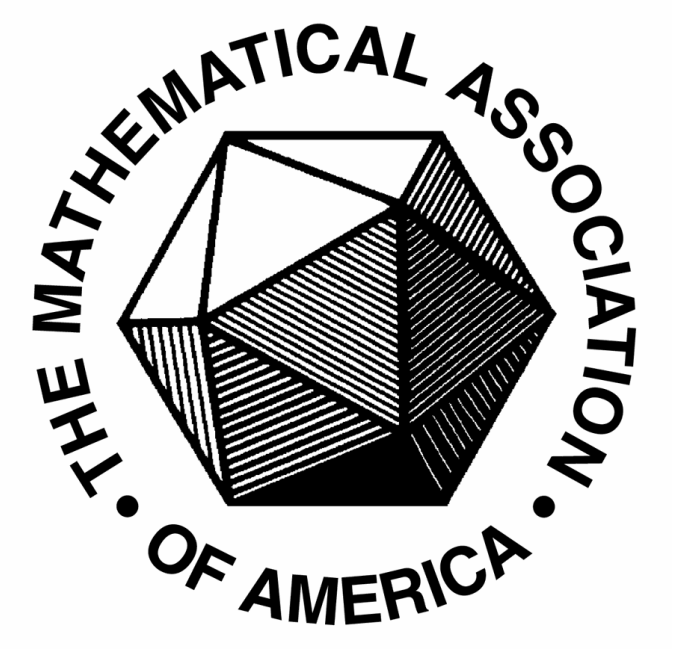
Annual Meeting
of the
Pacific Northwest Section
of the
Mathematical Association of America



University of Portland
Portland, Oregon

April 12-13, 2019

Annual Meeting
of the
Pacific Northwest Section
of the
Mathematical Association of America

Sponsored & Hosted by

University of Portland
Mathematics Department
College of Arts & Sciences
Portland, Oregon
April 12-13, 2019

Friday, April 12

<table>
<tr><td>7:45</td><td colspan="3">Packet pickup for Project NExT
Hall of Fame Room
Chiles Center</td></tr>
<tr><td>8:00

2:45</td><td colspan="3">Project NExT Meeting
Hall of Fame Room</td></tr>
<tr><td>3:00

5:30</td><td>Minicourse: Turning Routine Exercises. . . [1]
Franz Hall 206</td><td></td><td>Minicourse: Author Your Next Book. . . [2]
Franz Hall 125</td></tr>
<tr><td></td><td rowspan="2">Student Registration[1] & Reception

6:00-7:50
Franz Hall 120</td><td colspan="2">Project NExT Dinners & Discussions</td></tr>
<tr><td>7:30</td><td>Registration[1]
BC Aud Foyer</td><td>Various</td></tr>
<tr><td>8:00</td><td colspan="3">Invited Lecture: Brian Katz
How do mathematicians believe? [3]

Buckley Center Auditorium</td></tr>
<tr><td>9:15

10:15</td><td colspan="3">Reception
Buckley Center Auditorium Foyer</td></tr>
</table>

[1]Participants who registered on EventBright prior to the meeting may check-in to pick up badges and programs. There is limited on-site registration. Payments must be made by cash, check, or credit card.

Saturday, April 13

7:30		**Executive Committee Meeting** *Murphy Room* *Franz Hall (4th Floor)*
8:00	**Check-in & Registration** *Franz Skybridge*	
9:00		**Introduction and Welcome:** Herbert A. Medina, PhD Dean, College of Arts & Sciences, Professor of Mathematics **Invited Lecture: Su Dorée** *Writing Numbers as the Sum of Factorials* **[4]** *Buckley Center Auditorium*
10:30		**Contributed Talks** *Franz Hall 015, 034, 111, 206, 214, 223, 231*
12:30		**Lunch (provided)** *Franz Atrium*
1:15 1:50	**Business** *Meeting* *Franz 206*	
2:00 3:00	**Pólya Lecture 1: Carlos Castillo-Chavez** *The role of models of contagion: its impact in building interdisciplinary communities of undergraduates over 24 years* **[5]** *Bauccio Commons (Bluff Side)*	
3:15	**Contributed Talks** *Franz Hall 015, 034, 111, 206, 214, 223, 231*	
5:30	**Social Hour** *Board Room & Terrace - Bauccio Commons* No-Host Bar (*ID required*) - Hors d'Oeuvres	
6:30	**Section Awards** *Board Room - Bauccio Commons*	
6:45	**Pólya Lecture 2: Carlos Castillo-Chavez** *Role of social dynamics and individual decisions on the spread of infectious disease* **[6]** *Bauccio Commons (Bluff Side)*	

Program of Contributed Papers

The program of contributed papers appears on the following pages. In some cases, titles or other information are abbreviated for reasons of space; please see the full abstract for more information.

A dagger (†) indicates which contributor(s) will present when multiple contributors are listed and fewer are presenting the work. An asterisk (*) indicates the contributor is a graduate student. Double asterisks (**) indicate the contributor is an undergraduate student. Triple asterisks (***) indicate the contributor is a high school student.

Session Organizers

- *Algebra and Number Theory*: Thomas McKenzie, Gonzaga University
- *Algebra and Topology*: Kate Kearney, Gonzaga University, and Katharine Shultis, Gonzaga University
- *Topics in Undergraduate Mathematics Education*: Elise Lockwood, Oregon State University
- *Aligning Practice and Assessment with Course Learning Goals*: Craig Gin, University of Washington, and Kelsey Marcinko, University of Washington, and Jeremy Upsal, University of Washington
- *Incorporating Data Science in the Undergraduate Curriculum*: Xiaoyue Luo, Linfield College
- *Conversations About Equity in Mathematics*: Ksenija Simic-Muller, Pacific Lutheran University, and Katya Yurasovskaya, Seattle University

Please contact the session organizer with any questions about a session.

Moderators: Please start each talk on time, but **not** early. Meeting participants often move between sessions and will want to be there when the talks is scheduled to begin.

Contributed Talks – Saturday Morning

	Algebra and Topology	Topics in Undergraduate Mathematics Education 1	Topics in Undergraduate Mathematics Education 2
	Franz 206	*Franz 223*	*Franz 231*
10:30–10:45	*Knots Related by Knotoids* [33] **Allison Henrich, SU**	*Teaching an introductory programming course to non-science majors using SageMath* [57] **Razvan A. Mezei, SMU**	*Institutional Change: the Role of Peer Observation in the Adoption of Evidence-Based Instructional Practices* [37] **Carolyn James, Valerie Peterson and Stephanie Salomone†, UP**
10:50–11:05	*Reducibility of parameter ideals in low powers of the maximal ideal* [66] **Katharine Shultis, Gonzaga**	*Student Mathematical Connections and Adapted Inquiry in a Constrained Linear Algebra Class* [60] **Spencer Payton, Lewis-Clark State College**	*Near Peer and Recent Alumni Mentoring for Math and Computer Science Students at WWU* [31] **David Hartenstine† and Perry Fizzano, WWU**
11:10–11:25	*Computing the $RO(C_2)$-graded cohomology of equivariant Grassmannians* [35] **Eric Hogle, Gonzaga**	*Student Verification Schemes for Combinatorial Problems in a Computational Setting* [17] **Adaline De Chenne†* and Elise Lockwood, OSU**	*Supporting Ambitious Mathematics with Mathematics Majors Via Tasks, Routines, and Norms* [13] **Erin Glover†*, Megan Brunner†* and Rebekah Elliott, OSU**
11:30–11:45	*The Fundamental Groupoid of Graphs* [14] **Tien Chih, Montana State U-Billings**	*Derivatives and p values from Primary Sources* [42] **Dominic Klyve, CWU**	*Who is Talking and Who is Thinking? The Distribution of the Cognitive and Conversational Load during Undergraduate Mathematics Tutoring* [38] **Carolyn James, UP**
	General Contributed Talks		
	Franz 206		
11:50–12:05	*Determining the Steiner k-diameter of a Graph* [53] **Yaping Mao, Qinghai Normal University, and Chris Melekian†* and Eddie Cheng, Oakland University**	*Guided reinvention: Opportunities to learn about and gain fluency with mathematical language* [74] **Kristen Vroom*, PSU**	
12:10–12:25	*Epidemic Insurance: Simulations and Applications* [48] **Sooie-Hoe Loke†, CWU, and Christopher Powell, Seattle Health Practice of Milliman**	*Relationships between calculus students' units coordination and covariational reasoning* [29] **Jeffrey Grabhorn* and Steven Boyce, PSU**	

Contributed Talks – Saturday Morning

	Aligning Practice and Assessment with Course Learning Goals 1	**Conversations About Equity in Mathematics**	**Student Talks 1**
	Franz 111	*Franz 214*	*Franz 034*
10:30–10:45	*A take-home format for upper-level undergraduate mathematics courses* [59] **Pietro Paparella, UW Bothell**	*(De)Constructing Mathematical Authority* [40] **Brian Katz, Augustana College**	*The Price Ghost Coin: Bitcoin's price behavior using agent-based modeling* [71] **Joseph Thomas[†**] and Sooie-Hoe Loke, CWU**
10:50–11:05	*Standards-based grading for ordinary differential equations: a parallel study* [45] **Jakob Kotas, UP**		*Medical Imaging with Electrical Impedance Tomography, Part I of II: Background* [10] **Benjamin Bladow[†**] and Emma Kar[**], Gonzaga**
11:10–11:25	*Backward Design, Transparent Teaching, and Mastery-Based Grading in a first Linear Algebra course* [56] **Leanne Merrill, WOU**	*I figured it out so they should be able to . . .* [75] **Brandy Wiegers, CWU**	*Medical Imaging with Electrical Impedance Tomography, Part II of II: Recent Advances* [39] **Emma Kar[†**] and Benjamin Bladow[**], Gonzaga**
11:30–11:45	*Understanding what your students understand: Implications of using Specifications Grading in Undergraduate Mathematics Courses* [43] **Jessica Knoch[*], OSU**	*Challenging the Dominance of Mathematical Epistemologies through Community-Based Learning* [28] **Jesse Goncalves[**], SU**	*The Aftermath: Optimizing Medical Resource Allocation via Quadcopter Post-Disaster* [24] **Jessica Fossum[**], SPU**
11:50–12:05		*Taking Up Equitable Instruction in Higher Education: Learning from K-12 Observational Tools* [12] **Megan Brunner[*], OSU**	*The Impacts of Game of Thrones Dragons in the Real World* [15] **Audrey Collen[**], Abigail Northrop[**] and Grace Thompson-Johnston[**], Linfield**
12:10–12:25		*Elimination of Intimidation Factors* [70] **Kelemua Tesfaye[**], SU**	*How to Feed Your Dragon* [11] **Mark Brumberg[**] and Kole Yoshimura[**], SPU**

Contributed Talks – Saturday Morning	
	Student Talks 2
	Franz 015
10:30–10:45	*The Conditional Matching Preclusion of the Shuffle-Cubes* [9] **Sai Anantapantula†***, Northville High School, Chris Melekian*and Eddie Cheng, Oakland University**
10:50–11:05	*Musical Applications of Fourier Transforms* [64] **Sydney Schmidt**, Gonzaga**
11:10–11:25	*Designer Numerical Methods for Approximating Solutions to Differential Equations* [18] **Alana Dillinger**, Gonzaga**
11:30–11:45	*Multivariate Bell Polynomials and Derivatives of Composed Functions* [65] **Aidan Schumann**, UPS**
11:50–12:05	*A Connection Between Column Spaces and Eigenspaces* [58] **Fisher Ng**and Michaela McDougal**, Gonzaga**
12:10–12:25	*Leavitt path algebras over arbitrary unital rings and their two-sided ideals* [47] **Hans Nordstrom and S Joseph Lippert†**, UP**

Contributed Talks – Saturday Afternoon

	Algebra and Number Theory	Topics in Undergraduate Mathematics Education 3	Topics in Undergraduate Mathematics Education 4
	Franz 206	*Franz 223*	*Franz 231*
3:15–3:30	*Visualizing p-adic numbers* [16] **Dibyajyoti Deb, OIT**	*Putting the fundamental back in the Fundamental Theorem of Calculus* [21] **Tenchita Alzaga Elizondo[†*], Brittney Ellis[**] and Steven Boyce, PSU**	*"I notice, I wonder" in the college mathematics classroom* [67] **Ksenija Simic-Muller, PLU**
3:35–3:50	*Investigating the Inertias of Clique Graphs* [76] **Amy Yielding[†], Taylor Hunt[**], Jazmine Juarez[**] and Heath Sell[**], EOU**	*Flipping an Introductory College Algebra Course* [46] **Paul Krouss[†] and Kristin Lesseig[†], WSU Vancouver**	*Mathematics on the Internet: Charting a Hidden Curriculum* [22] **Ander Erickson, UW Tacoma**
3:55–4:10	*A visual decomposition of squares of even polygonal numbers* [20] **Tom Edgar, PLU**	*Implementing a Flipped Classroom: A comparison of implementation between secondary and post-secondary mathematics* [68] **Elyssa Stoddard[*] and Sylvia Fernandez[*], OSU**	*Opportunities Afforded by a Radical Textbook* [44] **Jessica Knoch[*], OSU**
4:15–4:30	*Arithmetic, geometric, and harmonic progressions defined on Fiboquadratic Numbers* [30] **Tomás Guardia[†] and Morgan McCurgy[**], Gonzaga**	*Using precalculus peer facilitators to increase student success* [26] **Emily Gismervig, Bryan White and Cinnamon Hillyard, UW Bothell**	*Inclusive Mathematical Teaching: Rational Functions for Students with Visual Impairments* [49] **CANCELLED** **Michael Lopez[*], OSU**
4:35–4:50		*Teaching Mathematics Disciplinary Practices in Advanced Mathematics Courses* [27] **Erin Glover[*], OSU, Portland CC**	
4:55–5:10		*Abstraction in a First Linear Algebra Course - Where, When and How Much* [69] **Jeffrey Stuart, PLU**	

Contributed Talks – Saturday Afternoon

	Aligning Practice and Assessment with Course Learning Goals 2	**Incorporating Data Science in the Undergraduate Curriculum**	**Student Talks 3**
	Franz 111	*Franz 214*	*Franz 034*
3:15–3:30	*Aligning Assignments and Assessments to Course Outcomes Can be a Win-Win* [63] **Michael Renne[*], Linn-Benton CC**	*Introducing Machine Learning in Python with Movie Recommendation* [62] **Jake Price[†], UPS and Jeremy Upsal[*], UW**	*Opioids: The New Plague, Part 1* [7] **Bryce Amato[†**], Meghan Childs[**], Ruthie Olson[**], Sam Rivas[**], Alex Tessner[†**]and Eli Goldwyn, UP**
3:35–3:50	*Should we harmonize how we expect students to learn with how we assess their learning?* [61] **David Pengelley, OSU**	*Incorporating Data Analysis and Visualization through Class Projects and Activities* [32] **Corban Harwood, George Fox**	*Opioids: The New Plague, Part 2* [8] **Bryce Amato[**], Meghan Childs[†**], Ruthie Olson[†**], Sam Rivas[†**], Alex Tessner[**]and Eli Goldwyn, UP**
3:55–4:10	*What do students really need to know about multivariable calculus?* [19] **Tevian Dray, OSU**	*Incorporating Causal Inference into a Data Science Program* [72] **Terri Torres[†]and Kenneth Davis[†], OIT**	*Modeling the Opioid Crisis with a Focus on Treatment* [50] **Ahmed Tariq Al Kindi[†**], Joseph Matveyenko[†**], Robin Cutshall[†**], Issac White[†**], Richard Lopez[†**]and Kara Colley, Portland CC**
4:15–4:30	*Implementing Writing Enriched Learning Outcomes in Fundamentals of Mathematics* [41] **Kate Kearney, Gonzaga**	**Panel discussion on data science** **Xiaoyue Luo, Linfield:** *Organizer* **Panelists:** ~~**Haiyan Cheng, Willamette**~~ **Peter Drake, Lewis & Clark** **Corban Harwood, George Fox** **Heather Kitada, Reed College** **Chris Lane, Pacific University**	*Unravelling the lynx-hare paradox* [52] **Amanda Mallott[**], Kathleen Maxfield[**], Thomas Schechter[**]and Jack Strand[**], Gonzaga**
4:35–4:50	*Aligning exams to learning goals and Bloom's taxonomy in a scientific computing course* [73] **Craig Gin, Benjamin Liu[*], Kelsey Marcinko[*]and Jeremy Upsal[†*], UW, and Jacob Price, UPS**		*Using Neural Networks to Solve Differential Equations* [55] **Stacey Meekhof[**], Bill Miller,[**]Breanna Smith[**]and Rachel Walker[**], CWU**
4:55–5:10	*Using Diagnostic Test to Gage Course Learning Goal Achievement* [77] **Katya Yurasovskaya, SU**		

Contributed Talks – Saturday Afternoon

	Student Talks 4
	Franz 015
3:15–3:30	*Link Invariants, Klein Links, and Interesting Patterns* [23] **Rusty Ford**[**], Gonzaga**
3:35–3:50	*Agree with me, K? Interrater Reliability using Cohen's Kappa* [25] **Jessica Fossum**[**], SPU**
3:55–4:10	*Fiboquadratic Numbers and Rithmomachia* [54] **Morgan McCurdy**[†**] **and Tomás Guardia, Gonzaga**
4:15–4:30	*Project RubiX* [36] **Adeline Jacobsen**[**] **and Katalina Biondi**[**], UW-Tacoma**
4:35–4:50	*Math PLUS: Mentoring Intermediate Mathematical STEM Fair Projects* [34] **Carmen Hoffbeck**[**], Linfield**
4:55–5:10	

Social Events

Thursday Project NExT Gathering
Stormbreaker Brewing (St. Johns), 8409 N Lombard ST

Friday Project NExT Dinner
Various - See Project NExT Program

Friday Student Reception
6:00-7:50 Franz Hall 120

Friday Invited Lecture
Role of social dynamics and individual decisions on the spread of infectious disease [6]
8:00 Buckley Center Auditorium

Friday Reception
9:15 Buckley Center 163

Coffee, Pastries, & Fruit
8:00-11:00 Franz Skybridge, 2nd Floor

Saturday Lunch
12:30 Franz Atrium

Coffee and Refreshments
2:00- 5:00 Franz Skybridge, 2nd Floor

Saturday Evening Social Hour
No-Host Bar & Hors d'Oeuvres
5:30 Terrace & Board Room, Bauccio Commons

Awards Ceremony
5:30 Terrace & Board Room, Bauccio Commons

Introduction of new Section Project NExT Fellows

Presentation of 25- and 50-year MAA membership certificates

PNW MAA Distinguished Teaching Award

Saturday Evening Invited Lecture
How do mathematicians believe?
Brian Katz [3]
6:45 Bauccio Commons (Bluff Side)

Minicourse Descriptions

Friday, April 13

1 *Turning Routine Exercises into Activities that Teach Mathematical Inquiry*
Su Doree, Augsburg College

Asking questions, checking examples, making conjectures, and constructing counterexamples are part of any mathematician's toolkit and important skills for our students to learn. The MAA CUPM curriculum guide agrees, calling us to "include activities designed to promote student's progress in learning to . . . assess the correctness of solutions, create and explore examples, carry out mathematical experiments, and devise and test conjectures" with the goal that "students should develop mathematical independence and experience open-ended inquiry." How do we help students develop inquiry skills and ignite their curiosity about mathematics? In this professional development workshop we explore some practical strategies you can use to transform routine textbook exercises emphasizing procedural fluency and basic conceptual understanding into activities that teach inquiry. Come ready to try your hand at creating inquiry-based activities.

2 *Rob Beezer, University of Puget Sound*
Author Your Next Book (or Class Notes) with PreTeXt

PreTeXt is a new source language for authoring scholarly documents, with excellent support for mathematics and textbooks. Its principal advantage is conversion to print and PDF formats, along with conversions to highly interactive online formats, all requiring no additional effort for each output format. It is an ideal platform for authoring an open source textbook that will be freely available.

This workshop will very briefly introduce the design philosophy of PreTeXt, and then work through a hands-on exercise creating a small example document in multiple output formats. Remaining time will be used to start on a small project of your choosing.

Learn more about PreTeXt at pretextbook.org

Abstracts of Invited Talks

(in chronological order)

3 *How do mathematicians believe?*

Brian Katz, Augustana College

Love it or hate it, many people believe that mathematics gives humans access to a kind of truth that is more absolute and universal than other disciplines. If this claim is true, we must ask: what makes the origins and processes of mathematics special and how can our messy, biological brains connect to the absolute? If the claim is false, then what becomes of truth in mathematics? In this session we welcome educators and students to discuss our beliefs about truth and how they play out in the mathematics classroom, trying to understand a little about identity, authority, and our joint educational endeavor.

4 *Writing Numbers as the Sum of Factorials*

Su Doree, Augsburg College

In standard decimal notation, we write each integer as the linear combination of powers of 10. In binary, we use powers of 2. What if we used factorials instead of exponentials? How can we express each integer as the sum of factorials in a minimal way? This talk will explore the factorial representation of integers, including historical connections to permutations, a fast algorithm for conversion, and the secret of the "third proof by mathematical induction." Next we'll extend this representation to rational and then real numbers, ending with some remaining open questions.

5 *The role of models of contagion: its impact in building interdisciplinary communities of undergraduates over 24 years*

Carlos Castillo-Chavez, Arizona State University

In 1996, the Mathematical and Theoretical Biology Institute or MTBI was established at Cornell University. The goal was to bring undergraduates from diverse backgrounds into the field of mathematics and its applications, particularly within computational, mathematical and theoretical biology.

In this lecture, I will discuss how MTBI (mtbi.asu.edu) was established and how it has evolved over the past 24 years. The role that MTBI has played in the development of nearly 160 PhDs and its impact on increased opportunities among underrepresented groups will also be highlighted. Finally, the extraordinary research generated by undergraduate participants over a few weeks, all available at https://mtbi.asu.edu/tech-report

6 *Role of social dynamics and individual decisions on the spread of infectious disease*

Carlos Castillo-Chavez, Arizona State University

I will revisit the field classical mathematical epidemiology starting from the contributions of Sir Ronald Ross in 1911. Extensions of Ross' framework and recent applications will be discussed in the context of the study of the spread of diseases that include social dynamics. Emphasis will be placed on the role of individual decisions, in changing socio-epidemiological landscapes and the control of epidemic outbreaks. Examples will be provided from communicable diseases under scenarios that account for various modes of transmission.

Abstracts of Contributed Talks

(in alphabetical order, by presenter)

7 *Opioids: The New Plague, Part 1*

Bryce Amato, University of Portland †
Meghan Childs, University of Portland **
Ruthie Olson, University of Portland **
Sam Rivas, University of Portland **
Alex Tessner, University of Portland †**
Eli Goldwyn, University of Portland

In 2016, more than 11 million people abused prescription opioids. Of all opioid overdoses, 40% of them were caused by one of these prescriptions. Over the last ten years this opioid crisis has become known as the national addiction epidemic and is impacting more and more people each year. Using mathematical infectious disease modeling techniques we are able to model certain patterns of the spread of this crisis. After extensive research, we have designed a model that incorporates several different prescription classes. This focuses on the differences in prescription and addiction rates for different opioids. Utilizing these differences we could begin to explain what happens if less prescriptions were written for one particular opioid and how that would impact the crisis overall. Our goal is to better understand the driving forces of the opioid crisis in order to understand how to better battle this growing epidemic. In part one, we will discuss background.

8 *Opioids: The New Plague, Part 2*

Bryce Amato, University of Portland **
Meghan Childs, University of Portland †**
Ruthie Olson, University of Portland †**
Sam Rivas, University of Portland †**
Alex Tessner, University of Portland **
Eli Goldwyn, University of Portland

In 2016, more than 11 million people abused prescription opioids. Of all opioid overdoses, 40% of them were caused by one of these prescriptions. Over the last ten years this opioid crisis has become known as the national addiction epidemic and is impacting more and more people each year. Using mathematical infectious disease modeling techniques we are able to model certain patterns of the spread of this crisis. After extensive research, we have designed a model that incorporates several different prescription classes. This focuses on the differences in prescription and addiction rates for different opioids. Utilizing these differences we could begin to explain what happens if less prescriptions were written for one particular opioid and how that would impact the crisis overall. Our goal is to better understand the driving forces of the opioid crisis in order to understand how to better battle this growing epidemic. In part two, we will discuss methods and findings.

9 *The Conditional Matching Preclusion of the Shuffle-Cubes*

Sai Anantapantula, Northville High School†***
Christopher Melekian, Oakland University*
Eddie Cheng, Oakland University

The matching preclusion number of a graph is the minimum number of edges whose deletion results in a graph that has neither perfect matchings nor almost-perfect matchings. For many

interconnection networks, the optimal sets are precisely those incident to a single vertex. The conditional matching preclusion number of a graph was introduced to look for obstruction sets beyond those incident to a single vertex. It is defined to be the minimum number of edges whose deletion results in a graph with no isolated vertices that has neither perfect matchings nor almost-perfect matchings. In this paper, we consider the problem of finding this number and the problem of classifying all such optimal sets for the shuffle-cube graphs, a variant of the well-known hypercubes.

10 *Medical Imaging with Electrical Impedance Tomography, Part I of II: Background*
Benjamin Bladow, Gonzaga University †**
Emma Kar, Gonzaga University**

Electrical Impedance Tomography (EIT) is a promising non-invasive medical imaging technology that can be used in many applications. Specifically, we use EIT to image an individual?s thoracic region. Our methods apply boundary currents and measure resulting voltages in order to reconstruct a 2D interior conductivity map. This 2D reconstruction is a direct solution to a severely ill-posed inverse problem, using a D-bar reconstruction method with a nonlinear Fourier transform. In this talk, we present background on EIT and the D-bar algorithm.

11 *How to Feed Your Dragon*
Mark Brumberg, Seattle Pacific University**,
Kole Yoshimura, Seattle Pacific University**

We model possible living conditions and arrangements for three dragons. Dragons considered in our model are of western reptilian descent and based off of the dragons of Daenerys Targaryen, presented in popular fantasy television series Game of Thrones. We develop a logistic regression equation which models our dragons weight and calorie consumption in order to determine how much food each dragon will need. We then model the number of American bison we would need to support these dragons, how much land we need to support the bison, and how much a herd of bison would cost. Later we consider the effect temperature has on our models.

12 *Taking Up Equitable Instruction in Higher Education: Learning from K-12 Observational Tools*
Megan Brunner, Oregon State University*

Over the last few decades, professional development programs and opportunities targeting inequities in K-12 education have been taken up to work towards instructional improvement (Ball & Cohen, 1999; Guskey, 2002). Reform movements for teacher practice, which target ideas of increasing student achievement, especially within historically underrepresented and underserved populations in mathematics, rely on capturing instruction through the use of measurement tools and protocols for accurate and targeted professional learning (Pianta & Hamre, 2009). Similarly, work in higher education has shifted to consider how teaching practices influence opportunities for learning within STEM classrooms; there is use of observational measures in these settings as well (Hora & Ferrare, 2014). In considering the ways that educators continue to learn in and from practice using observational measures, we must also question how these tools support equitable instructional practices and rigorous mathematics learning for all students (National Council of Supervisors of Mathematics & TODOS: Mathematics for ALL, 2016). Equitable instructional practices have been well studied in grades K-12, but need to be explicitly attended to in higher education. This session will explore how observational tools used in K-12 mathematics classrooms provide understandings of equitable

teaching practices. The ways in which equity is operationalized through dimensions and foci of the observational tools will then influence what educators attend to and how they engage in professional learning. I then consider some implications for improvement of instruction towards equitable ends, especially within post-secondary classrooms.

13 *Supporting Ambitious Mathematics with Mathematics Majors Via Tasks, Routines, and Norms*

Megan Brunner, Oregon State University[†]
Rebekah Elliott Oregon State University
Erin Glover, Oregon State University[†*]

Undergraduate mathematics courses serve a multitude of purposes. These purposes range broadly with many fields focused on the application of mathematics including to K-12 mathematics classrooms. Indeed, mathematics for teaching has been identified as a form of applied mathematics (Stylianides & Stylianides, 2009). Like applied mathematicians who use mathematics to solve perplexing questions in a context, teachers use mathematics to address perplexing learning questions in the context of teaching. The demands on teachers' knowledge are highly specialized to address the pressing problems of learning they face daily while teaching students (Ball, Thames, & Phelps, 2008). Policymakers suggest that secondary teachers learn mathematics for teaching via an undergraduate degree in mathematics and courses that support "looking back" at the transition of middle to high school level mathematics and from high school to college level mathematics (AMS, 2012).

Our project, *Supporting Ambitious Mathematics with Mathematics Majors* (SAMMM), serves undergraduates who are interested in becoming teachers to begin to hold their mathematical knowledge in ways that are useful for teaching (Ball, Thames, & Phelps, 2008). Like policymakers who suggest looking back at the secondary mathematics content, rather than always looking forward to content needed in subsequent math classes (AMS, 2012), we attend to tasks that press undergraduates to examine the underlying structures of taken for granted mathematical ideas, leverage multiple representations to construct a variety of viable arguments, and connect these arguments and representations to uncover key mathematical ideas. We are interested in how the purpose of learning mathematics mediates the ways that students engage in mathematics. In this presentation we examine activity in an undergraduate mathematics classroom the math tasks posed, the routines for engagement, and the norms for mathematical reasoning cultivated by the instructors and students to understand the purposes for learning mathematics. We use Engstrom's activity theory (2018) to explore the mediating tools guiding activity and the resulting outcomes for undergraduates. In our presentation, we consider the features of the activity system and the implications for undergraduate instructors who are supporting mathematics majors to hold their mathematical knowledge in ways that are useful for teaching.

14 *The Fundamental Groupoid of Graphs*

Tien Chih, Montana State University-Billings

The Fundamental Group(oid) is a topological invariant, whose operation is concatenation of classes of loops and paths. Such a construction is meaningful by considering homotopy classes of these loops and paths. Thus construction of a fundamental groupoid for Graphs necessitates a theory of graph homotopy. Previous attempts to define graph homotopy involve equipping a graph with a topological space and applying homotopy theory to the space. In this talk, we introduce a categorical homotopy theory internal to graphs. We then use this theory to construct a fundamental groupoid for graphs and describe some of it's properties.

15 *The Impacts of Game of Thrones Dragons in the Real World*
Audrey Collen, Linfield College[**],**
Abigail Northrop, Linfield College[**]**and Grace Thompson-Johnston, Linfield College**[**]

The popular TV Show *Game of Thrones* based on the book "A Song of Ice and Fire" by George R.R. Martin creates a convincing world and leaves people to wonder whether or not the earth could actually support a population of dragons. In the question provided by the International Math Modeling Competition, we were tasked to create a model of ecological impacts of dragons in the real world. In order to analyze whether or not dragons could in fact survive, many conditions and implications must be considered. Presenting assumptions on the physical characteristics and routines of the dragons, it is concluded plausible that the earth could support the three creatures. In the analysis, it was found that dragons are relatively sustainable for six years at their young age and small size. Though they do not require a ton of space initially, the larger the dragons get the more they will infringe on the human population and it may be difficult for the dragons to share space with each other if they wish to. After finding an equation that would give a caloric intake based on type of animal and weight, the group decided that we would assume that the dragons are seventy percent bird and thirty percent reptile. By using the caloric intake equation, we predicted the daily caloric intake of dragons based on their size at a certain age. We used population models to predict the future population of various livestock and determined the effect dragons would have on these future populations based on caloric intake. In addition, we considered six different cases that varied based on human relationship and region. Overall, though it is concluded that it is plausible earth can support three healthy dragons for 200 years, many populations of livestock dropped below zero.

16 *Visualizing p-adic numbers*
Dibyajyoti Deb, Oregon Institute of Technology

The p-adic numbers were first introduced by Kurt Hensel in 1897. Since then they have been used in several areas of mathematics, especially in number theory. Even though it is an abstract concept by itself, we shall look at a visualization of p-adic numbers in this talk using trees, and also answer some basic questions in p-adic analysis.

17 *Student Verification Schemes for Combinatorial Problems in a Computational Setting*
Adaline De Chenne, Oregon State University[†*]**,**
Elise Lockwood, Oregon State University

For many students, verifying solutions to combinatorial problems is difficult. In this talk, we examine how undergraduate students with no formal combinatorics training verify solutions to combinatorial problems in a computational setting. Eizenberg and Zaslavsky (2004) identified five schemes to verify combinatorial problems used by undergraduate students who have taken at least one class in combinatorics. We argue that a computational setting assists students in using two of these schemes: adding justification to the solution and using a different solution method to compare answers. Additionally, we argue that a computational setting may allow students to verify strategies with schemes that are distinct from those identified by Eizenberg and Zaslavsky. We conclude with implications and/or avenues for future research.

18 *Designer Numerical Methods for Approximating Solutions to Differential Equations*
Alana Dillinger, Gonzaga University [**]

Multistep methods are a computationally efficient way to approximate solutions to differential equations, especially when compared with other methods such as Runge-Kutta. However,

requiring more accuracy generally results in worse stability, i.e., more roundoff error. The stability domain is a picture in the complex plane that shows the problems and stepsizes for which a given method will give stable solutions. I will discuss the development and analysis of novel multistep methods created by introducing parameters that are allowed to vary. Dahlquist's First Stability Barrier puts a cap on the maximum order of a stable method; we seek to maximize the order while maintaining stability. Applying Taylor series gives a linear system for the unknown coefficients of a multistep method. Requiring stability gives bounds on the domains of the free parameters; varying the parameters within this domain results in changes in the size and shape of the stability domain, allowing us to produce methods that work better for a given differential equation.

19 *What do students really need to know about multivariable calculus?*
Tevian Dray, Oregon State University

Course content is determined by assessment: Many students really care only about what will be on the test – and many instructors teach to the test. But do those tests assess the desired skills? It's not enough to align assessment with learning goals; the goals themselves must be thoughtfully selected. Selecting goals on the basis of assessability can leave essential skills out of the conversation.

As part of more than 20 years of curriculum redesign at Oregon State University (mostly in the Department of Physics), we have redesigned both multivariable and vector calculus to emphasize geometric reasoning, rather than merely selecting the correct, memorized tool from an increasingly large toolbox. These courses now focus on a small number of geometric strategies, which are applied in multiple contexts, thus explicitly teaching students about problem-solving strategies and professional norms in science, not merely how to solve particular calculus problems.

This talk discusses both the ongoing process of redesigning these courses, and the resulting courses themselves.

20 *A visual decomposition of squares of even polygonal numbers*
Tom Edgar, Pacific Lutheran University

We will describe a few classical visualizations of integer sums including Nicomachus's Theorem for generating cubes. We generalize these types of sums to other less well-known arithmetic sums that will allow us to generate squares of even polygonal numbers. We include a new visual proof of these results (at least for squares of squares), which yields an interesting method for decomposing the fourth powers.

21 *Putting the fundamental back in the Fundamental Theorem of Calculus*
Tenchita Alzaga Elizondo, Portland State University †*
Brittney Ellis *, **Portland State University**
Steven Boyce, Portland State University

We describe our ongoing efforts to redesign differential and integral calculus courses around core concepts through an active learning approach. Part of this redesign focuses on adapting a research-based curriculum which foregrounds the Fundamental Theorem of Calculus. In this talk we will discuss our continual efforts to restructure these courses as well as plans for the future.

22 *Mathematics on the Internet: Charting a Hidden Curriculum*
Ander Erickson, University of Washington, Tacoma

This research project examines how undergraduate students in lower-division mathematics courses make use of online resources in order to assist with their studies. The preliminary results of a survey of students in a diverse undergraduate institution along with follow-up interviews suggest that students make use of online resources (beyond those assigned by the instructor) extensively and to a greater extent than in other subject areas. I present evidence of two distinct ways in which these resources are primarily being employed: adopting online lectures as a supplement to existing classroom instruction and the use of answer engines (e.g., Symbolab) as a way of self-diagnosing mathematical errors.

23 *Link Invariants, Klein Links, and Interesting Patterns*
Vesta Coufal, Gonzaga University
Rusty Ford, Gonzaga University[†**]
Tyler Gonzalez, Gonzaga University[**]
Kate Kearney, Gonzaga University
David Rudolph, Gonzaga University[**]

A knot is a closed curve in three dimensions and a link is a set of potentially interlocking mathematical knots. Klein links form a group of links which may be embedded across the surface of a Klein bottle. That is, a Klein link is a link which may be drawn across the surface of a Klein bottle without intersection. This particular group of links has not yet been well studied by the mathematical community.
Initially, our interest in these links stemmed from the relation between Klein knots and torus knots. It is a fairly well-known fact that all Klein knots are torus knots, but our research has shown that not all Klein Links are Torus links.
This presentation will provide a brief discussion of the major results of our continued research on Klein links. First, we will go over our basic construction of these links in both braid form and as an algebraic statement. We will then consider link invariants and other aspects of knots to show how our research findings are coming together.

24 *Agree with me, κ? Interrater Reliability using Cohens Kappa*
Jessica Fossum, Seattle Pacific University[**]

Exploring the topic of interrater reliability, this project uses Cohens κ (Kappa) to measure how reliably two raters code binary, categorical data. A function is programmed in R to perform this calculation. The function is expanded to handle non-binary categorical data and data that can be coded with multiple categories, using expansions on Cohens κ. The function also explores missing data and unused categories, and guidelines for interpreting Kappa values.

25 *The Aftermath: Optimizing Medical Resource Allocation via Quadcopter Post-Disaster*
Jessica Fossum, Seattle Pacific University[**]

Following a prompt about optimizing emergency response efforts through the Mathematical Contest in Modeling, this presentation offers a possible plan for disaster relief. Specifically targeting Puerto Rico after Hurricane Maria, this plan uses drones to deliver resources to five key hospitals and also capture video surveillance of areas hardest hit by the storm. Cargo containers are strategically packed with chosen ratios of three different types of medical packages, and drone flight paths are designed to optimize storage and route distances. Ultimately, this design sustains the needs of the five hospitals for nearly two years.

26 *Using precalculus peer facilitators to increase student success*
Emily Gismervig, University of Washington Bothell
Bryan White, University of Washington Bothell
Cinnamon Hillyard, University of Washington Bothell

Two years ago, we instituted a program in which undergraduate peer facilitators lead mandatory support classes that accompany our precalculus courses. The precalculus sequence has historically been a gatekeeper for many students; students who do not do well cannot enter calculus and are not able to apply to STEM and business majors. In our talk, we will detail our implementation of peer facilitators, provide data showing increased student performance and a narrowing of the gender achievement gap, and provide persistence data including students' subsequent performance in calculus.

27 *Teaching Mathematics Disciplinary Practices in Advanced Mathematics Courses*
Erin Glover, Oregon State University[*]

Much of the existing research literature in advanced mathematics towards the end of the last century centered on student cognition (e.g., Dubinsky et al., 1994), proof (Harel & Sowder, 1998), and problem solving (Schoenfeld, 1992). These studies often focused on students difficulties with mathematical content rather than their learning to engage in the practices of the discipline. I refer to these as mathematics disciplinary practices (MDPs) and define them to be the ways in which people who use mathematics go about solving complex tasks across content domains. These include such things as conjecturing, modeling, justification, and proof. The goal of my research is to explore the ways that instruction might support students learning related to MDPs. I interviewed mathematicians who teach advanced undergraduate courses and conducted case studies in two advanced-undergraduate mathematics courses in an effort to better understand how instructional environments and teaching practices may support learning related to these important practices. In this talk I will discuss some of the interesting themes that emerged from my interviews with the mathematicians and share preliminary findings from the two case studies that shed some light on how instruction might support students in engaging in MDPs.

28 *Challenging the Dominance of Mathematical Epistemologies through Community-Based Learning*
Jesse Goncalves, Seattle University[**]

The objective truth to which mathematics purportedly grants access was what initially drew me to the subject, and many scholars across disciplines have likewise been drawn to math as a method for accessing truth in their respective fields. However, the presentation of math as separate from social complexities, both in terms of the context in which it is produced and the outcomes it produces, has profoundly negative effects in math education and dangerous implications in general. I argue that giving students the opportunity to apply math to concrete situations they understand beyond a purely mathematical framework introduces them to the power and limitations of math for understanding our world. Accordingly, I describe my experiences with two projects that have challenged my personal understanding of mathematics.

29 *Relationships between calculus studentsÕ units coordination and covariational reasoning*
Steven Boyce, Portland State University
Jeffrey Grabhorn, Portland State University[†*]

This talk regards introductory calculus students' conceptual structures for reasoning quantitatively. 10 students participated in two hour-long clinical interviews. The first interview assessed students ways of reasoning about fractions in static measurement scenarios, and the second interview assessed students reasoning about scenarios involving quantities that co-vary. We will describe relationships between the ways students coordinated units in static situations and the ways students reasoned about co-varying quantities, and we will discuss implications for calculus instruction.

30 *Arithmetic, geometric, and harmonic progressions defined on Fiboquadratic Numbers*
Tomás Guardia, Gonzaga University †
Morgan McCurdy, Gonzaga University**

The historical board of Rithmomachia, consists of 48 numbers, following the rules of Greek Number Theory. It is known that some triplets of the historic board are in arithmetic, geometric, and harmonic progressions. Meanwhile, some quartets of the historical board are in two or three progressions at the same time. From a geometric point of view, the triplets and the quartets are discrete solutions of a plane or a quadratic surface in $\mathbb{R}^3$; Fiboquadratic Numbers being defined on an extension of the board to infinity. We ask then if the triplets and the quartets of a finite collection of Fiboquadratic Numbers are a discrete solution of the same surfaces coming from the triplets and quartets of the historic board.

31 *Near Peer and Recent Alumni Mentoring for Math and Computer Science Students at WWU*
David Hartenstine, Western Washington University†
Perry Fizzano, Western Washington University

The CS/M Scholars Program at Western Washington University is funded by an NSF S-STEM grant. First-year students are paired with students farther along in the major, who are in turned paired with Early Career Professional Mentors (ECPMs), recent WWU math and CS alumni. Topics discussed will include: the creation of the alumni network, logistics and management, feedback from students and ECPMs, and plans for the future.

32 *Incorporating Data Analysis and Visualization through Class Projects and Activities*
Corban Harwood, George Fox University

Experience in data science is an increasingly useful job/life skill and the incorporation of data analysis and visualization in the mathematics curriculum also helps tie in students earning a major/minor/certificate in Data Science. This talk presents examples of class projects and activities in differential equations, numerical analysis, and the calculus sequence which give students tangible examples which deepen their understanding of class content as well as data analysis itself. These projects and activities have students interact with data in a variety of ways: simulation, collection, management, statistical analysis, curve fitting, or visualization in multiple perspectives.

33 *Knots Related by Knotoids*
Allison Henrich, Seattle University

Knotoids are, loosely speaking, knotted objects that have loose ends. There are many ways of connecting these loose ends to obtain ordinary classical or virtual knots. This fact allows us to do something interesting: define a relation between knots using knotoids. In this talk, we will learn what it means for two knots to be "knotoid equivalent.? Armed with this definition, we will discuss which pairs of knots are knotoid equivalent and why. The answer may surprise you!

34 *Math PLUS: Mentoring Intermediate Mathematical STEM Fair Projects*
Carmen Hoffbeck, Linfield College[**]

The Math PLUS program at Linfield College puts classroom mathe- matics skills to use in a mentoring capacity, and brings undergraduates and younger math-interested students into the process of mathematical re- search. Through this program, we bring students from the local Yamhill- Carlton Intermediate School to campus and individually mentor math- themed science fair projects. The Math PLUS program is an important opportunity for undergraduates to gain experience teaching and mentor- ing in mathematics, and provides a chance for younger students to develop a mathematical inquiry project and pursue an interesting question. We will focus on a particular project involving mathematics and biodiversity.

35 *Computing the $RO(C_2)$-graded cohomology of equivariant Grassmannians*
Eric Hogle, Gonzaga University

The Grassmannian manifold of k-planes in $\mathbb{R}^n$ has a group action if $\mathbb{R}^n$ is taken to be a real representation of the group. When the group is C_2, the Schubert cell construction of the Grassmannian generalizes to an equivariant representation-cell structure. However, this generalization is not unique; an identification of representation with $\mathbb{R}^n$ must be chosen.

I am interested in computing the $RO(C_2)$-graded Bredon cohomology of these spaces. Although a theorem of Kronholm dictates that this must be free, determining the degrees of the generators is nontrivial. The ambiguity introduced by the choice mentioned above turns out to be an asset for this task. Using a computation by Dan Dugger of the cohomology of an infinite equivariant Grassmannian, and some theorems about equivariant flag manifolds, I will present a way to succeed in finding the cohomologies of several infinite families of finite-dimensional equivariant Grassmannians.

36 *Project RubiX*
Katalina Biondi, University of Washington, Tacoma[**]
Adeline Jacobsen, University of Washington, Tacoma[†**]

As President and Vice-President of the Mathematics Club at UWT our goal is to cultivate an active math community on our campus and surrounding community. We want to continue to inspire people that are already love math while also de-stigmatize the fear associated with math. We continue to achieve these goals through Project RubiX. Project Rubix is an interdisciplinary project that joins engineers, computer scientist, mathematicians, and the arts to design, build and communicate the process of building a robot to solve a 3x3 rubiks cube. The project involves other registered student organizations, which was a strategic plan to build RSO community at UWT while also learning the difficulties of communication in large multidisciplinary projects. In our presentation, we will walk through a timeline of Project RubiX, address the trials and tribulations we encountered, then discuss the goals we had at the beginning contrast to the ones we met.

37 *Institutional Change: the Role of Peer Observation in the Adoption of Evidence-Based Instructional Practices*
Carolyn James, University of Portland
Valerie Peterson, University of Portland
Stephanie Salomone, University of Portland[†]

In this session, we describe how peer observation can be used to promote lasting adoption of evidence-based instructional practices. Redesigning Education For Learning through Evidence and Collaborative Teaching (REFLECT) is a three-year NSF-funded project that leverages theories of institutional change to shift teaching culture toward more student-centered

approaches. In particular, our implementation of peer observation aligns with Henderson and colleagues' (2011) three characteristics of effective change efforts: (1) it address participant beliefs through structured reflection, (2) it involves long-term intervention via a cohort model, and (3) it is designed to be compatible with the larger structure within the university. This talk describes both affordances and barriers of peer observation implementation, and provides insight into ways to mitigate those barriers.

38 *Who is Talking and Who is Thinking? The Distribution of the Cognitive and Conversational Load during Undergraduate Mathematics Tutoring*
Carolyn James, University of Portland

Undergraduate math tutoring is an important context for student learning, yet little empirical work has been done to understand tutor-student interactions. In this session, I will describe who guides the conversation and cognitive load during a tutor-student interaction. Based on data from 10 tutoring episodes, we constructed a framework for understanding the conversational moves and the levels of cognitive demand exhibited during the interaction. We found that tutors led the interaction using statements and questions, and they took the lead in the deciding the approach to the mathematical problems. Students tended to ask question and respond to tutors, and they contributed most during the computational and conceptual areas of the interaction.

39 *Medical Imaging with Electrical Impedance Tomography, Part II of II: Recent Advances*
Emma Kar, Gonzaga University †**
Benjamin Bladow, Gonzaga University**

Electrical Impedance Tomography (EIT) is a promising non-invasive medical imaging technology that can be used in many applications. Specifically, we use EIT to image an individual?s thoracic region. Our methods apply boundary currents and measure resulting voltages in order to reconstruct a 2D interior conductivity map. This 2D reconstruction is a direct solution to a severely ill-posed inverse problem, using a D-bar reconstruction method with a nonlinear Fourier transform. In this talk, we present our recent advances in artifact filtering methods.

40 *(De)Constructing Mathematical Authority*
Brian Katz, Augustana College

Mathematics is a human endeavor, so it involves power and privilege. Scholars including Rochelle Gutiérrez and Sara Hottinger have argued that mathematics as we view it in the western academy operates as whiteness and supports white supremacy, but even educators who feel this connection every day continue to struggle with changing it. I think that this exclusionary system is sustained, in part, by our discipline's curious views on authority and the ways that authority is constructed and recreated in mathematics classrooms. This talk will focus on the interconnected issues I have faced while trying to build a classroom community that critiques and resists this system.

41 *Implementing Writing Enriched Learning Outcomes in Fundamentals of Mathematics*
Kate Kearney, Gonzaga University

In 2016, Gonzaga University implemented a new core curriculum. As part of the new core curriculum, students are asked to take nine credits of courses designated as Writing Enriched. To serve our students, I and several of my colleagues have successfully petitioned to have our proof-writing course, Fundamentals of Mathematics, designated as Writing Enriched. In this talk I will describe some of the changes that I've made to the course as I have adapted it to best fit the learning outcomes required for a Writing Enriched course.

42 *Derivatives and p values from Primary Sources*
Dominic Klyve, Central Washington University

In this talk, we will present two Primary Source Projects developed to teach undergraduate mathematics through the NSF-funded "Transforming Instruction in Undergraduate Mathematics via Primary Historical Sources" grant. The speaker will discuss projects he has written to teach p-values in an Introductory Statistics class, and derivatives of trig functions in Calculus 1.

43 *Understanding what your students understand: Implications of using Specifications Grading in Undergraduate Mathematics Courses*
Jessica Knoch, Oregon State University*

Specifications grading (and more generally, proficiency-based grading) requires clearly written course learning objectives. Students choose a "bundle" of assignments to achieve their desired grade, and they can show proficiency in multiple ways. In this talk I will outline the basics of specifications grading and give an example of how I used it in a vector calculus course, as well as how I aligned assessments with the course learning objectives. I will discuss benefits and challenges from the perspective of both instructor and student.

44 *Opportunities Afforded by a Radical Textbook*
Jessica Knoch, Oregon State University*

In this talk I outline the benefits and challenges of incorporating a new, open, free textbook in a math literacy course designed to prepare students for college-level liberal arts math. Lane Community College's math literacy course was redesigned in 2017 to make the best use of a new, radically different textbook that incorporates active learning techniques, small group work, growth mindset modules, and student projects based on real life data. I will discuss the implementation and results from our first two years with the new textbook.

45 *Standards-based grading for ordinary differential equations: a parallel study*
Jakob Kotas, Univesity of Portland

In standards-based grading (SBG), students are assessed based on their demonstrated mastery of specific learning outcomes, and multiple opportunities are given for students to demonstrate mastery over the course of the term. Three mathematics professors at the University of Portland in Portland, OR and Wentworth Institute of Technology in Boston, MA have implemented SBG for their undergraduate-level ordinary differential equations classes in the spring 2019 semester. We have collected data to find how SBG affects students' understanding of learning outcomes, as well as its impact on students' personal motivation and anxiety in the course over time. In this talk, preliminary findings will be shared. Final data analysis will occur after the end of the spring 2019 semester.

46 *Flipping an Introductory College Algebra Course*
Paul Krouss, Washington State University Vancouver
Kristin Lesseig, Washington State University Vancouver

In response to lower rates of student success both nationally and at our own institution for introductory/developmental college algebra courses, we implemented a flipped version beginning in 2014. Research on student attitudes, usage of course resources, performance, and persistence in future mathematics courses demonstrated positive impacts of the course. In this presentation we share the general course design and the impact measures that were considered. We also discuss how our learnings inform further revisions for such a course.

47 *Leavitt path algebras over arbitrary unital rings and their two-sided ideals.*
Hans Nordstrom, University of Portland
S Joseph Lippert, University of Portland†**

We provide an analog of a Hilbert basis theorem for Leavitt path algebras (LPAs) over associative, unital, noetherian rings. In addition we describe two classes of graded ideals of such rings, and provide a classification of all graded ideals using these classes. Lastly, we give characterization of when such LPAs are prime, and a description of graded prime ideals.

48 *Epidemic Insurance: Simulations and Applications*
Sooie-Hoe Loke, Central Washington University†
Christopher Powell

The inevitability and devastation posed by disease epidemics demands preparation. Toward establishing an insurance program robust enough for the company to remain solvent for the duration of an epidemic, this research combines stochastic epidemic models with modern actuarial concepts. Using Gillespie-type simulation, we analyze the dynamics between disease persistence, recovery rates, premiums, and costs of an epidemic insurance scheme. We apply these ideas to insurance surplus processes and study the corresponding ruin probabilities.

49 *Inclusive Mathematical Teaching: Rational Functions for Students with Visual Impairments*
Michael Lopez, Oregon State University*

College algebra is amongst the top failed courses in the nation, which is why it is important to explore new ways to connect the material with all our students. I propose that we begin to collaborate with special educators who are skilled in presenting mathematical topics to students who are visually impaired because these educators use innovative tools, such as graphing aids, audio graphing calculators, tactile material, and large displays/print that would likely prove beneficial to visually able students. Since students often struggle with rational functions in college algebra, I would like to share an approach to teaching rational functions that is inclusive to students who may or may not have visual impairments.

50 *Modeling the Opioid Crisis with a Focus on Treatment*
Ahmed Tariq Al Kindi, Portland Community College**Kara Colley, Portland Community College**
Robin Cutshall, Portland Community College**
Richard Lopez Portland Community College†****
Joseph Matveyenko, Portland Community College**Issac White, Portland Community College****

Opioid addiction has caused hundreds of deaths a year in the Portland area. The epidemic has had a significant effect on rural areas of Oregon as well. The overprescription of opioids for pain management has been the primary contributor to the issue. Past mathematical models focus on prevention through analysis of prescription parameters. Our model focuses on the effectiveness of treatment for Medicare recipients through two methods (medically assisted treatment and short-term detoxification). Understanding treatment options for addiction is important for the attenuation of the opioid epidemic. This would help with policy initiatives and decreasing the use of opioids locally.

51 *Panel discussion on data science*
Panelists: Haiyan Cheng, Willamette University
Peter Drake, Lewis & Clark College
Corban Harwood, George Fox Univeristy
Heather Kitada, Reed College
Chris Lane, Pacific University

Data Science is quickly becoming one of the most in-demand disciplines. This panel will help faculty get started by answering questions such as: How can you start a data science program? How can you design courses for data science? Where can you find resources and build connections with industry? This panel consists of colleagues who are leaders at their institutions in data science. They are going to share their experience with starting and/or teaching in a data science program. They will discuss first-hand experiences with the opportunities and challenges these new programs present. We will have ample time for questions.

52 *Unravelling the lynx-hare paradox*
Amanda Mallott Gonzaga, University[**]
Kathleen Maxfield, Gonzaga University[**]
Thomas Schechter, Gonzaga University[**]
Jack Strand, Gonzaga University[**]

Hudson Bay Company pelt trading data has served as a proxy for the population densities of the snowshoe hare and Canadian lynx in the Boreal forest. The data suggests that both populations exhibit cyclic behavior; however, peak population density of the Canadian lynx precedes that of the snowshoe hare, leading to the paradoxical conclusion that hare eat lynx. In this talk, we present a novel mathematical model that incorporates a trapping effect and argue that pelt data does not represent a reasonable proxy for population density. In addition, model results indicate that there exists parameter values that help explain the paradox.

53 *Determining the Steiner k-diameter of a Graph*
Yaping Mao, Qinghai Normal University
Chris Melekian, Oakland University[†*]
Eddie Cheng, Oakland University

In a connected graph, the Steiner distance of a set of vertices is the minimum order of a connected subgraph spanning the set, and Steiner k-diameter of the graph is the maximum Steiner distance of any k-element vertex set. These notions generalize the classical definitions of distance and diameter. In this talk we describe the relationship between Steiner diameter and connectivity and give conditions to exactly determine the Steiner k-diameter.

54 *Fiboquadratic Numbers and Rithmomachia*
Morgan McCurdy, Gonzaga University[**†]
Tomás Guardia, Gonzaga University

Created on the basis of Greek Number Theory, Rithmomachia is a medieval board game originating from the teachings of the quadrivium around the tenth or eleventh century A.D. By taking an infinite extension of the board, we are able to conclude that the Fiboquadratic Numbers do appear and that the extension then results in the solution of a recurrence relation. Therefore, this extension is the only one that preserves the original definitions coming from the Middle Ages, translating into the mathematical realm.

55 *Using Neural Networks to Solve Differential Equations*
Stacey Meekhof, Central Washington University[**]
Bill Miller, Central Washington University[**]
Breanna Smith, Central Washington University[**]
Rachel Walker, Central Washington University[**]

Well known methods of approximating solutions to differential equations result in discrete solutions or solutions of limited differentiability. We explore the use of neural networks to produce a continuously differentiable approximation to solutions of differential equations. By comparing this method with traditional numerical methods, we show that this approach produces a result of a similar accuracy as other leading numerical methods. From here, we analyze how we can use this model to develop an alternative method of approximating solutions for delay differential equations.

56 *Backward Design, Transparent Teaching, and Mastery-Based Grading in a first Linear Algebra course*
Leanne Merrill, Western Oregon University

The principles of backward design, transparent teaching, and mastery-based grading go hand-in-hand. Backwards design is the notion that instructors should start by identifying learning objectives and design their courses around those objectives. Transparent teaching is the idea that, by being explicit about the goals and motivation behind our assignments, students will be better able and more willing to meet the expectations we set. Mastery-based grading refers to the concept of grading students their ability to demonstrate mastery over a specific list of skills, regardless of the time or number of tries it takes them to demonstrate mastery. In this talk, I'll briefly discuss the research around these ideas, and talk about my own experiences implementing them in a Linear Algebra I course.

57 *Teaching an Introductory Programming Course to Non-Computer Science Majors Using SageMath*
Razvan Alex. Mezei, St. Martin's University

In this paper we propose an introduction to programming course using Sage- Math for non-Computer Science majors. A course outline on developing and designing the course will briefly be presented. Then we will share a set of course evaluation metrics anonymously submitted by students, as well as some in-class experiences, from such a course that we taught recently. Given the large amount of packages available in SageMath, such a course can easily be tweaked to match the need of a diverse student population, whether it is dominated by students majoring in Mathematics, Data Science, Computer Science, Information Technology, or a mix of these.

58 *A Connection Between Column Spaces and Eigenspaces*
Fisher Ng, Gonzaga University[**]
Michaela McDougal, Gonzaga University[**]

We present a curious relationship between the eigenspaces and column spaces of square matrices. We hypothesize that if A is a diagonalizable matrix with eigenvalues λ_j and $B_j = A - \lambda_j I$, then a basis for the column space $\mathrm{Col}(B_j)$ is the set of eigenvectors $\{v_i\}_{i \neq j}$. We present a proof in the case of a 2x2 diagonalizable matrix A with complex entries. We then discuss our work on 3x3 matrices.

59 *A take-home format for upper-level undergraduate mathematics courses*
Pietro Paparella, University of Washington

In this talk, we give an overview of a format for upper-level undergraduate mathematics courses which features take-home, collaborative problem-sets in lieu of in-class examinations. Relevant background, anecdotal findings, and directions for further inquiry are included.

60 *Student Mathematical Connections and Adapted Inquiry in a Constrained Linear Algebra Class*
Spencer Payton, Lewis-Clark State College

One aspect of an introductory linear algebra course that can be challenging to undergraduates is the large number of mathematical connections students are expected to make between various linear algebraic concepts. One way of connecting concepts in linear algebra is via a logical implication connection; connections of this structure are often summarized in theorems such as the Invertible Matrix Theorem. This presentation will describe a study that was designed to explore how these connections could be successfully taught in an introductory linear algebra class that faced constraints such as a large class size and limited class time. More specifically, this study also involved an exploration into how the principles of inquiry-oriented instruction could be adapted for implementation in this constrained context and used specifically for the teaching of mathematical connections. Throughout the study, students exhibited and used connections in interesting ways, particularly with regard to linear independence. Further, results of the study provide implications for how instructors can begin to transition to a more inquiry-oriented style of instruction, even in a constrained teaching environment.

61 *Should we harmonize how we expect students to learn with how we assess their learning?*
David Pengelley, Oregon State University

We expect students to do various things to learn, depending on our pedagogy, e.g., listen to lectures, read, write, solve or present problems in class or at home, work individually or in groups, complete projects. We also assess their learning in various ways, e.g., exams, quizzes, homework problems, presentations, writing.

Some of the learning activities may coincide with some of the assessment activities. Should they be the same or different? E.g., why do we assess with exams when we don't create them as learning tools? And why do we expect students to listen to lectures when we don't use them for assessment? Should we instead strive for learning and assessment to be in harmony?

I will consider these issues in the specific context of student motivation and my own 25 year evolution to an active learning pedagogy, and where it has settled, and why.

62 *Introducing Machine Learning in Python with Movie Recommendation*
Jake Price, University of Puget Sound[†]
Jeremy Upsal, University of Washington

In this talk we describe an introduction to machine learning course for high school students. Machine learning and data science are fast-growing, lucrative, and fascinating fields. The basic principles, however, are shockingly intuitive. As part of the STEM Upward Bound program (a summer school for underrepresented high school students in the Seattle area) through the University of Washington, we developed a machine learning course as an elective. Students were introduced to Python through Jupyter notebooks. In particular, we will highlight a module focused on classification algorithms with movie recommendation schemes as a motivating

example. We will show how high school students with no coding experience can develop software to make movie recommendations for their classmates based upon their own movie and trait choices! These techniques could easily be implemented in an introductory CS, scientific computing, or machine learning course at the undergraduate level.

63 *Aligning Assignments and Assessments to Course Outcomes Can be a Win-Wi*
Michael Renne, Oregon State University*

Increasing pressure on institutions to measure educational effectiveness has led to some institutions of higher education to mandate routine reporting on achievement of course outcomes. Accommodating this routine reporting creates both challenges and opportunities for the instructor. In this talk, I explore how I turned some of those challenges into opportunities by aligning assignments and assessments with the course outcomes. These alterations were not difficult and provided net benefit for both the students and the instructor.

64 *Musical Applications of Fourier Transforms*
Sydney Schmidt, Gonzaga University**

There are many connections between mathematics and music. In this presentation, we examine how the wave equation can be used to model the vibration of a guitar string when it is plucked. We begin by developing the solution to the boundary value wave equation problem employing standard techniques, including finding eignenvalues and eigenfunctions and identifying an appropriate Fourier series expansion. We will then look at how this solution models vibration and in particular use the model to explain how harmonics (or frequencies) of a note are made. Finally, we conclude with some new directions and open questions relating to chord construction and traditional note intervals, we plan to pursue in this application.

65 *Multivariate Bell Polynomials and Derivatives of Composed Functions*
Aidan Schumann, University of Puget Sound**

How do we take repeated derivatives of composed multivariate functions? for one-dimensional functions, the common tools consist of the Faá di Bruno formula with Bell polynomials; while there are extensions of the Faá di Bruno formula, there are no corresponding Bell polynomials. In this paper, we generalize the single-variable Bell polynomials to take vector-valued arguments indexed by multi-indices which we use to rewrite the Faá di Bruno formula to find derivatives of $\mathbf{f}(\mathbf{g}(\mathbf{x}))$.

66 *Reducibility of parameter ideals in low powers of the maximal ideal*
Katharine Shultis, Gonzaga University

It is well-known that a commutative, local, noetherian ring R is Gorenstein if and only if every parameter ideal of the ring is irreducible. A less well-known result due to Marley, Rogers, and Sakurai gives that there is an integer ℓ such that R is Gorenstein if and only if there exists an irreducible parameter ideal in the ℓ-th power of the maximal ideal. The proof of this result gives that ℓ is the smallest integer such that a certain map of Ext modules is surjective after taking socles. We investigate upper bounds on this integer ℓ. In this talk, we'll focus on examples where the ring R is a quotient of a power series ring.

67 *"I notice, I wonder" in the college mathematics classroom*
Ksenija Simic-Muller, Pacific Lutheran University

The "I notice, I wonder" warm-up routine is currently commonly used in K-12 classrooms, but is a powerful tool for use in a college mathematics classroom as well. Students look at an image, graph or video, and share what they notice and wonder about it. Because all responses are valued, this routine promotes equitable participation and mathematical discourse. In this talk we will look at some images and graphs that can be used to start rich conversations about mathematical content across the curriculum; and to bring in real-world contexts, including ones related to social justice, into the classroom.

68 *Implementing a Flipped Classroom: A comparison of implementation between secondary and post-secondary mathematics*
Elyssa Stoddard, Oregon State University[†*]
Sylvia Fernandez-Oregon State University

The flipped classroom, and more generally blended learning, is an instructional approach that is gaining popularity across K-16 mathematics education with the aim of increasing student engagement and achievement. These instructional approaches enable students to exercise some control over the pacing of content and also provide extended in class opportunities for student engagement as well as increased teacher and student interactions. This talk will explore two different implementations of a flipped classroom, one at the secondary level and another at the undergraduate level. Instructional strategies, goals, and tools will be discussed, as well as the limitations and advantages of implementation.. Additionally, we will consider how these experiences can be used to inform future research on the design and implementation of effective flipped classrooms.

69 *Abstraction in a First Linear Algebra Course - Where, When and How Much*
Jeffrey Stuart, Pacific Lutheran University

Reflecting on thirty years of teaching matrix theory and linear algebra at various levels, I offer suggestions as to what I have found most effective. In particular, I will focus on the span and its basic properties and consequences, and the levels of abstraction that naturally lie therein.

70 *Elimination of Intimidation Factors*
Kelemua Tesfaye, Seattle University[**]

How can we reorient mathematics education to support people who are under served in the current formal education system? In this talk, I will be using my experiences working with high school students as a case study, to explore the autonomy and agency of students in their mathematics education. As well as, how to challenge people's narratives of who has, and can contribute to mathematics.

71 *The Price Ghost Coin: Bitcoin's price behavior using agent-based modeling*
Joseph Thomas, Central Washington University[†**]
Sooie-Hoe Loke , Central Washington University

The purpose of this paper is to generate an agent based model for the price of Bitcoin. We create a simulated market with two distinct types of agents: miners and traders. Both are susceptible to ideas that Bitcoin is valuable which causes them to trade differently. We pair the spread of ideas with conditional Arithmetic and Geometric Brownian Motion. Our model shows that the simulated price behaves similarly to the historical data. We use a chi-square goodness of fit test and a proportional test to verify the adequacy of the model.

72 *Incorporating Causal Inference into a Data Science Program*
Terri Torres, Oregon Institute of Technology
Kenneth Davis, Oregon Institute of Technology

Causal Inference is a relative new area of statistics that will be integrated in to our data science proposal. Where to incorporate Causal Inference into an over packed degree, with a reference list of resources will be discussed and presented.

73 *Aligning exams to learning goals and Bloom's taxonomy in a scientific computing course*
Craig Gin, University of Washington*,
Benjamin Liu, University of Washington*,
Kelsey Marcinko*, **University of Washington,**
Jacob Price*, **University of Washington,**
and Jeremy Upsal University of Washington†*

The largest course in the Department of Applied Mathematics at the University of Washington is a 300-level introductory to scientific computing course. Historically, the class has lacked clear learning goals. Because of this, there has been a disconnect between what instructors want students to learn and what students practice on homework assignments and are tested on in exams. We have created clear and concise learning goals and new exams to match these learning goals. We have also categorized each new exam question according to Bloom's taxonomy of cognitive learning. In this talk, we will present our new course materials and learning goals and discuss successes and difficulties of placing exam questions into Bloom's hierarchy.

74 *Guided reinvention: Opportunities to learn about and gain fluency with mathematical language*
Kristen Vroom, Portland State University*

It is well documented in the research literature that undergraduate students struggle with many aspects of proof, including their understanding and use of mathematical language. In response, researchers have called for intervention studies geared toward seeking solutions. During this presentation, I will discuss preliminary findings from the first phase of a design study aimed at supporting students in learning about and gaining fluency with mathematical language. The data from this project draws on two teaching experiments (one conducted with a pair of students and another with a whole class) where the students reinvented several key concepts in real analysis. In the presentation, I will share instances where the reinvention context fostered discussion about mathematical language that provided opportunities for students to learn about the nature of mathematical language and develop their fluency with it.

75 *I figured it out so they should be able to . . .*
Brandy S. Wiegers, Central Washington University

"*I figured it out so they should be able to . . .*" This is the statement we make too often about our students' experiences in navigating the professional setting of mathematics. We are indoctrinated to the system as we navigate graduate programs which have often been designed to replicate the barriers, borders, and hurdles experienced by our predecessors rather than creating academic programs that replicate studied best practices of brain development, communities of practice, and educational theories. Even as you read this it is possible you are justifying that this is the way it must be to create grit and perseverance. So I challenge you,

how can we take a step back and design our undergraduate programs not continue this replication of privileged boundaries? In this session we will brainstorm small changes you can make in your classroom next week and then we will create broader challenges, radical big ideas that we'll work on for the next five years. Are you ready for the challenge?

76 *Investigating the Inertias of Clique Graphs*
Amy Yielding[†]
Taylor Hunt
Jazmine Juarez
Heath Sell, Eastern Oregon University

In this talk we introduce a family of graphs we coined, Clique Graphs and Partial-Clique Graphs. Throughout this talk we explore interesting relationships we discovered between the inertia table of a graph and its subsequent partial-clique and clique graphs. Of particular note is the change in the shape of the inertia table from non-trapezoidal to trapezoidal. We investigate the rate of this shift to trapezoidal inertias as well as establish the inertia tables for Clique Graphs of common named graphs.

77 *Using Diagnostic Test to Gage Learning Goal Achievement*
Ekaterina Yurasovskaya, Seattle University

Diagnostic test can be a powerful tool to establish students prior knowledge at the beginning of the course, and to verify achievement of learning goals at the end. If one of the stated or unstated course goals is psychological in nature for example, a reduction of math anxiety– then a diagnostic test can also measure a shift in students beliefs about mathematics and self. Using a diagnostic from our math course for future elementary teachers, we illustrate design and implementation of such a test, and discuss the resulting opportunities for course analysis.

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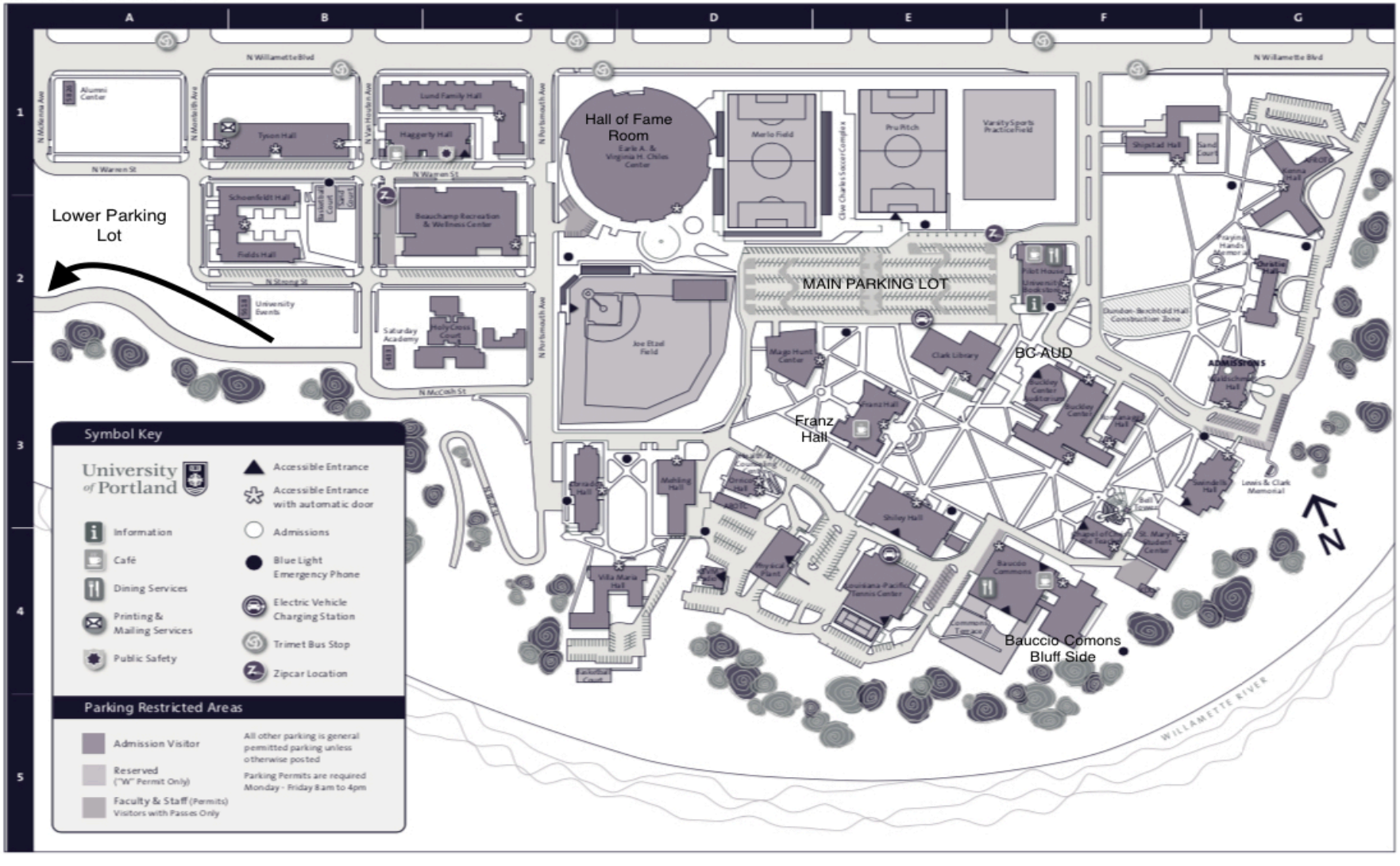

Acknowledgments

I'm proud that all of our meetings over the past two decades (hopefully this one included) have done an exceptional job of highlighting all the great work that is done in the region. We have great presentations and conversations about teaching and learning, and we have wonderful presentations by students doing research along side faculty. It is because of our collective hard work that our Pacific Northwest Section of the Mathematical Association of America has been so successful in highlighting and promoting our work as mathematicians and educators. I'm also thankful for all the help I've received in putting this meeting together. In particular, I would like thank:

My colleagues: Aaron Wootton, who took on the task of organizing accommodations; Valerie Peterson, who took on making local arrangements for the Project NExT program; Jakob Kotas who served as program chair.

Stephanie Salomone, Hannah Highlander, Carolyn James, and Eli Goldwyn who, perhaps, unknowingly, served as the invited program committee and helped with planning our plenary events.

Megan Buzby (University of Alaska), our new Project NExT director for the section. She and our NExTers put together a great program on Friday.

Carol Bruce (Mathematics and Communications Departments Office Manager) and our student workers; Carol helped with many of the essential tasks for the meeting, often on short notice. She is retiring this year, and I am indebted to her for her mindfulness and hard work for both this meeting and the 2012 meeting and everything in between.

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Finally, I'd like to that all our meeting participants, session organizers, volunteer moderators and speakers; without your continued support and patronage, the section would not have these great meetings!

Thank you,

Hans Nordstrom

Local Arrangements Chair