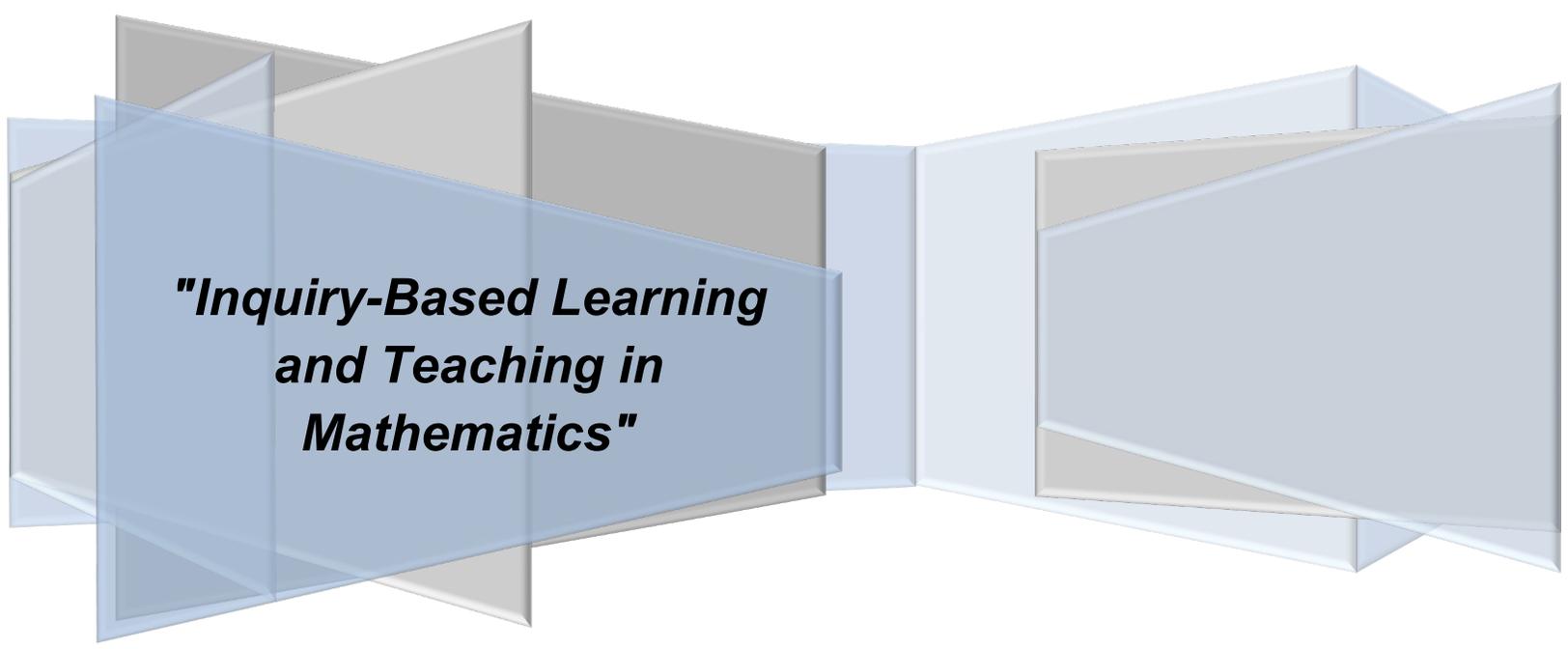


National IBL Conference

ABSTRACTS

May 31 thru June 2
2018



***"Inquiry-Based Learning
and Teaching in
Mathematics"***

Interactive Sessions Abstracts

Jason Belnap, University of Wisconsin Oshkosh

Using Inquiry and Non-Standard Assessment to Encourage the Development of Key Math Practices

Effective mathematics teaching requires deep, connected, and flexible knowledge of mathematics. Teachers must not only be able to perform mathematical procedures, but apply that knowledge to novel problems, generate examples and problems, make sense of and effectively responding to the validity of students' ideas. This type of knowledge is complex and can only be acquired through active engagement in varied tasks and situations.

Although inquiry based learning can help preservice teachers develop this type of knowledge, the reality is that there is not enough time in any program for preservice teachers to develop this type of knowledge for all of the math they will teach and encounter. They can, however, develop something even more critical, key mathematical practices that they can use to confidently access mathematical knowledge and attack challenging situations independently.

In this interactive session, participants will examine student work and identify student understanding, skills, and areas of improvement. Building on this, I will present a set of key mathematical practices, that have helped me effectively frame a number of content courses for preservice teachers, and discuss a modified form of grading that incorporates diverse forms of assessment in order to provide feedback and support for students' development of these practices.

Deependra Budhathoki, Ohio University; Bal Chandra Luitel, Kathmandu University; Binod Pd. Pant, Kathmandu University

Teacher's Learning Experiences: Hidden Curriculum for Teaching Mathematics as Inquiry

Experiencing mathematics with several roles helped us to realize that mathematics practices in Nepal are largely traditionally situated— focusing transfer of knowledge and the notion of behaviorism. Teachers and textbooks—which are considered the only source of knowledge —rarely provide spaces for students to interact and construct knowledge. Despite emerging student-centered and inquiry-driven practices, mathematics teaching in the majority of Nepalese classrooms have remained the same for decades. Recognizing inquiry-based teaching as tool for transforming Nepalese mathematics and understanding teachers' learning as a premise for their successful practice, a narrative research among three mathematics teachers of Kathmandu valley, Nepal was conducted. The research aimed at exploring their learning of mathematics, impacts of their learning on their teaching, and perceptions and practices of mathematics as inquiry to promote empowering mathematics learning of students. Based on its findings, this paper exhumes how teachers' learning experiences influence their classroom teaching. The discussion concludes that such experiences are hidden curricula for their teaching mathematics as inquiry. Interactive explanation: We believe that the inquiry practices can be contextual to teaching and learning environment. The sharing of our experiences and findings of the research may help the audiences to know the status and practice of inquiry-oriented mathematics teaching in Nepal. Some participants will be provided opportunities to share their related experiences. Furthermore, the stories of three teachers (research participants) can be a motivation for teachers to know and understand the several transitions in mathematics learning and teaching and how inquiry practices can be promoted from among the self-learning experiences.

Paul Dawkins, Northern Illinois University; Michael, Oehrtman, Oklahoma State University; Ted Mahavier, Lamar University

Student experiences in IBL Real Analysis

This session will present the outcome of a research collaboration between two mathematics education researchers and a highly experienced IBL practitioner. We studied one professor's IBL real analysis course to form an in depth model of his teaching practice and related accounts of student experiences in the course. We found that the professor's teaching was organized around achieving two primary goals: that students overcome significant challenges by independently creating proofs. We found that there was a significant variation among how the students engaged in the course and how the course created opportunities to meet these goals in a manner appropriate to each student. In our session, we will outline both the various practices the professor used to pursue his two key goals including varied assessment, reformulation of real analysis content, individualized feedback, and intentional invitations to further study and graduate school. The student experiences in the course primarily varied regarding the extent to which they bought in to the IBL teaching experience and whether they maintained a performance or learning orientation toward the course. Though some students exhibited low buy in to the IBL experience, we found that in many ways the professor was still successful in achieving his goals for those students' learning even while they negotiated to pursue their alternative goals for their engagement in the course.

Dorin Dumitrascu, Adrian College

Reflections on Flipping the Introductory Statistics Course

For four semesters I implemented the flipped pedagogy in the teaching of the introductory statistics course. Data was collected in order to analyze the effectiveness of the method with respect to students' learning, their attitudes toward statistics, and their attitudes toward instructor-made videos. After briefly reviewing the statistically significant measures pertaining to student learning, I will focus on analyzing the feedback received from the students about their flipped experience and on offering some perspectives from the instructor's point of view. These perspectives are data supported, based on questionnaires and tests of over 150 students. They will be helpful to people that consider utilizing the flipped pedagogy into their classes for the first time.

The interactive component of this session will consist of the following: in small groups, hypothesize some challenges that the students are likely to encounter when a class like this is flipped; after watching a portion of a video produced for the course and working out a class activity, revise the list of challenges; finally, discuss these in the context of the evaluations of the course experience provided by the students at the end of the semester.

Sarah Eichhorn, University of Texas at Austin

An IBL Game Theory Course-Based Undergraduate Research Experience

Game Theory is an ideal course in which to introduce students to mathematical research. The prerequisite knowledge requirements are low and many of the definitions and theory can be readily discovered by students through simply playing games. We will discuss IBL instructional approaches used in a lower-division introduction to mathematical research course. In particular, we will highlight how the IBL form activities prepared students to generate and explore mathematical research questions in game theory. Participants will engage in a sample activity, discuss the roles of student and instructor in building the formalism, and start formulating their own game theory research questions. This project was funded by NSF PRISM grant DMS-0928427.

Mary Flagg, University of St. Thomas

Teaching Linear Algebra with Primary Sources

When was Gaussian elimination first developed? The “obvious” answer is that it was developed in the nineteenth century by Gauss, but that is not true. The first appearance of solving a system of linear equations using array notation was in the ancient Chinese text *The Nine Chapters on the Mathematical Art*, from about 2000 years ago! The curriculum module “Solving a System of Linear Equations Using Ancient Chinese Methods” was written to introduce elimination in a standard linear algebra class by guiding the students through readings from the ancient Chinese text. The project was intended to be used in an active learning style using individual reading, group work in class and whole class discussion. The text contains selected quotes from the *Nine Chapters* with explanations and questions spaced throughout to guide the students to discover the method on their own. Participants in this session will encounter the Fangcheng Rule for solving a system of linear equations and apply the procedure to a problem from the *Nine Chapters*. My goal is to invite other instructors to take advantage of this project and other projects using original sources to introduce core mathematics concepts as resources for their classroom.

Heather Lynn Johnson, University of Colorado Denver; Gary Olson, University of Colorado Denver; Jeremiah Kalir, University of Colorado Denver; Amber Gardner, University of Colorado Denver; Amy Smith, University of Colorado Denver

Questioning our Questions in Online Math Tasks: From Soliciting Answers to Eliciting Reasoning

How can we provide opportunities for all of our students to engage in mathematical reasoning? What roles can our questions play in students’ opportunities for reasoning? And how might our expectations for students’ responses impact their opportunities for reasoning? Through our questions, we can position students as experts in their mathematical thinking. We share three design principles guiding how we pose questions in online mathematical tasks and facilitate student discussion around those questions. First, seek to elicit reasoning rather than solicit answers. Second, provide opportunities for students to make sense of others’ claims. Third, allow for gender ambiguity when incorporating student names into task questions. We situate our questioning within the mathematics of change and variation, connecting to topics addressed in courses including College Algebra and Precalculus. Participants will have opportunities to anticipate how students could respond to different questions and discuss teaching moves to facilitate student discussion around those questions. Participants can expect to gain insights into how instructors’ goals for questioning may impact students’ opportunities to engage in mathematical reasoning.

Matthias Kawski, Arizona State University

Navajo Math Circles

This film documents the meeting of two worlds: that of some of the country’s most accomplished mathematicians and math educators, with the children and teachers in the underserved, and rural Navajo educational system. Hundreds of Navajo children in recent years have found themselves at the center of a lively collaboration with mathematicians from around the world. The children stay late after school and assemble over the summer to study mathematics, using a model called math circles, which originated in Eastern Europe and which has proliferated across the United States. This notion of student-centered learning puts children in charge of exploring mathematics to their own joy and satisfaction, with potentially long-lasting results.

Eric Kuennen, University of Wisconsin Oshkosh; Jason Belnap, University of Wisconsin Oshkosh
Using Problem Solving to Motivate Mathematics Content in Courses for Future Math Teachers

To prepare pre-service teachers for their future mathematical work of teaching, mathematics content courses should give students experience in actually “doing mathematics”. This means students should analyze problems, make conjectures, make arguments, learn to listen to and evaluate the claims of others, and communicate their findings and ideas. By engaging in mathematical problem solving, both in small groups and during whole class discussions, students have the opportunity both to develop a deep understanding of mathematics content, and to develop mathematical sophistication (i.e. the habits, practices, and ways of knowing of the math community).

In this interactive session, we will share some of our favorite class activities, manipulatives, and resources that we have found most effective in providing our students with these experiences. Session participants will work collaboratively in small groups to solve two rich and engaging problems dealing with fraction operations and with number theory, and discuss the math content and practices that these problems can elicit. Through this experience, participants can appreciate how problem-solving as a method of instruction can be used to motivate an exploration of new mathematics content and lead to student development of new ideas.

Eric Kuennen, University of Wisconsin Oshkosh
Problem-Based Inquiry in College Algebra

College algebra is intended to prepare students with the algebra skills needed for calculus, and thus tends to focus on procedural knowledge of a wide variety of algebraic techniques. Traditionally, students are shown how to solve a problem, and are given exercises to practice the procedure shown, with little or no focus on why these procedures work. As such students do not see that algebra makes sense and is something that they can figure out and explain why it works. I am attempting to put the “college” back into College Algebra, revising the course to focus on conceptual understanding of the big ideas in algebraic thinking, through engaging students in authentic IBL. I have focused on the construct of “algebraic thinking” as defined by the three key “Algebraic Habits of Mind” identified by Mark Driscoll: Doing-Undoing, Building Rules to Represent Functions, and Abstracting from Computation.

In this session, participants will work in small groups on IBL tasks that I designed to highlight big algebraic ideas and spark a discussion of particular algebraic techniques and students’ alternate conceptions that lead to common algebra mistakes. Students are asked to analyze solutions and methods, explore representations, and explain why valid methods for simplifying expressions solving equations work, and explain why invalid methods do not work. Class discussions of these problems focus on the mathematical reasoning and proof needed to nurture longer-lasting understanding of the content.

Sandra Laursen, University of Colorado Boulder

Messaging in an Educational Movement: Why How We Talk About IBL Matters

I will summarize recent research by Haberler, Hayward and Laursen (2018) that examines how the history of IBL as an educational reform movement has influenced the framing of the movement—the “branding” or ways people inside and outside the movement understand it. Our research shows that intentional and unintended messages are attached to this movement; some of these deter instructors from participating. As participants in the movement, we can be more deliberate about considering the messages we offer. I will lead a discussion about the IBL “brand” and how we can influence the meaning of that brand to be more inclusive as we move forward.

Jae Ki Lee, Borough of Manhattan Community College; Sun Young Ban, Borough of Manhattan Community College

Learning Statistics based on Inquiry Based Learning Strategy

The introduction to Statistics is a fundamental course for data analysis. The topic covers basic concepts of collecting data, analyzing data, finding the central tendency, Probability, Hypothesis Test and so on. However, statistics is not typical mathematics. Unlike any regular mathematics subjects, it doesn't follow the regular mathematics properties. Thus, students struggle to understand the subject. The Inquiry Based Learning (IBL) provides a chance for students to explore the questions. It allows each student find solutions using different approaches. Throughout this IBL conference, I would like to share some examples, so that I would like to introduce how I set up the IBL in my Introduction to Statistics class, and how IBL developed the students' engagement of learning Statistics, and how deep students can learn and explore the topic. This demonstration involves few activities, so that participants indirectly experience my students' learning based on IBL.

Carolyn Luna, The University of Texas at San Antonio

The Classroom as Community: Using IBL to Create an Inclusive Learning Environment and Engage Large Classes

Faculty play an important role in creating a community of learners in the classroom, regardless of its physical design. In this session I will address possible curricular changes to improve student inclusion, increase retention, and allow for the success of diverse learners in mathematics classrooms using IBL methodology. This session will provide suggestions on how to improve student inclusion that are research-based and that will keep your classroom of over 100 students actively learning. I will share specific examples of 15-minute activities I use in my classroom to improve students' communication and problem-solving skills. Attend this session if you want to learn about and discuss specific inclusive pedagogy techniques that will transform your large mathematics classroom into a community environment that values all voices.

Susanna Molitoris Miller, Kennesaw State University

Reconciling Self-Directed Learning and Required Learning Objectives in a Mathematics Content Course

Self-directed learning (SDL) is a pedagogical tool which gives students increased autonomy, allowing them to control what and how they learn. However, most college courses which run multiple sections with different instructors have a required set of objectives to be met. These required objectives can seem quite in conflict with the open-ended nature of SDL. In this presentation we share the results of a self-study of how one professor, Susanna, adapted an SDL project for use in a mathematics content course for pre-service teachers. The instructor kept journal entries before, throughout, and after implementing the project, which serve as data for this study. After learning about a colleague's use of SDL in a flexible capstone course, Susanna worked to adapt the project for use in her more structured mathematics content course for pre-service teachers. To do so she made purposeful decisions concerning why she would incorporate SDL, how to introduce/explain the project to students, how to scale components of the project to fit within her course, and how to grade the projects. She later reflected on the effectiveness of these choices and possible alternatives for future use. Attention is given to the benefits, challenges and drawbacks a professor might experience when using SDL for the first time. I seek a discussion about navigating the tension between open learning opportunities and strict course objectives.

Sarah A. Nelson, Lenoir-Rhyne University

Embodied Activities: Engaging Students via Life Size Exploration

At the 2016 MAA MathFest, I was fortunate enough to participate in the Project NExT workshop led by Dr. Hortensia Soto (University of Northern Colorado) on embodied activities. By having students take on the role of the object(s) they are studying, embodied activities afford students the opportunity to experience the associated concepts and challenge students to develop a deeper understanding of the related definitions. My experiences have shown that these assignments promote student engagement, allow students to struggle productively within a safe environment, and support student success. In this session, I will share materials I have developed for studying Venn Diagrams, the Cartesian Coordinate System, and graphing. After I share how I designed and implemented these activities into my Spring 2018 courses, we will work together to brainstorm ideas for embodied activities focused on other mathematical concepts. As time permits, we will also collaborate to develop such activities. I hope this session leads to ongoing collaborations to develop embodied activities.

Sandra Nite, Texas A&M University; Kimberly Currens, Texas A&M University

Exploring Periodic Functions Created by Sound Waves

Participants will work in groups to gather data from tuning forks, microphone probes, and calculator based laboratories (CBLs). This real life data will be used to explore period functions and their transformations. Participants will discuss ways to use inquiry to facilitate a deeper understanding of periodic functions such as sine and cosine, their characteristics, and their transformations. Students in the classroom would be given the task of finding a periodic function model for the data collected. **Please bring a graphing calculator (e.g., TI 84 or TI Nspire), if possible.**

Possible Questions for Exploration:

How can you set a good window for the data gathered? How does the graph show the characteristics of a function? How is the graph of this data like any previous functions you have studied? How is the graph different? If you knew the name of the parent function, what transformations could be used to model your data? How would you find the amount for the shifts and stretches?

Gary Olson, University of Colorado Denver; Heather Lynn Johnson, University of Colorado Denver; Jeremiah Kalir, University of Colorado Denver; Amber Gardner, University of Colorado Denver; Amy Smith, University of Colorado Denver

Two graphs are better than one: Techtivities for College Algebra

We share five Desmos Techtivities designed in collaboration with Dan Meyer for use in a College Algebra classroom. These Techtivities are freely available and link animations with dynamic graphs in innovative and exciting ways. Students interacting with the Techtivities can create and interpret different graphs to represent relationships between attributes capable of varying and possible to measure. During the session, participants will have an opportunity to explore the Techtivities on their own device (**laptop or tablet preferred**). We will model best practices facilitation of the Techtivities and discuss connections that can be made with the existing college algebra curriculum.

Cody Patterson, University of Texas at San Antonio

Connecting Real Analysis to Secondary Mathematics Teaching Through Inquiry-Based Learning

In this session, we will discuss insights gained from a graduate-level introductory real analysis course for inservice secondary mathematics teachers. The goal of the graduate course was to develop deep understanding of the mathematical foundations of some of the key ideas presented in introductory calculus courses: limits of functions and continuity, differentiability and linear approximation, integrability, and convergence of infinite sequences and series. The course used an inquiry-based model in which participating teachers presented major theorems in class. Teachers had access to versions of notes with and without proofs of the theorems to be discussed, so that they could challenge themselves to prove theorems on their own outside of class, but could also easily find assistance if they got stuck.

We will share some connections between learning of real analysis and secondary mathematics teaching that emerged from teachers' work on the problems in the course, such as robust thinking about rates of change, the use of pseudovariables as a tool for scaffolding the practice of generalization, and the role of graphs in thinking about functions and variation. We will also ask session participants to brainstorm and share ideas on how to connect real analysis to the mathematical work of teaching high school algebra, precalculus, and calculus.

Eileen Perez, Worcester State University; Hansun To, Worcester State University

Implementing IBL in a General Education Math Course at an Urban State College

All instructors have taught the course Survey of Math for four years using some aspects of Inquiry Based Learning. The course is a general education course for students majoring in Liberal Arts fields. For most of these students this is the last and only math course required for graduation. Placement into the course is open to all students including those with developmental math placements and needs. IBL has been shown to work well with the range of students taking this course.

For the course 5 units are covered and this demonstration will focus on one topic, Numeration Systems. The four basic operations addition, subtraction, multiplication and division in different number bases are covered. The instructors will introduce the material and go over several examples of each type. Next the students working together in pairs will investigate and enhance their understanding by working problems together on worksheets provided by the instructors. The worksheets provide problems to solve and pose questions to ensure the students develop a deep understanding. After the investigation phase students

will present their problems and lead the discussion. For this talk about 5 minutes will be spent introducing the material, then 10 minutes will be devoted to the demonstrating how this process works with the participants taking on the student role; leaving some time at then end for discussion among the participants.

Victor Piercey, Ferris State University

Fry Efficiency: An Inquiry-Based Introduction to Algebraic Formulas

One of the concepts that developmental mathematics students struggle with is building meaning out of symbolic expressions. In this talk, the audience will work through an activity designed to guide students to building a formula that is needed to complete a spreadsheet for a fast food franchise. In the process, a foundation is laid for further guided inquiry into constructing, deconstructing, and ultimately manipulating algebraic formulas. **This activity involves using google sheets, which can be accessed via a smartphone, tablet, or laptop computer.** Participants without a screen can share with partners.

Janice Rech, University of Nebraska at Omaha; Michael Matthews, University of Nebraska at Omaha
Using IBL to Prepare Teachers in a Noyce Scholarship Program

It is often quoted that "teachers teach as they were taught (Hall et al., 2006)." Current research revealed that teachers actually teach in the way they preferred to be taught, or the way they believe their students will learn best. (Cox, 2014). For teachers to integrate the mathematical practices of teaching (Cobb et al., 2011), they must have these experiences first as students in a mathematics classroom and even better - as a part of the instructional team. The University of Nebraska at Omaha was awarded a Noyce grant to prepare secondary mathematics teachers in 2015. Through this grant program, the math department at UNO committed to active engagement of students in a variety of ways in efforts to create better prepared math teachers. Throughout the country, mathematics departments should address their role in preparing future mathematics teachers. This session will involve discussions of ways in which participants' departments and schools have proactively engaged in teacher preparation in a variety of mathematics classes. Participants will share and report to the group various strategies employed. As part of the UNO Noyce program, several scholarship recipients have been engaged as Learning Assistants in IBL classrooms. This learner-centered method engages students in sense-making and requires the learning assistant to be part of the process with students. The Learning Assistants were selected from the Noyce Scholars and worked closely with the faculty in preparing for classes, as well as within the classes. The faculty trained the learning assistants to serve as support personnel for the students throughout the course. In this session, sample activities from the IBL Calculus classroom will be presented, as well. The use of Noyce Scholars in this role has been a positive component of the Noyce program. The Scholars bring their experiences back to the group of Scholars and Interns, but also their time in this capacity provides invaluable experience to them as they prepare to be excellent high school math teachers.

Janice Rech, University of Nebraska at Omaha; Michael Matthews, University of Nebraska at Omaha
Using IBL to Prepare Teachers in a Noyce Scholarship Program

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Milos Savic, University of Oklahoma; Gulden Karakok, University of Northern Colorado

ZEPs: Zero-Expectation Problems in IBL

Sometimes, in IBL, problems are posed to students with expectations. These expectations are part of an instructor's math "agenda"; they may include content-coverage problems or specific proof/problem-solving techniques. What if some problems were either open-ended, ill-posed, or even created by the students? In this session, participants will be engaged in creating zero-expectation problems with the hopes of further engaging students in rich mathematical thought. We will also share ways of assessing such problems. Our hope is to provide a way to humanize mathematics by allowing for students to create their own math "agendas."

Elizabeth Thoren, Pepperdine University

Leveraging Children's Mathematical Thinking in a Course for Future Elementary Teachers

Video observations of children doing mathematics can be a powerful tool for developing pre-service elementary teachers' mathematical knowledge for teaching. However, it can be challenging to connect children's thinking to pre-service teachers' understanding of the mathematics in a productive way. In this session participants will engage in a video observation of children doing mathematics as students in my course for pre-service elementary teachers would, we will reflect on the experience and discuss some techniques for effectively leveraging video observations of children's thinking in such a math class.

Belin Tsinnajinnie, Institute of American Indian Arts

Rehumanizing and Decolonizing Mathematics Through Inquiry Based Learning

Mathematics educators have pushed towards implementing policies, principles, and standards that promote active learning as a means to both promote equity and a richer mathematical learning experience. Such shifts have implications for the mathematical identities that are co-constructed in the classroom. Considerations of such implications would entail examining how we construct what it means to effectively do and learn mathematics and examining the ways our students see themselves as having the capacity to not only learn and do mathematics, but to create mathematical knowledge themselves. For students from historically marginalized communities, these shifts have the potential to reframe the roles of mathematics education in the transformation of their communities. In this presentation, I explore

ways in which inquiry based learning could support efforts towards equity, decolonizing, and rehumanizing mathematics. In build upon the work of decolonizing pedagogies through indigenous perspectives to frame the goals of mathematics education through inquiry based learning as not only a movement to reshape the mathematical education experiences of our students, but also a movement to reframe our relationships with the worlds around us. Groups will discuss our educational goals and the meaning of empowerment at classroom, institutional, and community levels.

Paul Yu, Grand Valley State University; Hope Gerson, Grand Valley State University

Technology, Inquiry, and Aesthetics in an Interactive Geometric Setting

In this interactive presentation we will use the lens of aesthetics (Sinclair, 2006) to explore mathematical creativity in an interactive geometric environment from three different perspectives: inquiry, teaching, and mathematical resolution. We will be illustrating mathematical inquiry and creativity with a video-episode where academically talented middle school students are working with Shape Makers (Battista, 2003) in Geometer's Sketchpad. At one point in the lesson, a student makes a triangle looking shape with the Kite Maker Tool and asks, "Can a triangle be a kite?" We see creative inquiry reflected in three ways: in the exploration of the kite-maker tool, in the teacher's instructional choices, and in the resolution of the mathematical discussion by the students. The creative and aesthetic qualities of open inquiry, the Geometer's Sketchpad and teacher moves, created a setting where students and the teacher made aesthetic choices to build understanding of geometric properties of kites and triangles as well as the limitations of sets of geometric properties in classifying geometric shapes. While the episode presented in this case is in a K-12 setting, this lesson has also been used in college mathematics courses, and the concepts presented also extrapolate to collegiate mathematics. Participant comments will be encouraged.

Working Groups Abstracts

Christine Andrews-Larson, Florida State University and Amanda Ruiz, University of San Diego
Teaching through Inquiry with an Eye toward Equity

“Active” approaches to learning have been linked to improved student learning and success across a broad range of studies in undergraduate science, technology, engineering, and mathematics (STEM; Freeman et al., 2014). Additionally, some research presents promising results of inquiry-based approaches to “level the playing field” (Laursen et al., 2014, p. 412), e.g. for men and women in mathematics, while other research suggests that simply adopting an inquiry-oriented approach to instruction is insufficient to guarantee equitable learning opportunities for students from various groups (Johnson et al., under review). The sometimes-invisible barriers faced by students from some groups can be amplified in such settings, particularly if instructors are unaware of potential barriers. For instance, linguistic barriers can arise for non-native language speakers, and students from historically marginalized groups in STEM (e.g. women, some racial minorities, LGBTQ students, students with disabilities) may be unintentionally or intentionally marginalized (e.g., interrupted, ignored, not taken seriously) by their peers or instructors. This session will begin with an overview of research that points toward the conditions under which inquiry-oriented instruction might provide equitable learning opportunities for different groups of students. Participants will discuss how issues of equity may play out in situations common in inquiry-oriented mathematics classrooms (e.g., whole class discussions; small group work), particularly working to identify ways in which these situations can create potential barriers to full participation for some students. Pedagogical strategies for removing these barriers will be discussed. Participants will be encouraged to share, discuss, and reflect on their own experiences through this lens.

Doug Corey, Brigham Young University
Lesson Study for College Mathematics Instructors

In this working group we will focus on the practice of Lesson Study to improve instruction. Lesson study has been practiced for decades in Japan and is being effectively adapted and implemented in the US, although usually in K-12 contexts. In the first half of the working group we will discuss keys for effective Lesson Study practices and how the practice can be implemented at the tertiary level. Lesson study has proven particularly effective in creating engaging, interactive lessons, like those advocated by IBL groups. A common variation of Lesson Study is a detail-oriented development of a lesson by a group of teachers, implementation of the lesson that is observed by many instructors (including those that did not help to develop the lesson), then analysis and discussion of the lesson afterwards. Lessons are often revised based on ideas in the discussion and taught again. Lesson study benefits those involved in developing the lesson and those observing and analyzing the lesson. However, lesson study can benefit those not involved by sharing the final product of lesson study: a refined, detailed, lesson plan with a deep background on the mathematics, the student mathematical thinking, and the justification and reasoning behind instructional decisions. Unfortunately, no comprehensive system exists for storing and sharing detailed instructional knowledge at the college level. In the second half of the working group we will discuss this problem of storing and sharing instructional knowledge (generated in a variety of ways, not just through lesson study) in college mathematics education and work towards a viable solution.

Shandy Hauk, WestEd

Blending Inquiry-Based and Flipped Classroom Approaches

The goals of the session are that participants learn something about what "flipped classroom" means, explore (a bit) the current research and practice literatures about flipped models and activity-based learning, and do some intellectual work to help improve the next round of research in collegiate math ed about IBL and flipped instruction. In the first part of the session participants will examine and discuss the similarities and differences between IBL and flipped approaches. This will be based on definitions established in a shared video and short reading and will include discussion of the nature of applied research and action research (e.g., SoTL) in collegiate math ed. In the second part of the session, participants think about what they would expect to learn/want to know about flipping some or all of a chosen course. Then, participants will get 3x5 cards with variables used in recent research (e.g., survey items for students on classroom practices, reflective logs by instructors) and sort the cards into categories based on practical and scholarly interests. Ensuing discussion will compare and contrast examination of one's own practice with the design and conduct of research in math ed (e.g., of flipped versus non-flipped IBL). The final part of the session will engage participants in a problem-posing task: What challenges of instructional practice in flipped IBL need study? Attendees will work in pairs/small groups in a google doc to produce three lists of questions for: (a) practitioners (b) educational researchers, (c) research and development to generate an NSF IUSE proposals.

Billy Jackson, SUNY Geneseo and Alma Ramirez

Examining Practice and Research on Inquiry: Oriented Instruction in Courses for Future Teachers

The goal of the session is for participants to learn about current inquiry-oriented instructional strategies in courses for future teachers. This will be accomplished by exploring the current research and practice literatures in teacher education and activity-based learning. The session will begin with a brief presentation on distinguishing between thoughtful report of practice and reports of mathematics education research for the purpose of examining what research has found thus far about impact of inquiry-oriented instruction in undergraduate mathematics. Participants will then explore different established avenues for locating 5 practice resources for use in/discussion of math content courses for future teachers. Next, participants will explore different established avenues for locating 5 research reports about math content courses for future teachers. Whole group discussion then follows about kinds of questions addressed in reports found, methods used, results obtained, and implications for practice. This will be followed by small and whole group discussion about participating in the peer review process. Focus questions include: Are faculty looking to report on their practice or participate in/conduct research? How would they going about doing this, and where might they consider publishing their final results? The session will conclude with active discussion on reporting out on practice/conducting research.

Gulden Karakok, University of Northern Colorado

Math Circles-Inquiry through Problem Solving

Math Circles for K-12 teachers and students are learning communities that enrich participants' mathematics knowledge through engaging rich mathematics problems. Sessions facilitated by mathematicians provide active learning environments in which participants not only enhance their problem-solving skills but also build a collaborative community. In addition, Math Teachers' Circles provide a meta-level teaching experience for participating teachers that they can implement in their own K-12 classrooms. Circle sessions are consistent with principles of teaching with inquiry (e.g. inquiry-based learning (IBL) or inquiry-oriented instruction (IOI)). For example, participants of Circle sessions are deeply

engaged in rich mathematical tasks and have many opportunities to collaborate with others to develop collective sense-making. Facilitators guide participants problem-solving activity as they inquire into participants' thinking and challenge them to make further mathematical connections and extensions. In this session, we explore the alignment between Circles and IBL as we work on Circle-style problems. Participants will learn more about structure of Math Circles and additional resources for their own classrooms or Circles. In addition, results from research studies related Circles and problem solving will be shared and possible future research study ideas will be generated.

Elise Lockwood, Oregon State University

Initial Conversations about Incorporating Computational Thinking and Activity into Mathematics Classrooms

In recent decades, with new technological tools and resources regularly being developed, there has been increased attention on computation in mathematics. Evidence for this increase is seen in the creation of dedicated computational mathematics departments, in job ads specifically targeting computational mathematicians, and in computational requirements for mathematics majors. These trends suggest a shift in the kinds of mathematical thinking and activity we should have our students develop. In light of the current environment and the promise of inquiry-based approaches, there is a need to explore and to better understand effective ways of teaching and learning of computing within mathematics. In this working group, we will facilitate conversations about using inquiry-based approaches to incorporate computational thinking and activity into undergraduate mathematics classrooms. The working group session will include both presentations and time for discussion. First, the organizer will summarize some key literature and identify questions that the field is facing moving forward. Specifically, we will talk about definitions of computational thinking and activity, provide examples of such thinking in mathematical contexts, and suggest three potential avenues of research: a) What is the nature of computational thinking and activity in mathematics?, b) how can computational thinking and activity help students learn mathematical concepts and develop mathematical practices?, and c) how can inquiry-based approaches help students develop computational thinking and activity in classroom settings? Most of the time during the working group will consist of time for discussion, which will afford attendees opportunities to share their own experiences with computing in undergraduate classrooms, to generate pressing questions that both researchers and practitioners should address, and to begin to develop collaborations with other attendees. A proposed outcome of the working group will be a list of questions and ideas for investigation that we would like to see the field address.

Alison Marr, Southwestern University, Chris Rasmussen, San Diego State University, T.J. Hitchman, University of Northern Iowa, and Victor Piercey, Ferris State University

Expansion and Enhancement of IBL: MLI Strategic Planning

For over two decades the Educational Advancement Foundation (EAF) has been a driving force behind a widespread community of college/university mathematics teachers who employ Inquiry Based Learning (IBL) methods to lead their students to independent thinking, critical analysis, problem posing and solving and confidence in their mathematical and problem solving abilities. The community has grown and gained recognition that could not have been predicted at its start. The leadership of EAF concluded that for the movement to continue to grow and become more visible, it needed more diverse leadership and broader funding and support resources. Thus the Initiative for Mathematics Learning by Inquiry (MLI) was formed as a public, nonprofit 501(c)3 organization to advocate, market and seek new resources for the broad Inquiry Learning community. The MLI Strategic Planning Committee surveyed the broad IBL/RUME communities and held four virtual and two face-to-face workshops. Four high impact focus areas were selected from issues identified as high priority by the community. The areas are: a) Regional Inquiry

Learning Communities; b) Partnerships and Collaborations; c) Professional Development; d) Advocacy, Marketing and Broader Impacts. Members of the MLI Strategic Planning Committee want to hear your thoughts on these issues as part of finalizing the plan, which will be revealed at 2018 MathFest. Join us in determining the role of MLI in supporting the expansion and enhancement of Mathematics Learning by Inquiry for all students.

Matt Thomas, Ithaca College
IBL in Statistics

With the growth in popularity of IBL methods, many instructional strategies have been developed along with materials for specific mathematical disciplines. While a great deal of attention has been paid to implementation in particular subjects like calculus, analysis, and differential equations, fewer resources exist for teaching statistics in an IBL style. Statistics is a field in which data exploration plays a natural role (and is often explored through labs), but the development of statistical ideas themselves are not often treated in an IBL style. In this working group session, we will discuss and share existing resources for using IBL in a variety of statistics courses from introductory through more advanced courses, share strategies which have been used by those in the group, and discuss which resources still need to be created. This list of needed resources will provide a starting point for the group to begin to develop these tools.

Michael Starbird, University of Texas at Austin
Workshop on Intro to Inquiry-Based Learning: Mathematics and Beyond

When students prove theorems on their own and present their results to their peers, interesting things happen. Expected outcomes include students' understanding mathematics more deeply and meaningfully. But beyond those mathematical outcomes, an IBL experience frequently advances fundamental goals of education: students develop independent thinking, creativity, communication skills, and a willingness to make and learn from mistakes. This session is specifically designed as an entry point for participants who are new to IBL or this community, but all are welcome.

Live Classroom Abstracts

Megan Wawro, Virginia Tech

Discovering Definitions in Inquiry-Oriented Linear Algebra

Participants will work together on a task sequence that is intended for use starting on the first day of the semester for introductory linear algebra classes (it has also been used successfully in high school classrooms). The instructional design facilitates the use of experientially real tasks that allow for active participant engagement in the guided reinvention of key mathematical ideas and definitions. Participants will work together in small groups on problems, share their tentative progress and solutions with the whole group, and develop conjectures about the mathematical ideas being encountered.

Alfonso Gracia-Saz, University of Toronto

Combinatorics by Discovery

This will be a session "by discovery". I will give you a combinatorics problem and a worksheet with some guidance; you will explore the problem and (perhaps) solve it and prove your conjectures. This is a real math session for the real you: you won't be role playing or pretending to be students. You will actually be using all your knowledge and skills to try and do some math. You will need to be comfortable with proof writing and with basic combinatorial concepts. Given that we have limited time, you may or may not get very far. That is okay.

I want you to experience what is like to be a student in an IBL class. This sometimes includes anxiety or frustration when you get stuck, but it also includes satisfaction and growth when you make a breakthrough. We know struggle can be productive. But don't worry: there will be no judgement or grades at the end.

Michael Starbird, University of Texas at Austin

Using puzzles to Illustrate Strategies of Thinking

Participants will work on some puzzles, not to solve them, but to discuss methods of thinking that lead to discovering ideas. Using puzzles in this manner is a great way to get students to think about effective methods of thinking and about how ideas are discovered.

Susan Crook, Loras College

Moderating Presentations and Giving Useful Feedback

In this session participants will examine and critique proofs written by previous students. Participants will engage with the material as our students do and will experience the thought process students face as they work to give useful feedback in a forward but encouraging way - often to a student they may not know well in a classroom full of students they do not know. We will also tackle a situation in which no one in the class has a completed proof, but several have ideas on where to start. IBL classrooms require not only maturity and management from the professor, but also from the students. This classroom will help us get into the minds of our students and what they experience in their first IBL classroom.

Intended for faculty who have taught an IBL course before or have basic knowledge of what an IBL classroom might look like. The facilitator has run a somewhat similar session (though much shorter) at a previous IBL Conference.

Patrick Rault, University of Arizona
Online IBL in an Introduction to Proofs Class

Participants will explore a puzzle by Lewis Carroll (also known as Charles Lutwidge Dodgson), and how it can be used in an Introduction to Mathematical Proof course. Group work and presentations will both be featured. We will prove theorems using its convoluted sentence structures, and use this to rationalize consistency of notation in mathematics. Participants will also experience an online IBL class, and learn about the videoconferencing classroom tool Adobe Connect. The ensuing reflection session will be face-to-face (see the program), and will include discussion of both the mathematics content and the online setting.

Technology requirements: Equipment will not be provided, so participants will need a computer with a headset microphone (or a very quiet hotel room to join us from); please test your equipment and software for compatibility in advance by visiting this site:

https://na1cps.adobeconnect.com/common/help/en/support/meeting_test.htm. No computer camera will be needed. Touchscreen computers with a stylus are encouraged but not required.

Location information: a room has been reserved in the schedule for this Live Classroom session and its ensuing reflection. For the Live Classroom period, you are encouraged to find a quiet place to connect from (such as a hotel room), and to use the designated room if that is unfeasible. We will then meet in the designated room on the program for the ensuing face-to-face reflection.

Aaron Wangberg, Winona State University
Promoting discussion using manipulatives in Multivariable Calculus

Working in groups, participants will use physical manipulatives to discover several key relationships underlying the function, derivative, and integral concepts in multivariable calculus. Three short activities are designed to promote both small group and whole class discussion from the first day of class. Participants will try the materials as “students” and discuss productive classroom moves as “instructors”. This session is open to a broad audience (calculus knowledge could be helpful.... or not....).

Danielle Champney, Cal Poly, San Luis Obispo
Team-Based Problem Solving

Participants will work together on some non-routine problem solving (with manipulatives), and discuss how all team members’ ideas are important and beneficial to optimizing the team’s final solution. After solving the posed questions, teams will pose related problems, and solve their own (and other teams’) new problems. During this session, we will emphasize how to handle being stuck, how to utilize your group members productively, and how to persevere during problem solving sessions. The expectation is that every team member will be an active participant in their team’s process, and that everyone can bring something unique and important to the problem solving process.

Poster Abstracts

Elizabeth Ayisi, Ohio University; Otto Shaw; Harman P. Aryal

Visualizations of Complex Valued Functions and Mappings using GeoGebra

According to the National Council of Teachers of Mathematics (2000), good teaching establishes content knowledge to focus on learning while implementing tasks that promote reasoning and problem solving. In this presentation, we will discuss some curriculum materials for teaching college level complex variables and validation of the visualization of complex valued functions and mappings using GeoGebra. We will give some examples of visualization for exponential, Joukowski, power, and logarithmic functions, stereographic projection, and modules of functions. Multiple representations of any mathematics problem are very important in learning mathematics courses, such as algebra, geometry, calculus and statistic, especially at the secondary school education. The Common Core State Standards emphasizes the significance of emerging a geometric and algebraic expression of mathematical objects. At this poster, we will display how GeoGebra can be used in college complex variables and how to visualize complex valued mappings. In agreement with the Mathematical Association of America (2000) and the National Council of Teachers of Mathematics (2000), technology is one of the effective tools for an inquiry based classroom.

Deborah Loewenberg Ball, University of Michigan

(How) Can Mathematics Teaching Disrupt Racism and Oppression?

Historical and persistent marginalization and oppression permeate all aspects of contemporary life, including education. Institutional structures and exclusionary practices rooted in social and cultural status groups and identities preserve and reinforce racialized and gendered norms. Teaching at all levels has enormous potential to disrupt these patterns, but it has instead often reproduced inequality and reified injustice through the discretionary spaces that are inherent to teaching. These discretionary spaces enable teachers to adapt responsively to cultural contexts, communities, and students, but they also make classroom practice vulnerable to actions and decisions that perpetuate oppression. This talk will investigate how patterns—particularly enacted patterns and signals of low expectations for marginalized students—are produced and reproduced, minute to minute, day to day, and week to week, inside of these discretionary spaces in teaching. We will explore how mathematics can be taught in ways that can change the nature of the experiences of students and affect their sense of identity, belonging, and success and will consider what it would take to make such instruction a reality inside of classrooms.

Sun Young Ban, Borough of Manhattan Community College

The Effect of Classroom Discourse in Inquiry-Based Learning on Teaching and Learning Mathematics

According to The National Council of Teachers of Mathematics (2000), “Effective teaching involves observing students [and] listening carefully to their ideas and explanations” (p. 19). This project explores how teachers prepare to ask different kinds of questions that helped students to develop their reasoning behind processes. Especially, the communication between a teacher and students in a class helps students not only to work together in making sense of mathematics, but also to justify mathematical processes in problem solving. In this paper, the researcher focuses on how students are curious and try

to seek patterns and connections in their thinking based on the teachers' questioning strategy, think-pair-share strategy, and classroom discourse. I also expect to have discussion with others to improve the next steps of this study.

Santiago Betelu, University of North Texas

Teaching Differential Equations and Numerical Analysis with Parallel Computers

Physical simulations of real life problems are enormously engaging to students of mathematics, physics, and engineering. Through this poster, I will share my experiences teaching numerical methods for the Wave, Transport, and Navier Stokes equations in intermediate undergraduate courses of numerical analysis and differential equations. In particular I will show how these problems can be used to introduce the students to parallel computing without requiring much programming experience on the part of the students. I will also show demos on a computer screen.

Memet Bulut, Texas A&M San-Antonio

Examining the Effects of Technology Enhanced Art Project (TE-AP) Approach on Students' Understanding of Functions in College Algebra

As seen and experienced every day, technology is changing very rapidly; therefore, teachers and administrators either need to keep up with or catch up to new digital tools such as Internet, social media, and smartphone applications. Moreover, those new innovations change our daily life and habits tremendously and the ways education is being delivered. One innovative delivery method for education, Technology Enhanced Art Project (TE-AP), will be discussed in this study. This study addresses how the TE-AP model of instruction differs from traditional classroom model instruction when comparing student achievement, attitude, and mathematics anxiety measures in higher education mathematics classroom. This study is important and beneficial for Hispanic serving university administrators and professors to consider prior to implementation of the TE-AP model. This study also ensures a review of college algebra that initially implemented TE-AP classroom in a Hispanic serving university that is located in south part of Texas.

David Clark, SUNY New Paltz; Pathania Samrat, Wallkill High School

Upcoming Conference on Guided Inquiry Geometry

I will present a poster announcing a June conference hosted by the University of Michigan that will focus on my book, "Euclidean Geometry: A Guided Inquiry Approach". At that conference I will tell about this book itself and why it was written. I will also talk about the follow up book that I am currently writing: "High School Geometry for the Theoretical Mathematician". I believe this June conference, or at least this topic, will be of interest to people attending this conference. Questions about the conference and the book are welcome.

Celil Ekici, Texas A&M- Corpus Christi; Cigdem Alagoz, Texas A&M- Corpus Christi

Strategic Competence with Representations in Modeling Inquiry-Based Learning of Radicals

The concept of radicals is difficult for learners to grasp in Grades 4-8. Here we present an interactive session on our inquiry-based learning tasks towards developing intuitions for radicals in a mathematics content course for teachers. The founding idea of duplicating areas is used here as a thread across the

learning tasks we developed to model inquiry-based approach to radicals. Adopting an integrated approach to geometry for teachers, we support the development of fluency and strategic competence with multiple representations in discovering the radicals in context with its founding ideas and the conceptual connections. Students experience the multiple instantiations of the idea of radicals as they strategically revise, refine, and connect their representations. We examine how the mathematical agency is fostered in a discussion-based learning environment where learners have simple yet rich and purposeful mathematical tasks accessible through multiple representations. We trace and expound upon the multiplicity among student learning discourse as they formulate problems, frame, and develop their approach with alternative representations. We discuss how the IBL modeling activity supports the development of strategic competence with multiple representations in building the concept of radicals from conjectures emerging out of geometrical and arithmetical patterns. Participants will engage in tasks and manipulatives, sample student work, and reflect on their experience.

Maria Fung, Worcester State University; Pamela Hollander, Worcester State University

Writing in an IBL Algebra for Teachers Course

We will describe a series of writing to learn assignments that fit well into the IBL format of Algebra for K-6 Teachers course at Worcester State University. We discuss the results of a pre- and post-survey and student comments.

Rebecca Glover, University of St. Thomas; Debbie Monson, University of St. Thomas; Lisa Rezac, University of St. Thomas

STEM Integration for Elementary Preservice Teachers through Inquiry

Recent trends in educational research have indicated that an integrated approach to K-12 STEM education, especially implemented at an elementary level, could help increase STEM-literacy for students, expand the participation of underrepresented groups in STEM fields, and better prepare all students to enter an increasingly technological workforce. This integration may be obvious to some, but to elementary preservice teachers, whose coursework is often siloed, integration may be such a large hurdle that they choose not to try to overcome it. In this poster, I will discuss a mathematics course for elementary preservice teachers that was created to help connect the mathematics required for elementary teachers to the K-6 classroom and other STEM subjects. Our goals for this course were to build mathematics content knowledge, present topics using inquiry and student-centered pedagogy, and give students time to reflect on the connections between mathematics and other content areas. Students explored several integrated, inquiry-based activities in class, wrote journal reflections on each activity, and as a final project, created their own lesson for the K-6 classroom that presented mathematics in an integrated way. In this poster, I will share details about some activities implemented in the class, themes related to course objectives that appeared in the journal entries, and the students' final project ideas. This is a preliminary report of data collected over two semesters.

Annie Han The City University of New York; Margaret Dean, The City University of New York; Fangyan Shen, The City University of New York

Mentoring Success Stories from the NOYCE NEST (NYCCT+BMCC) Project

For over thirty years, the United States has expressed concern about the lack of competitiveness of U.S. students in the areas of science, technology, engineering, and mathematics (STEM). Although national and local policies have emphasized STEM education, progress in these fields has been slow. Without a qualified pool of teachers who have degrees in STEM fields, we continue the cycle of unprepared STEM students taught by underprepared teachers. STEM teachers with weak backgrounds simply do not promote passion and commitment in students to pursue STEM careers. A major component of increasing students' STEM achievement is raising the quantity and quality of STEM teachers. The New York City College of Technology (NYCCT) and Borough of Manhattan Community College (BMCC) NOYCE NEST Project focuses on these concerns by uniting the two colleges to mentor pre-service teachers through Inquiry-Based Learning. Our Four-Movement Classical Symphony mentoring model fosters students' interest early on and sparks a lasting desire to pursue a career as a STEM teacher. The purpose of this presentation is to share our success stories of the Four-Movement Classical Symphony: Mentoring Pre-Service Teachers Through Inquiry-Based Learning Model.

Kimberly Hartweg, Western Illinois University

Trying Triangles: Mathematical Discovery and Connections

What can you discover about triangles when given three side lengths? This poster will show how students can use various squares to investigate which side lengths will create triangles and to create an additional question for further study. The openness of the question provides students the opportunity to investigate, gather data, find/test patterns and draw conclusions that can then be shared with the class. Students become the "giver of knowledge" about topics such as types of triangles, angles, squares, square roots, the Pythagorean Theorem, area, perimeter, and perfect squares. The poster will include sample student work and potential tasks, and discussion can focus on mathematical connections, the value of student led explorations, and the importance of teacher questions/guidance/listening.

TJ Hitchman, University of Northern Iowa; Ted Mahavier, Lamar University; David Clark, SUNY at New Paltz; Nathaniel Miller, University of Northern Colorado

The Journal of Inquiry Based Learning in Mathematics

The Journal of Inquiry Based Learning in Mathematics (JIBLM) has served as a repository for IBL course notes for over a decade, giving IBL practitioners a way to share their work on course materials as a practical scholarship of teaching. The journal has focused on complete, semester-long courses so far. With this poster, we advertise the expansion of the mission of JIBLM to include shorter units, which we call Modules, and a new section of Reviews; share a vision for what these new sections of the journal can be; and invite the participation of the IBL community as both authors and referees in these new efforts.

Meri Hughes, University of Mary Hardin-Baylor
IBL Techniques in History of Math with Study Abroad

Partly because it provides an appropriate avenue for study abroad for math, engineering, computer science, and mid-level math education majors, History of Mathematics remains an integral part of the mathematics curriculum. By incorporating inquiry-based and active learning techniques in the classroom, effective teaching can occur to a broad level of mathematical abilities. I would like to share my experience in implementing the curriculum, especially as it pertains to sites of mathematical historical interest around London and Paris, and gather ideas for adapting the curriculum to the Mediterranean region.

Matthias Kawski, Arizona State University
Math Circles as a Teaching Laboratory: From School Seniors to Second Graders

We compare and contrast Math Circles in the most remote parts of rural Indian reservations and in the Phoenix metropolitan area. The latter started eight years ago as a social enterprise to serve high school students whose mathematical hunger could not be satisfied by their schools, and who wanted to connect with mathematical research. The former include many sessions held at small schools all the way down to second graders in the most remote hamlets in the Dine (Navajo) Nation, and in a small high school Math Circle in the Pima Maricopa Salt River Indian Reservation.

Most prized are open-ended problems, which are easily motivated and understood by even middle school age students, and even younger, yet which yield threads that connect to current research, even Nobel and Abel Prizes and Fields Medals. We carefully examine what prerequisites are truly needed and how to best motivate the problems for each age group. Such exploring of new ways to develop topics amounts to teaching experiments – which, after fine-tuned and successful in the Math Circle, may make it back into upper division undergraduate classes.

Janelle Lorenzen, Southeastern Louisiana University
The Effect of Instructional Strategy on Preservice Elementary Teachers Math Anxiety and Achievement

This study addressed how different instructional strategies affected preservice elementary teachers' levels of math anxiety and their achievement in a math content course while considering descriptions of their experiences in the course. The instructional strategies used were traditional teaching methods and inquiry-based learning (IBL). Participants completed the Mathematics Anxiety Rating Scale – Short Version (MARS-S) and a 20-item content knowledge assessment to measure their level of achievement pre- and post-intervention. Participants' journal entries throughout the semester contained self-reported measures of math anxiety and understanding of course content as well as descriptions of their experiences in the course regarding their anxiety and understanding. Results showed that as the semester progressed, the math anxiety of IBL participants decreased, whereas the math anxiety of traditional participants increased. Differences between the groups in terms of their level of achievement were not significant even though within both groups, participants experienced significant learning gains. Correlational analysis showed a significant negative relationship between math anxiety and achievement. Common themes from students' journal entries that were identified as impacting participants' anxiety and understanding of course material included course content, teaching methods, assessment, and student behaviors. I wish to speak directly with colleagues from other institutions who are interested in the research.

Judith Quander, University of Houston-Downtown; Timothy, Redl, University of Houston-Downtown
Building a Community of Practice to Develop and Integrate Innovative Instructional Strategies in College Algebra Classes

This poster will discuss a community of practice created to address student complaints about faculty teaching in college algebra. In general, students described faculty as being unwilling to engage and using lecture as the primary mode of instruction. As these complaints were not specific to any one type of instructor, we targeted our tenure-track, full-time and adjunct faculty who teach college algebra. Our goal was to bring a subgroup of these instructors together to explore effective instructional teaching practices based on NCTM's Principles to Actions. We had an initial 2-day summer workshop where we created action plans for integrating practices and looked at enriching existing college algebra tasks. At the end of the summer workshop, each member developed an action plan and a mathematical task to try out and then revise. During the following fall semester, members tried out their chosen mathematical practices and their mathematical tasks. We then observed each other's teaching and met to reflect on our experiences. The poster will include details of our action plan for the mathematical practice we chose, the rubric for the college algebra tasks, and the observation protocol. I will also give examples of the types of tasks we developed. I will also talk about the experience of being in a community of practice that included adjunct faculty, full-time lecturers, and tenure track faculty.

Candice Quinn, Middle Tennessee State University
Connecting Calculus to the Real World through a FAST, Fun, and Furious Problem

The Formula One Racing Strategy project was developed to help students make connections between a real-world competitive application of calculus and the content. The project covers a range of concepts learned in algebra, precalculus, and calculus, and has a variety of correct solutions. Concepts include constructing equations, understanding averages, limits, identifying rate of change from graphs and equations, summation, and integration. Students are introduced to the project by watching a video relating calculus to racing cars. Students reason through the project as they learn each topic while working through a guided workbook. The workbook includes the driving question, metacognitive questions, and questions linking the calculus in class to the project. First, students are asked to brainstorm ideas for solving the problem before learning any calculus. The narrative for the project included parameters about that current Formula One Grand Prix race, in which students are asked to calculate the optimal refueling strategy for one of the racecar drivers. After the initial brainstorming activity, students worked in groups of four at least one hour a week on the project. The project culminated in a class wide race simulation where the students saw their solutions come to life. The goal of the simulation is to beat the instructor, who has the optimal solution, and come in first place. This poster will contain an in-depth description of the project, solutions, and student work.

Widodo Samyono, Jarvis Christian College
Implementing IBL at a Small Liberal Arts, HBCU, College

There are some challenges to implementing IBL in a small liberal arts, historically black college and university (HBCU), college for some advanced mathematics courses. The challenges are how to prepare the students for the discussions in the classes, how to reduce their anxieties about mathematics, and how to improve their critical thinking, problem solving, and persistence. In order to face these challenges, we set up the courses as blended courses. Before coming to the classes, the students have to do the flipped homework posted on our learning management system (Jenzabar), i.e. watching video lectures and

answer the questions in the pre-classes graded assignments. During the classes we used IBL to discuss the topics that we covered that day. The questions in the homework, exams, and IBL used mastery learning based on the Bloom's Taxonomy. Additionally, in certain courses we used automatic grading homework software (MyOpenMath), Excel, R, and Wolfram Alpha. On this poster we will explain our implementations of the IBL for different courses, the challenges, our teaching strategies, results, and future directions.

Megan Selbach-Allen, United States Naval Academy; Amy Ksir, United States Naval Academy
Raising the Bar with Standards Based Grading

In many courses, gradebook items have labels like "Quiz 4." In Standards Based Grading, gradebook items have labels like "Identify series that are geometric" or "Use the structure of a proof by contradiction." Students have multiple opportunities to demonstrate proficiency or mastery of each item. A student's course grade is determined by how many standards they have met, or which ones.

The two of us have used Standards Based Grading in two very different IBL contexts: a calculus course and an introduction to proofs course. We think that Standards Based Grading is a good fit for an IBL class. We have found that standards based grading makes the connection between learning and grades more direct and transparent to students. It also allows us to ensure that students experience success in key portions of our courses. We like that it aligns well with developing a growth mindset in students. All of these factors contribute to an overall strong positive impact on classroom culture. The largest challenges we have faced relate to time management, both for ourselves and our students. On this poster we will describe our implementations of Standards Based Grading. We will also describe the benefits, as well as the challenges and how we have addressed them. We draw from our own experience and from numerous rich conversations with colleagues at other institutions.

Amdeberhan Tessema, Middle Tennessee State University; Strayer F. Jeremy, Candice M. Quinn, & Lucy Watson, MTSU

Calculus Students' Covariational and Quantitative Reasoning Abilities when Solving Mathematics Problems

This study compares pathways and non-pathways students' ability to reason covariationally with quantities; Pathways students are those students who learned pre-calculus using the Pathways to Calculus materials, which focused on inquiry based teaching and learning (Carlson, Oehrtman, & Moore, 2016). Most university Calculus students have difficulty reasoning covariationally with quantities. In this research study, 291 pathways and non-pathways students participated. The quantitative research results showed that pathways students demonstrated greater ability to reason graphically, ability to describe quantitative relationship between two variables clearly, and ability to define variables fluently when compared to their counterparts. Moreover, Pathways students showed evidence of stronger reasoning on problems that required making sense of graphs and variable definition when compared to their counterparts. This result indicates that students who instructed using Pathways to Calculus curriculum materials before taking Calculus I might have more success in developing covariational and quantitative reasoning abilities than students who arrive in Calculus I from other avenues.

Na Yu, Lawrence Technological University
A Group Projects Approach to Calculus

Multivariable Calculus has wide applications in natural and social science and engineering. This poster will share interdisciplinary projects the I have incorporated, how the projects were implemented in the regular course, how students responded and performed in the class, and the benefits of these projects. I will invite other participants to try a couple of projects that had been used in my class.