene, Mary Philomena, Montana State University, marygreene1@montana.edu
Greenstein, Steven, Montclair State University, greensteins@montclair.edu
Gresalfi, Melissa, Vanderbilt University, melissa.gresalfi@vanderbilt.edu
Griffin, Camille, University of Illinois at Urbana-Champaign, cgriffi5@illinois.edu
Griffin, Casey, University of Delaware, crgrif@udel.edu
Grigorian, Sergey, University of Texas Rio Grande Valley, sergey.grigorian@utrgv.edu
Guajardo, Lino, Texas State University, lrg74@txstate.edu

Guang, Claire, University of Notre Dame, cguang@nd.edu
Guerra Rodríguez, Abraham Emmanuel, Universidad de Guadalajara, abraham.guerra5480@alumnos.udg.mx
Gunes, Canan, Simon Fraser University, canan_gunes@sfu.ca
Gustaveson, Anna, University of North Carolina, annagus@unc.edu
Gustavsen, Trond Stølen, University of South-Eastern Norway, trond.gustavsen@usn.no
Gutierrez de Blume, Antonio Partida, Georgia Southern University, agutierrez@georgiasouthern.edu
Gutierréz-Pulido, Humberto, Universidad de Guadalajara, humberto.gutierrez@cucei.udg.mx
Habib, Kathryn, University of North Carolina, kaldrich@unc.edu
Hackenberg, Amy J, Indiana University-Bloomington, ahackenb@indiana.edu
Hahs-Vaughn, Debbie, University of Central Florida- Orlando, debbie@ucf.edu
Haiduc, Ana-Maria, Purdue University, ahaiduc@purdue.edu
Haines, Cara, University of Nevada-Las Vegas, cara.haines@unlv.edu
Hall, Elisha, Western Michigan University, elisha.d.hall@wmich.edu
Hall, Sandra, University of Saskatchewan, sandra.hall@usask.ca
Hallman-Thrasher, Allyson, Ohio University, hallman@ohio.edu
Hamm, Jill V, UNC Chapel Hill, jill.hamm@unc.edu
HAMMONDS, KATHERINE ELIZABETH, Auburn University, hammoke@gmail.com
Han, Simon Byeonguk, Portland State University, byeonguk@pdx.edu
Hanan, Adam, University of Idaho, hana3274@vandals.uidaho.edu
Hand, Victoria, University of Colorado Boulder, victoria.hand@colorado.edu
Hardison, Hamilton, Texas State University, HHardison@txstate.edu
Harper, Suzanne R., Miami University, harpersr@miamioh.edu
Harris, Courtney, The Ohio State University, harris.1050@buckeyemail.osu.edu
HARTMANN, CHRISTINE, Utah State University, christine.k.hartmann@gmail.com
Heck, Daniel, Horizon Research, Inc., dheck@horizon-research.com
Hedrick, Alison, Kennesaw State University, ahedric1@kennesaw.edu
Heikila, Tara, Washington State University- Vancouver, tara.heikila@wsu.edu
Henson, Robert, UNC Greensboro, rahenson@uncg.edu
Herbst, Pat G, University of Michigan, pgherbst@umich.edu
Hernández García, Adrián, UPN, adrianhernandez28@hotmail.com
Herrera, Erick, Indiana State University, eherrera2@sycamores.indstate.edu
HERREROS TORRES, DIANA, Departamento Didáctica de la Matemática. Universidad de Valencia, diaheto@alumni.uv.es
Hertel, Matthew, The University of Texas, at Austin, hertelma@utexas.edu
Hetrick, Carolyn, University of Michigan, hetrickc@umich.edu
Hidayat, Angga, the Ohio State University, hidayat.8@osu.edu
Higgins, Heidi J, University of North Carolina Wilmington, higginsh@uncw.edu
Hillen, Amy, Kennesaw State University, ahillen@kennesaw.edu
HINDEN, ANNA, UNC, annarh@unc.edu
Hirni, Megan, University of Missouri, Columbia, mj.hirni@missouri.edu
Hoermann-Elliott, Jackie, Texas Woman's University, jhoermannelliott@twu.edu
Hoffman, Rebecca, Bemidji State University, rebecca.hoffman@bemidjistate.edu
Hohensee, Charles, University of Delaware, hohensee@udel.edu
Holl-Cross, Cathy, UNC Charlotte, chollcro@uncc.edu
Holman, Kenneth, University of Central Florida,

kennethholman@knights.ucf.edu
Hong, Dae S., University of Iowa, dae-hong@uiowa.edu
Hopkins, Theresa, University of Tennessee, thopkins@utk.edu
Hornburg, Caroline Byrd, Virginia Tech, chornburg@vt.edu
Houle, Julie, Lester B. Pearson School Board, jhoule02@lbpearson.ca
Howlett, Brooke, The University of Maine, brooke.howlett@maine.edu
Hua, Annie, The New School, huaa162@newschool.edu
Huang, Siqi, University of California, Berkeley, shuang123@berkeley.edu
Huffman Hayes, Amanda, Purdue University, huffma33@purdue.edu
Hunt, Jessica H., North Carolina State University, jhunt5@ncsu.edu
Hwang, Jihye, Michigan State University, hwangji7@msu.edu
Hwang, Sunghwan, Seoul Gaju Elementary School, ihwang413@gmail.com
I, Ji Yeong, iowa state university of science and technology, jiyeongi@iastate.edu
Ion, Michael, University of Michigan, mikeion@umich.edu
Izard, Blair, SUNY Empire State College, blair.izard@esc.edu
Jackson, Brent, WestEd, bjackso@wested.org
Jackson, Christa, Saint Louis University, christa.jackson@slu.edu
Jacobson, Erik, Indiana University, erdajaco@indiana.edu
Jansen, Amanda, University of Delaware, jansen@udel.edu
Jarnutowski, Becca, University of Arizona, jarnutowski@math.arizona.edu
Jarry-Shore, Michael, Boise State University, mjarryshore@boisestate.edu
Jeannotte, Doris, UQAM, doris.jeannotte@uqam.ca
Jegede, Kehinde, Illinois State University, kojeged@ilstu.edu
Jensen, Bryant, Brigham Young University, bryant_jensen@byu.edu
Jeon, Soobin, University of Michigan, sbjeon@umich.edu
Jessup, Naomi, Georgia State University, njessup@gsu.edu
Jiang, Nan, University of Arizona, jiangn@arizona.edu
Johnson, Heather Lynn, University of Colorado Denver, heather.johnson@ucdenver.edu
Jong, Cindy, University of Kentucky, cindy.jong@uky.edu
Jordan, Kerry, Utah State University, kerry.jordan@usu.edu
Joseph, Manjula, Fresno Pacific University, manjula.joseph@fresno.edu
Jung, Hyunyi, University of Florida, hyunyi.jung@coe.ufl.edu
Kacerja, Suela, University of South-Eastern Norway, suela.kacerja@usn.no
Kamaldar, Azar, Florida State University, ak22@fsu.edu
Kamlue, Nitchada, Western Michigan University, nitchada.kamlue@wmich.edu
Kang, Rui, Georgia College & State University, rui.kang@gcsu.edu
Karagoz Akar, Gulseren, Bogazici University, gulseren.akar@boun.edu.tr
Karami Isheqlou, Leyla, Utah State University, a02370623@usu.edu
Karanevich, Peter, CU Boulder, peka7558@colorado.edu
Kastberg, Signe, Purdue University, skastber@purdue.edu
Kaufman-Ridout, Bailey Anne, Fordham University, bkaufman12@fordham.edu
Kaur Bharaj, pavneet, University of Massachusettes Boston, pkbharaj@indiana.edu
Keazer, Lindsay M., Sacred Heart University, keazerl@sacredheart.edu
Kebreab, Lybrya, Saint Louis University, lybrya.kebreab@slu.edu
Keiser, Jane M., Miami University, Keiserjm@miamioh.edu
Kendrick, Rose, Louisiana State University, rkendr3@lsu.edu
Kent, Laura Brinker, University of Arkansas, lkent@uark.edu
Kercher, Andrew, Simon Fraser University, andrew_kercher@sfu.ca
Kernin, Aysia, Boise State University, aysiakernin@u.boisestate.edu
Kerrigan, Sarah, George

Fox University, skerrigan@georgefox.edu
Kim, Jisun, Virginia Tech, jisunk@vt.edu
Kim, Soojung, Purdue University, West Lafayette, IN, kim2358@purdue.edu
Kim, Youngjun, Montclair State University, kimy8@montclair.edu
Kinach, Barbara, Arizona State University, barbara.kinach@asu.edu
Kirkland, David, University of Nevada, Reno, davidkirkland@nevada.unr.edu
Kirkland, Patrick, University of Norte Dame, pkirklan@nd.edu
Kirmizi, Mehmet, Texas State University, m_k307@txstate.edu
Kirwan, J Vince, Kennesaw State University, jkirwan@kennesaw.edu
Kitchen, Richard, University of Wyoming, rkitchen@uwyo.edu
Knight, John, University of Texas Rio Grande Valley, john.knight01@utrgv.edu
Knowe, Madison, Vanderbilt University, madison.l.knowe@vanderbilt.edu
Knurek, Robert, University of Colorado Denver, Robert.knurek@ucdenver.edu
Knuth, Eric, National Science Foundation, eknuth@nsf.gov
Ko, Inah, University of Michigan, Ann Arbor, inahko@umich.edu
Ko, Yi-Yin, Indiana State University, Winnie.Ko@indstate.edu
Kocabas, Sezai, Purdue University, skocabas@purdue.edu
Kochmanski, Nicholas, UNC Greensboro, nmkochmansk@uncg.edu
Kokushkin, Vladislav, Virginia Tech, vladkok@vt.edu
Koltz, Jessica L., Utah State University, jessica.koltz@usu.edu
Koskey, Kristin, Drexel University, kk3436@drexel.edu
Kosko, Karl Wesley, Kent State University, kkosko1@kent.edu
Krejci, Brooke, Winona State University, brookekkrejci@gmail.com
Krell, Michael W, University of Maryland, College Park, mkrell@umd.edu
Kroesch, Allison M, Illinois State University, amkroes@ilstu.edu
Kruger, Jennifer, University of Rochester, jkruger@warner.rochester.edu
Krupa, Erin E., North Carolina State University, eekrupa@ncsu.edu
Kuhlman, Adrian, North Carolina State University, akuhlma@ncsu.edu
Kularajan, Sindura Subanemy Kandasamy, Texas State University, s_k252@txstate.edu
Kulow, Torrey, Portland State University, kulow@pdx.edu
Kwon, Oh Hoon, University of Wisconsin - Madison, kwon@math.wisc.edu
Lafay, Anne, Concordia University, anne.lafay@concordia.ca
Lamb, Lisa, San Diego State University, Lisa.Lamb@sdsu.edu
Lamberg, Teruni, University of Nevada, Reno, Terunil@unr.edu
Lambert, Rachel, University of California Santa Barbara, rlambert@ucsb.edu
Leatham, Keith R., Brigham Young University, kleatham@mathed.byu.edu
Leckie, Emily, Boise State, emilyleckie@boisestate.edu
Lee, Alees, Weber State University, aleeslee@weber.edu
Lee, Boram, University of Texas at Austin, boram_lee@utexas.edu
Lee, Hollylynne S., NC State University, Hollylynne@ncsu.edu
Lee, Hwa Young, Texas State University, hylee@txstate.edu
Lee, Ji-Eun, Oakland University, lee2345@oakland.edu
Lee, Mi Yeon, Arizona State University, mlee115@asu.edu
Lee, Seoyeon, University at Buffalo-SUNY, seoyeonl@buffalo.edu
Lei, Qingli, University of Illinois Chicago, qlei@uic.edu
Leonard, Helene, Montclair State University, leonardh2@montclair.edu
Leos, Victor Baldemar, University of Colorado Boulder, victor.leos@colorado.edu
Leppma, Monica, West Virginia University, monica.leppma@mail.w

vu.edu
Leshin, Miriam S, Stanford University, mleshin@stanford.edu
Lesseig, Kristin, Washington State University Vancouver, kristin.lesseig@wsu.edu
Liang, Su, University of Texas, San Anotonio, su.liang@utsa.edu
Litster, Kristy, Valdosta State University, klitster@valdosta.edu
Liu, Bingyu, Purdue University, liu1972@purdue.edu
Liu, Di, East China Normal University, dliu@spe.ecnu.edu.cn
Liu, Jinqing, University of California, Irvine, jinqinl@uci.edu
Lizano, Cheryl, Southern Illinois University Edwardsville, Ceames@siue.edu
López-Iñesta, Emilia, Departamento Didáctica de la Matemátia. Universidad de Valencia, emilia.lopez@uv.es
Love, Candice, Vanderbilt University, candice.love@vanderbilt.edu
Lovin, LouAnn, James Madison University, lovinla@jmu.edu
Luczak, Rileigh, Michigan State University, luczakri@msu.edu
Luengo, Guillermo, Departamento Didáctica de la Matemática. Universidad de Valencia, guiluena@alumni.uv.es
Lunney Borden, Lisa, St. Francis Xavier University, lborden@stfx.ca
Luo, Fenqjen, Montana State University, fluo@montana.edu
Ma, Yue, University of Delaware, yuemajoy@udel.edu
MacDonald, Beth L., Illinois State University, blmacd1@ilstu.edu
Madva, Alex, California State Polytechnic University, Pomona, ammadva@cpp.edu
Magiera, Marta T., Marquette University, marta.magiera@marquette.edu
Mainzer, Emily, Penn State University, eadause@gmail.com
Males, Lorraine M, University of Nebraska-Lincoln, lmales2@unl.edu
Manouchehri, Azita, The Ohio State University, manouchehri.1@osu.edu
Margolis, Claudine, University of Michigan, czmars@umich.edu
Marino, Matthew, University of Central Florida, matthew.marino@ucf.edu
Marsh, Dalton Dayne, California State University, San Bernardino, Dalton.Marsh@csusb.edu
Martin, Jason, University of Central Arkansas, jmartin@uca.edu
Martinez, Robert, UNC Chapel Hill, rrmartin@email.unc.edu
Masingila, Joanna, Syracuse University, jomasing@syr.edu
Mask, Walker, University of Kentucky, walker.mask@uky.edu
Mason, Erica N., University of Illinois, Urbana-Champaign, enmason@illinois.edu
Matney, Gabriel, Bowling Green State University, gmatney@bgsu.edu
Matranga, Anthony, California State University San Marcos, amatranga@csusm.edu
Matthews-Johnson, Alicia, Michigan State University, Math325@msu.edu
MAUNTEL, Matthew, University of New Hampshire, mcm1196@unh.edu
Max, Brooke, Purdue University, bmax@purdue.edu
Mayes, Amanda S., Purdue University, asmayes@purdue.edu
Mbewe, Rose, PURDUE UNIVERSITY, rmbewe@purdue.edu
McCulloch, Allison, University of North Carolina at Charlotte, amccul11@uncc.edu
McElveen, Tamika L., Purdue University, tmcelvee@purdue.edu
McGathey, Natalie, Prairie State College, nmcgathey@prairiestate.edu
McGraw, Rebecca, University of Arizona, rmcgraw@math.arizona.edu
McVicar, Elzena, University of Washington-Seattle, elzenam@uw.edu
Meagher, Michael S, Brooklyn College - CUNY, mmeagher@brooklyn.cuny.edu
Medina, Sienna, Drexel University, sm4688@drexel.edu
Melhuish, Kathleen, Texas State University, melhuish@txstate.edu
Melville, Matthew, Purdue University Fort Wayne, mdmelvil@pfw.edu
Melzi, Gigliana, New York University,

gigliana.melzi@nyu.edu
Méndez Huerta, Dinorah, Universidad de Guadalajara, diino.me.hue@gmail.com
Middleton, James A, Arizona State University, jimbo@asu.edu
Miller, Mikhail, Drexel University, mm4879@drexel.edu
Miranda, Isaias, IPN, CICATA-Legaria, imirandav@ipn.mx
Mirin, Alison, University of Arizona, amirin@asu.edu
Mojica, Gemma F., NC State University, gmmojica@ncsu.edu
Moldavan, Alesia Mickle, Georgia Southern University, amoldavan@georgiasouthern.edu
Montero-Moguel, Luis E, The University of Texas at San Antonio, luis.monteromoguel@utsa.edu
Montufar Soria, Paola, New York University, paola.montufar@nyu.edu
Mooney, Edward, Illinois State University, mooney@ilstu.edu
Moore-Russo, Deborah, University of Oklahoma, dmr@ou.edu
Morales, Jr., Hector, Northeastern Illinois University, h-morales3@neiu.edu
Moreno, Juana, Louisiana State University, moreno@lsu.edu
Moreno-Armella, Luis, Cinvestav-IPN, lmorenoarmella@gmail.com
Morge, Shelby, University of North Carolina Wilmington, morges@uncw.edu
Moss, Diana L., University of Nevada, Reno, dmoss@unr.edu
Muñoz González, Luis Antonio, Universidad de Guadalajara, luis_87mg@hotmail.com
Munter, Charles, University of Missouri, munterc@missouri.edu
Nabie, Michael Johnson, University of Education Winneba, nabizie@yahoo.com
Nagle, Courtney, Larson Texts, Big Ideas Learning and Penn State Behrend, crt12@psu.edu
Naresh, Nirmala, University of North Texas, nirmala.naresh@unt.edu
Nathan, Mitchell J., University of Wisconsin - Madison, mnathan@wisc.edu
Navarro Robles, María Estela, Universidad Pedagógica Nacional, m.estela.navarro@gmail.com
Nazelli, Christopher, Wayne State University, ac3361@wayne.edu
Newton, Jill, Purdue University, janewton@purdue.edu
Nguyen, Hong, The New School, nguyh376@newschool.edu
Nguyen, Kayla, Vanderbilt University, khanh.m.nguyen@vanderbilt.edu
Nguyen, Phi, University of Missouri, phinguyen@mail.missouri.edu
Nguyen, Tomy, University of California Santa Barbara, tomynguyen@ucsb.edu
Nitta, Kathleen, Assistant Professor, Gonzaga University, nitta@gonzaga.edu
Njue, Emmy Wanditi, Syracuse University, ewnjue@syr.edu
Norton, Anderson, Virginia Tech, norton3@vt.edu
Nti-Asante, Emmanuel, University of Massachusetts, Dartmouth, emmaasante2012@gmail.com
Nuguid, Maria Eloisa, Purdue University, mnuguid@purdue.edu
Nzuki, Francis, Stockton University, Francis.Nzuki@stockton.edu
Öçal, Mehmet Fatih, Ağrı İbrahim Çeçen University, fatihocal@gmail.com
O'Dell, Jenna R, Bemidji State University, jenna.odell@bemidjistate.edu
Odiwuor, Brian, Syracuse University, bodiwuor@syr.edu
Oehrtman, Michael, Oklahoma State University, michael.oehrtman@okstate.edu
Offenholley, Kathleen, BMCC/CUNY, koffenholley@bmcc.cuny.edu
Ogden, Lori, West Virginia University, Lori.Ogden@mail.wvu.edu
Olanoff, Dana, Widener University, dolanoff@widener.edu
Olgun, Beyza, Middle East Technical University, bolgun@metu.edu.tr
Oliwe, Ruth, The Ohio State University, oliwe.1@osu.edu
Olson, Amy, Duquesne University,

olsona@duq.edu
Olson, Travis Austin, University of Nevada, Las Vegas, travis.olson@unlv.edu
Omoze, Hillary Ongoyo, Purdue University (West Lafayette), homoze@Purdue.edu
Onyeukwu, Enyinnaya Nnaemeka, Kennesaw State University, eonyeukw@students.kennesaw.edu
Oriowo, Olanrewaju, University of North Carolina at Charlotte, ooriowo@uncc.edu
Oropeza Legorreta, Carlos, Facultad de Estudios Superiores Cuautitlán UNAM, coropeza96@hotmail.com
Orozco, Claudia, Universidad de Guadalajara, claudia.orozcor@academicos.udg.mx
Orrill, Chandra Hawley, ReThink Learning Labs, chandra.orrill@rethinklearning.com
Orsini, Arielle, Concordia University, a.orsini@hotmail.ca
Ortiz, Daniel, CINVESTAV-IPN, daniel.ortiz@cinvestav.mx
Ortiz Galarza, Mayra Lizeth, University of Texas Rio Grande Valley, mayra.ortizgalarza@utrgv.edu
Osana, Helena P., Concordia University, helena.osana@concordia.ca
Oslund, Joy Ann, Grand Valley State University, oslundj@gvsu.edu
Otten, Samuel, University of Missouri at Columbia, ottensa@missouri.edu
Özgün-Koca, Asli, Wayne State University, aokoca@wayne.edu
Ozturk, Ayse, The Ohio State University, Newark, anuroztrk@gmail.com
Pace, Michelle, North Carolina State University, bmmurphy@ncsu.edu
Pacheco, Mike, University of Nevada, Reno, mpacheco@doe.nv.gov
Pak, Byungeun, Utah Tech University, b.pak@utahtech.edu
PALIWAL, VEENA, University of West Georgia, vpaliwal@westga.edu
Panda, Rahul, University of Wisconsin-Madison, rpanda3@wisc.edu
Pandiscio, Eric, University of Maine, ericp@maine.edu
Panorkou, Nicole, Montclair State University, panorkoun@montclair.edu
Paoletti, Teo, University of Delaware, teop@udel.edu
Park, Jungeun, University of Delaware, jungeunpark124@gmail.com
Parks, Amy Noelle, Michigan State, parksamy@msu.edu
Parrent, Parker, University of Kentucky, parker.parrent@uky.edu
Partridge, Eric, University of Missouri, egpbk6@missouri.edu
Patterson, Cody L, Texas State University, codypatterson@txstate.edu
Payne, Rolonda L., University of Maryland, College Park, rpayne18@umd.edu
Perkoski, Andre, Montclair State University, perkoskia1@montclair.edu
Perlander, Annika, University of South-Eastern Norway, annika.perlander@usn.no
Peru, Larissa, University of Arizona, larissap@arizona.edu
Peterson, Blake E, Brigham Young University, blake@byu.edu
Petrosino, Anthony, Southern Methodist University, apetrosino@mail.smu.edu
Pham, Autumn, Portland State University, autpham@pdx.edu
Pierce, Sheniqua, Georgia State University, spierce8@student.gsu.edu
Pineda, Jose Luis, Universidad de Guadalajara, jose.pineda4867@alumnos.udg.mx
Poling, Lisa L, Appalachian State University, polingll@appstate.edu
Pomponio, Erin, Montclair State University, pomponioe1@montclair.edu
Pop, Kellie J., University of Nevada, Reno, kpop@nevada.unr.edu
Powell, Sarah R, The University of Texas at Austin, srpowell@austin.utexas.edu
Prishker, Nydia, St. Thomas Aquinas College, nprishke@stac.edu
Proulx, Jerome, Université du Québec à Montréal,

proulx.jerome@uqam.ca

Provost, Amanda, Montclair State University, provosta1@montclair.edu

Pujiyanto, Fnu, Western Michigan University, fnu.pujiyanto@wmich.edu

Purpura, David J., Purdue University, purpura@purdue.edu

Quaisley, Kelsey Isla, University of Nebraska-Lincoln, kquigley@huskers.unl.edu

Quansah, Abigail Lois, Texas State University, alq8@txstate.edu

Quintos, Beatriz, University of Maryland, bquintos@umd.edu

Raja, Waleed Ashraf, Syracuse University, waraja@syr.edu

Reinsburrow, Amanda, Drexel University, alr352@drexel.edu

Rhodes, Sam, Georgia Southern University, srhodes@georgiasouthern.edu

Rice, Jenna, Carleton University, jennarice@cmail.carleton.ca

Rich, Erin, University of Alabama, eerich@crimson.ua.edu

Ricks, Thomas, Louisiana State University, tomricks@lsu.edu

Riling, Meghan, Vanderbilt University, meghan.riling@vanderbilt.edu

Rios, Jocelyn, Colorado State University, jocelyn.rios@colostate.edu

Ristroph, Ingrid, The University of Texas at Austin, ingrid.ristroph@utexas.edu

Rizzolo, Douglas, University of Delaware, drizzolo@udel.edu

Roan, Elizabeth, Texas State University, eaw109@txstate.edu

Roberson, Lee, Colorado State University, lee.roberson@colorado.edu

Robinson, Molly L, Portland State University, molrob2@pdx.edu

Roman, Christopher Orlando, Portland State University, roman7@pdx.edu

Roman, Kathryn E., Portland State University, kroman@pdx.edu

Romero Castro, Offir Neil, Western Michigan University, offirneil.romerocastro@wmich.edu

Roth McDuffie, Amy, Washington State University, mcduffie@wsu.edu

Rouhani, Andre, Arizona State University, arouhani@asu.edu

Ruiz, Beatriz, Universidad Iberoamericana, b_ruiz_b@hotmail.com

Ruk, Joshua M., University of Wisconsin-Whitewater, rukj@uww.edu

Rygaard Gaspard, Brandi, Texas State University, brr102@txstate.edu

Saclarides, Evthokia Stephanie, University of Cincinnati, saclares@ucmail.uc.edu

Sacristán, Ana Isabel, Cinvestav-IPN, asacrist@cinvestav.mx

SADOWNIK, STEPHANIE Ann, University of Toronto, Stephanie.sadownik@utoronto.ca

Safi, Farshid, University of Central Florida, Farshid.Safi@ucf.edu

Salazar, Fany, University of Arizona, fanysalazar@math.arizona.edu

Sanchez, Wendy, Kennesaw State University, wsanchez@kennesaw.edu

Sánchez Guerra, José Isaac, Facultad de Estudios Superiores Cuautitlán UNAM, joejade@hotmail.com

Sanz, Maria Teresa, Cepartamento Didáctica de la Matemática. Universidad de Valencia, m.teresa.sanz@uv.es

Sapkota, Bima Kumari, The University of Texas Rio Grande Valley, bima.sapkota@utrgv.edu

Sayavedra, Alyssa, California State University, Monterey Bay, asayavedra@csumb.edu

Schmitt, Sara A., University of Oregon, sschmitt@uoregon.edu

Schwarts, Gil, University of Michigan, gils@umich.edu

Selbach-Allen, Megan, Stanford University, mselbach@stanford.edu

Sencindiver, Benjamin D., City University of New York, ben.sencindiver@gmail.com

Seyranian, Viviane, California State Polytechnic University, Pomona, vseyranian@cpp.edu

Sharpe, Sheree, University of New Hampshire, sheree.sharpe@unh.edu

Shaughnessy, Meghan,

Boston University, mshaugh@bu.edu
Shumar, Wesley, Drexel University, shumarw@drexel.edu
Sidney, Pooja Gupta, University of Kentucky, pooja.sidney@uky.edu
Siebert, Daniel, Brigham Young University, dsiebert@mathed.byu.edu
Silverman, Jason, Drexel University, js657@drexel.edu
Simensen, Anita Movik, The Artic University of Norway, anita.m.simensen@uit.no
Simon, Martin, New York University, msimon@nyu.edu
Simpson, Amber, Binghamton University, asimpson@binghamton.edu
SIQING, LI, Law Ting Pong Secondary School, siqing.li@hotmail.com
Skultety, Lisa, University of Central Arkansas, lskultety@uca.edu
Slavit, David, Washington State University Vancouver, dslavit@wsu.edu
Smith, Bernard Ronald, University of Central Arkansas, bsmith25@cub.uca.edu
Smith, Ethan P., Washington State University Tri-Cities, ethan.p.smith@wsu.edu
Smith, Shawnda, Texas Woman's University, ssmith115@twu.edu
Smithey, Montana, Georgia Southern University, msmithey@georgiasouthern.edu
Smucker, Karoline, Eastern Oregon University, ksmucker@eou.edu
Son, Ji-Won, The State University of New York at Buffalo, jiwonson@buffalo.edu
Son, Kyunghoon, Boston College, sonky@bc.edu
Sondergeld, Toni Ann, Drexel University, tas365@drexel.edu
Sorto, M. Alejandra, Texas State University, sorto@txstate.edu
Soto, Hortensia, Colorado State University, Hortensia.Soto@colostate.edu
Sourwine, Jasmine, Iowa State University, jasmines@iastate.edu
Speed, Emmett, Utah State University, espeed@utah.gov
Staples, Megan, University of Connecticut, megan.staples@uconn.edu
Steinhorst, Dana, Karl G Maeser Prep Academy, dana.steinhorst@maeserprep.org
Stephens, Ana, University of Wisconsin-Madison, acstephens@wisc.edu
Stepnowski, Waldemar, Temple University, wstepnowski@temple.edu
Stevens, Alexis, James Madison University, stevenal@jmu.edu
Stevens, Irma, University of Rhode Island, irma.stevens@uri.edu
Stone, Gregory Ethan, MetriKs Amerique LLC, gregory@metriks.com
Stringer, Brinley Poulsen, San Diego State University, bstringer@sdsu.edu
Stroud, Rena, Merrimack College, stroudr@merrimack.edu
Stroup, Walter M., University of Massachusetts, Dartmouth, wstroup@umassd.edu
Stylianou, Despina, The City College of New York, dstylianou@ccny.cuny.edu
Suárez, Mayra Zulay, Centro de Investigación y de Estudios Avanzados del IPN, mayra.suarez@cinvestav.mx
Suarez Tellez, Liliana, Instituto Politecnico Nacional, lsuarez@ipn.mx
Suazo-Flores, Elizabeth, Purdue University, esuazo@purdue.edu
Suh, Jennifer M., George Mason University, jsuh4@gmu.edu
Sutton, Christy, University at Buffalo, csutton2@buffalo.edu
Swartz, Barbara, West Chester University, bswartz@wcupa.edu
Switzer, John Matt, Texas Christian University, j.switzer@tcu.edu
Tabares Sánchez, Liliana Aurora, CINVESTAV IPN, lilytabares@gmail.com
Tague, Jenna, Clovis Community College, jenna.tague@cloviscollege.edu
Taite, Geena, Montclair State University, taiteg1@montclair.edu
Talbot, Jennifer, Illinois State University, jkane@ilstu.edu
Tang, Haoran, Purdue University, tang474@purdue.edu
Tasova, Halil Ibrahim, California State University San Bernardino, halil.tasova@csusb.edu
Taub, Michelle, University of Central Florida,

michelle.taub@ucf.edu
Taylor, Cynthia, Oberlin College, ctaylor@oberlin.edu
Templeton, Tran, Columbia University, ttn2114@tc.columbia.edu
Teuscher, Dawn, Brigham Young University, dawn.teuscher@byu.edu
Thacker, Ian, University of Texas at San Antonio, ian.thacker@utsa.edu
Thanheiser, Eva, Portland State University, evat@pdx.edu
Thomas, Casedy Ann, University of Virginia, cat6hu@virginia.edu
Thomas, Jonathan Norris, University of Kentucky, jonathan.thomas1@uky.edu
Thrasher, Emily, NC State University, epthrash@ncsu.edu
Tillema, Erik S, Indiana University, etillema@indiana.edu
Tobias, Jennifer M., Illinois State University, jtobias@ilstu.edu
Towers, Jo, University of Calgary, towers@ucalgary.ca
Tran, Le M., The University of Texas at Austin, tran.le@utexas.edu
Tremaine, Rachel, Colorado State University, rachel.tremaine@colostate.edu
Trocki, Aaron, Elon University, atrocki@elon.edu
Troup, Jonathan David, CSUB, jtroup@csub.edu
Turan, Nurdan, New York University, nt2124@nyu.edu
Turner, Blake O'Neal, University of Maryland, bclark37@umd.edu
Turner, Erin, University of Arizona, eturner@email.arizona.edu
Tyburski, Brady A, Michigan State University, tybursk2@msu.edu
Umeh, Emmanuel Chukwuebuka, University of Missouri Columbia, ecung6@umsystem.edu
Utley, Juliana, Oklahoma State University, juliana.utley@okstate.edu
Valdivia, Isabel, Virginia Tech, isabelvl@vt.edu
Valenzuela, Carlos, Universidad de Guadalajara, carlos.valenzuela@academicos.udg.mx
Van Zoest, Laura R., Western Michigan University, laura.vanzoest@wmich.edu
Vargas-Alejo, Veronica, University of Guadalajara, veronica.vargas@academicos.udg.mx
Varley Gutierrez, Maura, University of Arizona, maurav@arizona.edu
Velasco, Richard, University of Oklahoma, richard.velasco@ou.edu
Vescio, Jamie, Vanderbilt University, jamie.vescio@vanderbilt.edu
Videlock Barstow, Alexandra, Boston University, abarstow@bu.edu
Vishnubhotla, Madhavi, Montclair State University, madhavi.sanskriti@gmail.com
Vogelstein, Lauren, Vanderbilt University, lauren.e.vogelstein@vanderbilt.edu
Voyias, Karley Violet, Syracuse University, kvvoyias@syr.edu
Vroom, Kristen, Michigan State University, vroom@msu.edu
Waddell, Jr., Glenn, University of Nevada, Reno, gwaddell@unr.edu
Walker, William, Purdue University, wswalker@purdue.edu
Wambua, Mitchelle Mbete, University of Missouri-Columbia, wambuamitchelle@gmail.com
Wang, Kun, University of Massachusetts Dartmouth, kwang1@umassd.edu
Wang, Sasha, Boise State University, SashaWang@boisestate.edu
Wang, Xiaohui, University of Texas Rio Grande Valley, xiaohui.wang@utrgv.edu
Wang, Ze, University of Missouri at Columbia, wangze@missouri.edu
Warshauer, Hiroko Kawaguchi, Texas State University, hw02@txstate.edu
Warshauer, max, 1951, max@txstate.edu
Watkins, Jonathan D, Ball State University, jdwatkins@bsu.edu
Webel, Corey, University of Missouri, webelcm@missouri.edu
Webster, Kate, Brigham Young University, m01webster@gmail.com
Weingarden, Merav, University of New-Hampshire,

merav.weingarden@unh.edu
Welder, Rachael Mae, University of Nevada, Reno, rachael@rachaelwelder.com
Wessman-Enzinger, Nicole Marie, George Fox University, nmenzinger@gmail.com
Whitacre, Ian, Florida State University, iwhitacre@fsu.edu
Wiest, Lynda R., University of Nevada - Reno, wiest@unr.edu
Wiezel, Adi, Arizona State University, Adi.Wiezel@asu.edu
Williams, Karmen, Louisiana State University, kwil419@lsu.edu
Williams, Steven R., Brigham Young University, williams@mathed.byu.edu
Wilson, Aaron Thomas, University of Texas Rio Grande Valley, aaron.wilson@utrgv.edu
Wilson, Jonee, North Carolina State University, jwilson9@ncsu.edu
Wilson, P. Holt, UNCG, phwilson@uncg.edu
Winsor, Matthew, Illinois State University, mwinsor@ilstu.edu
Wiseman, William Brad, University of Kentucky, william.wiseman@uky.edu
Witt, Nicholas, Western Michigan University, nicholas.e.witt@wmich.edu
Wladis, Claire, BMCC/CUNY, CUNY Graduate Center, CWLADIS@gmail.com
Wood, Marcy B, University of Arizona, mbwood@arizona.edu
Wrightsman, Elizabeth, Texas State University, e_w52@txstate.edu
Xin, Yan Ping, Purdue University, yxin@purdue.edu
xx, *Samantha, Universidad Autonoma de Coahuila, samanthaq.rivera@gmail.com
Yakhno, Alexander, Universidad de Guadalajara, alexander.yakhno@academicos.udg.mx
Yakubu, Sumaila, Montana State University Bozeman, ysumaila.ys@gmail.com
Yao, Xiangquan, Pennsylvania State University, xzy73@psu.edu
Yavuz, Selim, Indiana University, syavuz@iu.edu
Yenioglu, Busra Yilmaz, Purdue University, byilmazy@purdue.edu
Yenioglu, Samed, Purdue University, samedyenioglu@gmail.com
Yeo, Sheunghyun, University of Alabama, syeo@ua.edu
Yilmaz, Zuhal, Louisiana State University, zyilmaz@lsu.edu
York, Toni, Montclair State University, yorka1@montclair.edu
Yu, Karmen, Montclair State University, yuk4@montclair.edu
Yu, Paul Woo Dong, Grand Valley State University, yupaul@gvsu.edu
Zaldívar, José David, Universidad Autónoma de Coahuila, Facultad de Ciencias Físico Matemáticas, david.zaldivar@uadec.edu.mx
Zazkis, Dov, Arizona State University, dzazkis@asu.edu
Zazkis, Rina, Simon Fraser University, zazkis@sfu.ca
Zhang, Jingyuan, Purdue University, zhan3598@purdue.edu
Zhang, Pingping, Winona State University, pzhang@winona.edu
zhou, Lili, California State University, Los Angeles, lzhou18@calstatela.edu
Zhuang, Yuling, Emporia State University, yzhuang@emporia.edu
Zolfaghari, Maryam, Kent State University, mzolfagh@kent.edu
Zolt, Holly, Texas State University, hmz10@txstate.edu
Zwanch, Karen, Oklahoma State University, karen.zwanch@okstate.edu

SUBJECT INDEX

Technology: 006, 008, 013, 014, 043, 045, 047, 050, 062, 076, 078, 084, 098, 104, 108, 110, 111, 123, 141, 147

Undergraduate Education: 012, 013, 025, 026, 033, 050, 066, 067, 076, 078, 083, 087, 088, 090, 111, 112, 113, 122, 125, 130, 131, 133