

9:00 – 10:00 AM Facilitated Session**Conversations among Partner Disciplines: The Fishbowl Model**

Abstract: What does quantitative reasoning mean in your discipline? What skills are needed? What habits of mind are necessary? What can and should math departments do to support this? In this session, we will simulate the “fishbowl” model of conversations among partner disciplines used in the Curriculum Foundations research conducted by the Mathematics Association of America committee on Curriculum Renewal Across the First Two Years. In this activity, members of the non-mathematics disciplines discuss questions such as those above, while the mathematicians listen, reflect, but do not speak. This model is currently part of the work of a consortium of ten institutions under a National Science Foundation grant. The grant funds the improvement of lower-level mathematics courses through interdisciplinary collaboration, including the infusion of quantitative reasoning in calculus and differential equations.

Presenter: Victor Piercey, Associate Professor of Mathematics, Ferris State University

9:00 – 9:30 Paper Session**How to Write Papers for Numeracy: An Editor’s Perspective:**

Abstract: Authors sometimes lament, "I wish editors would just tell us what they are looking for!" This session is intended to do just that. Drawing on nearly 200 published pieces in the journal and his experience guiding papers through the publication process, *Numeracy* co-editor Nathan Grawe will talk through the elements of successful submissions to the journal, including discussions of: powerful abstracts, clear organization, effective communication of results, insightful discussion sections, and productive citations (i.e. those which advance the conversation within the discipline by making meaningful connections to the ideas that have come before us). In addition to examining paper elements, Nathan will discuss successful paper types such as descriptions of new QL/QR programs, assessments of teaching interventions, discussions of previous *Numeracy* publications, and notes on teaching tools. We will be sure to have plenty of time for Q&A at the end of the session.

Presenter: Nathan Grawe, Professor Economics at Carleton College. Nathan is co-editor of *Numeracy*.

9:30 – 10:00 Paper Session**Quantitative Literacy for Public Scholarship**

Abstract: As scholars, we have a civic responsibility to engage in the public discourse and to try to bring our work to bear on the difficult, messy, contentious problems that face us as a society. This is public scholarship, and it is particularly important in the current political climate. Quantitative literacy is a critical part of making it work; as Lynn Steen pointed out, quantitative literacy is now a necessary condition for engaged citizenship. But even if we have quantitatively literate citizens, the whole endeavor of public scholarship is doomed to fail without a different kind of quantitative literacy: academics who can effectively communicate quantitative information to non-academics. This talk will explore the connection between useful public scholarship and the ability to present quantitative ideas to a general audience.

Presenter: Kira Hylton Hamman, Lecturer in Mathematics, Pennsylvania State University

Q-Centers & Writing Centers: Useful parallels for developing peer support

Abstract: There has been growing attention to the development and support of students in their QR-related skills and a significant portion of the work in this area involves QR Centers. Directors and other

learning support professionals running QR Centers need to not only create a network, but work together to share resources, collaborate on center projects, and piggyback on existing materials. Especially when it relates to peer and professional tutoring, learning centers across college and university campuses share resources through professional and social networks, such as the National College Learning Center Association, but these organizations lack a QR focus. The Writing Center community has successfully supported community sharing through professional networks, such as the International Writing Center Association, and via their use of peer training materials. The presenters believe much can be learned from the parallel between the QR Center and Writing Center communities.

This session will overview the need for sharing in the QR Center community and highlight the parallel of this need with what the Writing Center community has done, with a focus on the training of peer tutors. Specifically, the presenters will first discuss their positions and centers; second, touch briefly on the development of QR Centers up to present time; third, discuss the development of Writing Centers as an illustration of a path forward for QR Centers; four, describe aspects of existing peer tutor training best practices that QR Centers should be repurposing, sharing, and utilizing; and five, provide time for discussion of other particular needs of QR Centers with an emphasis on potential resources both internal and external to the QR community.

Presenters: Dr. Justine Chasmar Stauffer, Assistant Professor and Q/R Center Director, Goucher College, Baltimore, MD. Ben Smith, Director, Quantitative & Symbolic Reasoning Center, Peer Education Coordinator, Hamilton College, Clinton, NY

10:15 – 11:15 AM Facilitated Session**Teaching empirical reasoning across the curriculum**

Abstract: The systematic use, organization, production, and analysis of qualitative and quantitative data should be a skill that rises to the same level that writing does in a liberal arts curriculum. Barnard has taken a distinctively liberal arts approach by combining empirical reasoning with critical inquiry and has invested in infrastructure, the Empirical Reasoning Center (ERC), to support faculty members incorporating empirical reasoning within their courses across the curriculum. In particular, students should learn to effectively address the following questions: • What constitutes relevant data? • How do you find them? • How (and why) were they produced? • Do the sources impart bias or limit applicability? • If so, what alternatives or corrections can you propose? Students must learn these skills early in their college careers and the knowledge must be reinforced throughout the curriculum, not only in specialized, discipline-specific courses. This session will feature faculty members from a range of disciplines who have worked with the Barnard ERC to design empirical assignments for their courses. Faculty members will discuss their experience, lessons learned, and strategies/approaches for incorporating empirical reasoning in both traditionally empirical and non-empirical courses.

Facilitators (Barnard College): Alisa Rod, Associate Director of the Empirical Reasoning Center; David Weiman, Faculty Director of the Empirical Reasoning Center. **Speakers** (Barnard College): Alan Dye, Professor of Economics; Gergely Baics, Assistant Professor of History and Urban Studies; Christel Kesler, Assistant Professor of Sociology; Gale Kenny, Assistant Professor of Religion; Ellen Morris, Assistant Professor of Classics and Ancient Studies.

10:15 – 10:45 AM Paper Session.**Assessing Quantitative Literacy in Higher Education**

Abstract: Quantitative literacy (QL) is an important student learning outcome (SLO) that has been identified by both the higher education and workforce communities. Despite its importance, international assessment results have shown that adults in the U.S. are underprepared to use quantitative skills, and employers argue that few college graduates are well prepared to work with numbers and statistics. With the increased importance of SLOs such as QL, there is a critical need to evaluate whether students are developing these skills successfully prior to graduating college. One way of evaluating students' QL skills is through SLO assessments. SLO assessments have been increasingly used by higher education institutions for a variety of purposes such as evaluating student learning gains from freshman to senior years, fulfilling accreditation requirements, and strategic planning. Student performance on these assessments can be used by higher education institutions to benchmark performance, analyze trends, evaluate individual programs, and develop and improve curriculum. An SLO assessment for QL could provide an institution with information to identify gaps in students' QL performance and evaluate group-level performance at one or multiple time points, thus providing information that could help identify potential changes in the curriculum and instruction that may need to be made to ensure that students are prepared to use QL skills upon graduating college. In this paper session, we intend to discuss the development and evaluation of HEIghten Quantitative Literacy, a college-level SLO assessment intended to evaluate a students' ability to comprehend, detect, and solve mathematics problems in authentic contexts across a variety of mathematical content areas. The assessment is one module out of a five-assessment HEIghten Outcomes Assessment suite intended to measure general education SLOs for all college students. The 45-minute computer-based assessment consists of a combination of selected-response or numeric entry items written in real-world contexts (workplace, personal/everyday life, and society).

Presenter: Katrina Roohr, Managing Research Scientist, Educational Testing Service

10:45 – 11:15 AM Paper Session**The Q/R for College Science (QuaRCS) Assessment: Emerging Themes from 5 Years of Data**

Abstract: The Quantitative Reasoning for College Science (QuaRCS) Assessment is a validated assessment instrument that was designed to measure changes in students' quantitative reasoning skills, attitudes toward mathematics, and ability to accurately assess their own quantitative abilities. It has been administered to more than 5,000 students at a variety of institutions at the start and end of a semester of general education college science instruction. I will begin by briefly summarizing our published work surrounding validation of the instrument and identification of underlying attitudinal factors (composite variables identified via factor analysis) that predict 50% of the variation in students' scores on the assessment. I will then discuss more recent unpublished work, including: (1) Development and validation of an abbreviated version of the assessment (The QuaRCS Light), which results in marked improvements in students' ability to maintain a high effort level throughout the assessment and has broad implications for QR assessments in general, and (2) Our efforts to revise the attitudinal portion of the assessment to better assess math anxiety level, another key factor in student performance on numerical assessments.

Presenter: Kate Follette, Assistant Professor, Amherst College

10:45 – 11:15 AM Paper Session**Linking Library to Student Retention: A Statistical Analysis**

Abstract: What is the role of the information literacy in student retention? The session will highlight the findings of a recent study that examined whether library instruction has a greater significance on student retention over expenditure. Improving on a previous analysis in academia, this study also sought to determine if library instruction at associate degree-granting colleges correlated to retention. Library statistics for expenditures, library instruction, and associated data were drawn from the Association of College and Research Libraries (ACRL) Metrics database which provides reports collected from academic institutions. Using IBM SPSS, a Pearson correlation coefficient (r) was calculated to determine any interrelation between each category and student retention, in degree, direction, and significance. While most analysis mirrored the former attempt, some results indicated a trend persistent in current literature regarding information literacy, especially for the two-year college. The session will focus on these findings and if students may be more apt to use library resources based on their demographic status and instruction.

Presenter: Derek Stadler, Assistant Professor, CUNY LaGuardia Community College

11:30 – 12:30 Facilitated Session**Statistics and Social Studies (SASS) – Lessons that Promote QR**

Abstract: This session will focus on how teachers can develop students' quantitative reasoning skills in social studies classes. The presenter will share his experiences creating and implementing QR lessons in social studies classes, and participants will have an opportunity to dialogue about, and engage in interdisciplinary collaboration.

Presenter: Mark Russo, District Supervisor Mathematics. Pascack Valley Regional High School District

11:30 – 12:00 Paper Session**“To Make Meaningful Comparisons, we use Ratios.” Really? Why?**

Abstract: In 2014, my home institution, Xavier University in Cincinnati Ohio, with roughly 4500 undergraduates and 2000 graduate and professional students, introduced a new undergraduate core curriculum, which included, for the first time, a Quantitative Reasoning requirement. While students can satisfy this requirement outside of the mathematics department, we decided to enrich one of our general education courses with a strong Quantitative Reasoning. This course focuses on functions, and is intended to prepare students for a general education Calculus treatment. We selected Eric Gaze's materials “Thinking Quantitatively” as our text and course materials. As in several other text options, the idea of “proportional reasoning” is a central theme. It is based on the assumption that we compare quantities using ratios. After teaching this course several times, our instructors, including myself, were not able to draw an “overview- map” of the course that shows how the various (sub) topics are connected. All we could see they have in common is that all of them involve ratios.

During several meetings and conversations with Eric Gaze, we discussed a fundamental question concerning the motivation and justification of the study of ratios, which is relevant for the instructor and for the students: At the very beginning of the 3-Chapter treatment of “ratios, many applications, and proportionality” in Eric Gaze's Text, he simply writes: “To make meaningful comparisons, we use ratios.” And the fundamental Question is this: “Really? If I compare my salary to my friend's, I use a difference!” For many of our students, up to this point in their lives, ratios and fractions are more likely things they avoided than something they embrace. Unless an instructor of this course is convinced that ratios are, indeed, used in practice rather than differences, and unless the instructor is ready to share both evidence and reasons for why this is so, it is difficult to motivate reluctant students, and to present a coherent, convincing, and satisfying course.

In this presentation, I will share some of my thoughts and ideas that resulted from addressing the question “Why Ratios? Why not the difference?”. This presentation will be non-technical, in part because a technical explanation will be unlikely to convince any student. I will look at the question with the questioning student in mind, and I will use examples to try to demonstrate that first: using a ratio can easily lead to opposite conclusions than using a difference, and second, that even in a situation where both ratio and difference could be used, the ratio is more robust to distortions and thus preferable. My explorations have led me to visualize what a ratio measures in a “comparison bar-graph”, which we plan to include in our course-presentation beginning in fall 2017.

Presenter: Dr. Bernd Rossa, Associate Professor Department of Mathematics, Xavier University, Ohio.

12:00 – 12:30 PM Paper Session**Quantitative Reasoning Approach to Algebra**

Abstract: In this talk, I share excerpts from a hybrid quantitative reasoning/algebra two-course sequence that challenges the common assumption that quantitative literacy and reasoning are less rigorous mathematics alternatives to algebra. Specifically, I will show that a quantitative reasoning framework can be used to teach traditional algebra. After a brief description of my personal perspective on what I mean by “algebra,” I will describe a 6-week instructional module intended for undergraduate business students that was delivered to students who had placed into beginning algebra. This will be followed by evidence of success.

Presenter: Victor Piercey, Associate Professor of Mathematics, Ferris State University

12:00 – 12:30 PM Paper Session**The Heart of Numeracy: The Grammar of Ordered Relations**

Abstract: Addition and multiplication are order free, but subtraction and division are order dependent. Some students have difficulty with the grammar of ordered relations. These grammar problems include prepositions (from vs. to), verbs (borrow vs. loan) and nouns (premise vs. conclusion). These grammar problems affect all statements involving ratios: the male-female ratio; the ratio of students-to-teachers; the percentage of women who are runners; Men are more likely to commit crimes than women. The results of a simple grammar survey involving ordered-relation grammar (taken by over a hundred students) will be presented, analyzed and discussed.

Presenter: Milo Schield, Augsburg College

2:15 – 3:15 PM Facilitated Session

Word problems across the curriculum: Lessons learned from Computational Geology

Abstract: The session will begin by outlining the 20+ year history and evolution of the course “Computational Geology” at the University of South Florida. Based on a case series consisting of personal experiences, informal student interviews and work analyses, and alumni interviews, we will discuss (in the words of sedimentologist Bob Ginsberg) “what we’ve learned for sure,” “what we think we’ve learned,” and “what we wonder whether it might be true.” We’ve learned for sure that context is key for making the math real for geology students. We think we’ve learned better ways to present this context via word problems. We wonder if perhaps some of these methods might apply more broadly, or what might be needed to adapt them to different disciplines and contexts. The focus of the presentation will center on the word problem as the central item for bringing the skills, competencies, and habits of mind we want for problem solving into the geologic context we need for our students to succeed after graduation.

The presentation will conclude by summing up this case series in the context of teaching Numeracy/QL/QR in the Geosciences (i.e., its implications for practitioners of Discipline Based Education Research, or specifically Geoscience Education Research or GER). We will then open a discussion with the attending audience on the hypotheses we’ve formulated over our time teaching Computational Geology. We will be seeking your input from your experiences teaching Numeracy/QL/QR within or for students of specific non-mathematics disciplines and suggestions for further study within our own field and QL generally, in terms of the hypotheses that we will present. Questions for prospective audience members to consider might include: * What sort of attitudes do students have about math when they enter your classroom/discipline? * How have traditional math educational/curricular approaches helped or harmed these students before they reached you? * What do you want students to actually do with your QL course – what skills and/or habits of mind are important to you and your discipline for long term retention? * How (if at all) can the methods that seem to be successful at the intersection of QL and geoscience be adapted to other disciplines?

Presenters: H. L. Vacher (Professor), and Victor J. Richezza (Graduate Teaching Assistant), University of South Florida School of Geosciences, Tampa FL

2:15 – 2:45 Paper Session

Applying Lessons from Elementary Math Pedagogy to Teaching Proportional Reasoning

Abstract: Elementary and middle school math educators identify two distinct meanings for division: partitive division and measurement division. Understanding these two different division stories enable these young students to work with real-world problems, and particularly find meaning in fraction division. (The measurement model can be used to explain why dividing by a fraction is the same as “invert and multiply”.) When teaching older students, our tendency is to use algebraic techniques, which hide the two different meanings of division, but our students are not equally comfortable with both of them. When asked to write a story problem illustrating division, students typically produce one that aligns with the partitive meaning, and those who struggle with proportional reasoning have more difficulties with problems that align with the measurement meaning of division. I will share data and examples from my quantitative reasoning and elementary math education students. Recognizing and explicitly identifying these two different division stories gives instructors and students a tool for reasoning through common proportional problems.

Presenter: Jessica Polito, Lecturer, Quantitative Reasoning Program, Wellesley College

2:15 – 2:45 Paper Session

Fighting Alternative Facts: Teaching Quantitative Reasoning with Social Issues

Abstract: Mathematics has a unique and powerful role to play in the teaching of social justice issues. There is substantial quantitative evidence for social injustice, but many citizens lack the quantitative skills to understand that evidence. A course in quantitative reasoning is a unique opportunity to provide this quantitative understanding to a wide range of students in a general education context. Quantitative reasoning skills provide citizens with the tools they need to critically analyze misinformation and make good decisions about civic issues. This session will provide faculty with examples of ways to infuse social justice into their quantitative reasoning courses. After an introduction to a variety of topics that the presenter has used in his course, the group will have the opportunity to brainstorm ideas and develop their own projects in this vein. The output of the session will be collected and distributed to participants.

Presenter: Dr. Mark Branson, Assistant Professor Stevenson University

2:45 – 3:15 Paper Session**Quantitative Literacy and Co-construction in a High School Math Course**

Abstract: This session will discuss some of the key findings from a practitioner-action research study that analyzed the impact of co-construction, a process where students work alongside their teacher to plan units, lessons, and assessments, on students' quantitative literacy and attitudes towards mathematics. Key themes to be discussed will include the recasting of traditional classroom roles, the relationship between developmentally appropriate assignments and students' situational and individual interest, and a reconsideration of traditional mathematics teaching in terms of content, technology, and classroom practices.

Presenter: Mark Russo, District Supervisor Mathematics. Pascack Valley Regional High School District

2:45 – 3:15 Paper Session**Data Literacy in the Workplace**

Abstract: <Forthcoming>

Presenter: Harshil Parikh, CEO of TUBA: The Data Literacy Company

3:30 – 4:30 PM Facilitated Session**Strategies for Teaching QR at Minority Serving Institutions, Colleges that Serve Economically Disadvantaged Students, and/or Community Colleges**

Panelists (CUNY): Esther Wilder, Lehman College; Sarah Hoiland, Hostos Community College; and Frank Wang, LaGuardia Community College/

3:30 – 4:00 PM Paper Session

Liberal Arts Consortium for Online Learning (LACOL): Developing QR Modules

Abstract: Faculty and technologists from the LACOL institutions are currently collaborating to build a shared framework for curating, implementing and assessing online instructional modules for quantitative skills (QS) and quantitative reasoning (QR) to be deployed for just-in-time review and skill-building across disciplines. Our work seeks to assist faculty teaching courses that use QS in context who find they need methods to support students with opportunity gaps in their QS/QR preparation. The strategy draws on a body of research in higher education and experience at our institutions showing that online modules can be a beneficial component of an overall QS/QR support program. The individual modules, known as Qbits, review quantitative topics and demonstrate the topic's applications in different disciplinary contexts (for example, a module might review logs and then consider the application to decibels and sound perception in psychology, the Richter scale in geology, the concept of pH in chemistry, etc.). Beginning with a pilot in Fall 2017, Qbits will be implemented through a combination of videos and quizzing, and consist of an initial knowledge check, short videos to review specific quantitative skills, structured application problems that give students practice applying the quantitative skill in disciplinary contexts, and a final knowledge check. Developing online resources that can be used in multiple contexts to help students strengthen their quantitative skills serves two purposes. First, by demonstrating the relevance of specific QS in various disciplinary contexts, students learn to view quantitative skills as fundamental and transferable skills that they can draw on in many areas of their liberal arts experience. Second, the consortial effort allows us to collect meaningful data about the effectiveness of the various modules for a greater number of students in a wider variety of contexts. Specific aims of the project include: * Developing a collaborative framework for design, implement and assessment of online modules for QS/QR instruction and review at residential liberal arts institutions. * Crafting an initial set of four instructional modules for use in fall 2017 on high-priority QS/QR topics, drawing on high quality, curated instructional content in partnership with Yale ONEXYS and others. Using what we learn in this pilot, we plan for the development of 21 more. * Assessing module effectiveness in three instructional contexts: as stand-alone refreshers, as just-in-time instruction embedded in coursework, and as components of QS/QR support or bridge programs. * Gathering data to evaluate the impact of modules on student learning and confidence in each phase of the project and beyond.

Presenter: Laura J. Muller, Director of Quantitative Skills Programs and Peer Support, Williams College

3:30 – 4:00 PM Paper Session**Information Literacy: Faux Numbers and Dubious Data**

Abstract: <Forthcoming>

Presenter: Marc Isaacson, Augsburg University

4:00 – 4:30 PM Paper Session**Linking Library to Student Retention: A Statistical Analysis**

Abstract: What is the role of the information literacy in student retention? The session will highlight the findings of a recent study that examined whether library instruction has a greater significance on student retention over expenditure. Improving on a previous analysis in academia, this study also sought to determine if library instruction at associate degree-granting colleges correlated to retention. Library statistics for expenditures, library instruction, and associated data were drawn from the Association of College and Research Libraries (ACRL) Metrics database which provides reports collected from academic institutions. Using IBM SPSS, a Pearson correlation coefficient (r) was calculated to determine any interrelation between each category and student retention, in degree, direction, and significance. While most analysis mirrored the former attempt, some results indicated a trend persistent in current literature regarding information literacy, especially for the two-year college. The session will focus on these findings and if students may be more apt to use library resources based on their demographic status and instruction.

Presenter: Derek Stadler, Assistant Professor, CUNY LaGuardia Community College

4:00 – 4:30 PM Paper Session**Numeracy: Where Math, Statistics and Critical Thinking Converge**

Abstract: In the early years of numeracy there was some tension between the mathematics side and the statistics side. This paper reviews the exchange between Lynn Steen (Mathematics) and Richard Scheaffer (Statistics) on the relation between numeracy and statistics. Steen argued that numeracy was quite distinct from statistics; Scheaffer argued that numeracy was largely a part of statistics. The 2016 update to the GAISE Guidelines is reviewed. These guidelines make recommendations on what should be taught in introductory statistics courses. This paper argues this GAISE update has eliminated much of the difference between Steen and Scheaffer. There is also a tension between critical thinking on the one hand and math/stats on the other. Limited critical thinking about how to model a situation or which model to use is OK. But critical thinking about how things are defined, what they should be compared with, and what things should be taken into account is deemed problematic. In the latter, the answer is not a number. The audience will be polled on how they see numeracy in relation to mathematics, statistics and critical thinking. These results will then be discussed.

Presenter: Milo Schield, Augsburg College

4:45 – 5:30 PM Keynote Address**Questioning Quantiles**

Presenter: Joel Best, author of Lies, Damned Lies and Statistics

9:00 – 10:00 AM Facilitated Session

Assessing Student Learning in Newly-Developed Q/L Courses at Michigan State University

Abstract: Quantitative literacy (QL) courses are increasingly common at public institutions of higher education across the United States. Faculty at Michigan State University, for example, are in the midst of scaling up two newly-developed QL courses that constitute a new route by which undergraduate students can complete the mathematics graduation requirement. The continuing expansion of course sections offered is complicated by the necessary addition of more instructional staff, the reshuffling of instructional staff roles, and the addition of extra recitation sections required for a subset of students with low scores on the mathematics placement exam. With these substantial changes in curriculum and stakeholders comes a need for sustained analysis of student learning with respect to course-level learning goals -- the predominant focus of our work.

Current primary course-level learning goals across the two courses include: making and checking predictions about quantitative situations, analyzing quantitative information, recognizing limits of mathematical and statistical methods, interpreting mathematical models of social issues, and representing mathematical information in multiple ways. These broad goals encompass QL as it has been operationalized at MSU, and are distinct from the more specific learning objectives particular to the modules in a given course. The purpose of choosing course goals, rather than objectives, is to center our attention -- as individuals outside the daily teaching of the courses -- on the extent to which the vision for these courses aligns with their enactment. We are positioned in the MSU Hub for Innovation in Learning and Technology, and have experience in assessment design and assessment of student learning in both QL and other STEM contexts.

Our prior qualitative work indicates that, when presented with quantitative information about an important social issue (such as rising college tuition), students in these QL courses do choose unprompted to analyze the quantitative information in the course of reasoning through the issue, though they also reason in other ways that are not inherently quantitative. In our current study (with data collection in progress), we are analyzing students' abilities in an interview setting to reason through constructed-response tasks similar to those on course exams (e.g., interpreting a graph in a news article), as well as tracking gains over the semester using pre- and post-administrations of the Quantitative Literacy and Reasoning Assessment (QLRA). We will report on analyses of these data with the tentative expectation that students will perform well on near transfer tasks, and we will identify implications for teaching practices at our own institution as well as for future efforts in QL assessment.

In this session, we will engage with participants through discussion and activities regarding the following questions and topics: 1) What is valued as evidence of students becoming more quantitatively literate at participants' institutions? 2) How is this evidence (or common understanding of evidence) managed at institutions that have widely distributed course options for satisfying a quantitative literacy requirement, particularly when these courses are not traditional math courses in preparation for calculus? 3) Review of proposed linkages between various assessment tasks and learning goals.

Presenters (Michigan State Univ.): Luke Tunstall and Rebecca Matz

9:00 – 9:30 AM Paper session**Integrating QR in a Pre-Calculus Course**

Abstract: The goal of my talk is to describe how I infuse a quantitative reasoning component into a one-semester 4-credit pre-calculus course. My conceptualization of the course stems from four factors: the audience, the course timeline and the required writing and applied components. One of the defining aspects of the course is that its audience consists of students who are not mathematics or science majors; rather, they belong to a wide variety of fields including real estate, hospitality, sports management, social science and information systems management. It is important that students appreciate the connections of this required course to their fields: however, the span of majors requires that there be a carefully designed selection of applications that are pertinent and stimulating for all students. In addition, students' ages vary considerably, ranging from students who have just finished high school to working professionals, which intensifies the need for a variety of applications and tailored pedagogy. The course meets once a week for two-and-a-half hours: it also features a writing component required by the NYU School of Professional Studies, which students may not necessarily anticipate in a mathematics course.

Focusing a course on a progression of inquiries is a widely implemented pedagogical tool in mathematics. The central feature of my course is a set of weekly carefully constructed discussion questions which are explored and solved in class. I develop my discussion questions in three distinct parts: questions from the required reading, application problems that acquaint students with the week's topic, and further scaffolding questions that guide students through the algebraic and trigonometric tools needed to better analyze the material. Throughout the semesters in which I have taught pre-calculus, I have tailored this progression in a manner that can effectively inform and sustain the presentation of material over a long span of time. My talk will lead audience members through this progression in depth and in particular will address variations and supplements to this framework, including short weekly essay responses as well as various exercises that enable students to effectively verbalize the mathematical tools they have learned.

Presenter: Donatella Delfino, NYU Donatella Delfino, Ph.D., Clinical Associate Professor of Mathematical Studies. New York University School of Professional Studies Division of Applied Undergraduate Studies

9:00 – 9:30 AM Paper Session

Risk and Statistical Literacy for Adults in the 21st Century

Abstract: Engagement in public discourse, according Ramos-Safford (2008), requires adults of the twenty-first century to possess quantitative literacy to “argue with numbers, to research and organize quantitative data, and to think critically about public issues” (p.14-15). According to Gigerenzer (2014), the ability to calculate probabilities is not sufficient to understand risk nor is risk literacy taught in high schools, law, or medical schools. Risk is a complex, abstract concept that employs the use of mathematical metaphor (Nunez, 2007) and involves calculating and evaluating risk in context (social, cultural, environmental, legal, medical or financial) resulting in outcomes or corresponding risk. This paper draws on a developmental research project aimed at designing an instructional resource to develop risk literacy for students enrolled in non-STEM programs at the post-secondary level employing language, critical and statistical thinking to identify, discuss and critique published probabilities. Recent studies on adult literacy and numeracy raise several issues such as (a) over the last 20 years there has not been significant improvement in adult literacy and numeracy in Canada; (b) regions within Canada will not have enough post-secondary graduates with sufficient literacy skill to fill the jobs created by the Canadian economy; (c) declining numeracy may be due to gender discrimination and skill mismatch in the workplace contributing to the shrinking pool of skilled labour; and (d) currently, there are no existing numeracy programs for non-STEM students at the postsecondary level to address the issue of

innumeracy or risk illiteracy (OECD, 2013). In addition, like statistical literacy, risk literacy requires familiarity and comprehension of the statistical and risk lexicon that is often confused and/or misused in the public sphere. Bolton (2010) remarks that published statistics are inappropriately used when they are presented without context, use confusing terminology, and misuse or use ambiguous terms. He adds further that, the concept of uncertainty is often “lost, forgotten or ignored by authors” creating misleading and/or inaccurate estimates that do not reflect the entire scenario.

The study used cases that required understanding risk and confirmed that risk comprehension can be achieved by expressing probability as a natural frequency and rephrasing risk in natural language. Respondents commented that they found it necessary to refer to contextual information in-order to follow arguments, comprehend data, and to formulate a stable basis from which to make comparisons and draw conclusions. As well, participants remarked that self-assessment provided them the opportunity to review their own understanding of the data and to check their application of the concept against the information provided.

Study findings also revealed several assumptions about adult numeracy such as (a) upon graduation from post-secondary education adults possess and maintain a constant literacy level need to comprehend and communicate risk throughout their lifetime; (b) graduates from STEM programs fully comprehend and possess the skills to evaluate and communicate risk in personal and professional contexts; (c) understanding the mathematics of probability is sufficient to understand and communicate risk and (d) risk literacy and/or risk comprehension is maintained by access to technology. These assumptions were found to be incorrect. Furthermore, exploration of teacher education programs requires probing into the preparedness of educators to provide risk instruction and further examination of risk comprehension based on gender, as the literature indicates there are difference in perception based on gender.

Presenter: Dianne J. Kenton, Faculty of Graduate Studies, Brock University, St. Catharines, Ontario, Canada

9:30 – 10:00 AM Paper Session

Business-and-Technology Approach to Quadratic Functions and Parabolas

Abstract: There is a strong evidence that students grasp mathematical concepts quicker and understand them better when a connection between the concept and the world of business and/or technology is established. The reason is that the students are visibly more interested and involved when possible applications are presented first, forming a ground for further more formal and rigorous considerations. This paper aims to show how the suggested approach can be used in teaching quadratic functions and parabolas - a topic encountered at every level of teaching and learning mathematics and the one with a wide range of applications. It is shown how different types of information: business and technological, and visual and spatial may be combined to serve better perception and understanding of the topic.

Presenter: Alexander Vaninsky, Hostos Community College CUNY

9:30 – 10:00 Paper Session

Statistical Thinking: What's Brewing in Authentic Investigations?

Abstract: Statistical thinking is best achieved by actively engaging students in authentic investigations, modeling the way statisticians work in the real-world. This presentation will share a project designed to investigate a familiar, real-world problem on coffee pricing that puzzled and intrigued students. In this project, the starting point was a rich readily understood context. Working collaboratively, students gathered and analyzed data to compare the price of iced and hot coffee. Students had to decide how best to obtain and then visually represent the data. Descriptive and inferential statistics were used and results were communicated in a jargon free manner, ensuring that students could share their findings with people in their disciplines and a general audience. Data analysis left students with unanswered questions, which highlighted the need for qualitative data to fully understand the results. The project was scaffolded and pedagogical practices were designed to facilitate a harmonious beneficial group dynamic, creating a culture of collaborative inquiry. Students worked independently and enthusiastically to understand their data sets. This project modeled how statisticians work, increased student engagement, clarified misconceptions, and offers educators an alternative way to teach and assess statistical thinking.

Presenter: Marla A. Sole, Assistant Professor of Mathematics, Guttman Community College, the City University of New York

10:15 – 11:15 AM Facilitated Session

Developing Quantitative Reasoning: Helping Elementary Teachers Overcome Math Anxiety

Abstract: Over the past 15 years, I have conducted professional development in a wide variety of school districts and taught Elementary Mathematics and Methods to novice elementary teachers in the certification program at Teachers College. Several instructional strategies have emerged in helping these teachers better understand mathematics and bring deeper understanding into their classrooms. In my session, participants will work individually as well as in small groups using four strategies I employ in my course to address math anxiety and the preponderance of procedure-based math instruction. The result: increased competence as well as confidence in developing numeracy lessons that focus on quantitative reasoning.

Most philosophical and sociological perspectives indicate that the most influential factor contributing to a productive and responsible society is education. In an effort to achieve a balance of numeracy with literacy, our society has entrusted this important task to elementary educators, and unfortunately the publishers of today's textbooks which often dictate scope and sequence as well as methodology in the classroom. It is my belief that although secondary mathematics is important and contributes to greater quantitative capabilities on the part of our secondary students, the probability is quite low that instruction at this level produces any substantial change in either quantitative reasoning or students' perseverance in problem solving. Once students perceive mathematics as a static discipline born out of excessive proceduralization and memorization, the opportunity for the development of quantitative reasoning is greatly diminished.

The critical pivot point in addressing quantitative reasoning lies in how we deliver math instruction in elementary classrooms. It is not the secondary but the elementary programs that result in the greatest gains in numeracy and deeper understanding. The affective drought in mathematical literacy exacerbated by the common core has only made the teaching of mathematics an even more dire exercise for today's teachers. Research has shown that despite the best efforts of teacher preparation programs many beginning teachers enter the classroom unprepared to teach the topics specified by today's standards. Hence, in their best effort to succeed, many teachers resort to teaching in a manner defined by how they were taught.

So, for many teachers their own math anxiety acquired from their participation in those "procedure and rule based classrooms" has resulted in minimal numerical understanding, quantitative reasoning and knowledge of the hierarchical development required to effectively teach mathematics. These factors unfortunately found in many novice teachers transfer that same narrow static quantitative perspective to today's students, thus perpetuating the lack of fundamental numeracy by many of our students. Positive engagement, free of anxiety, can break this mind set and create an opportunity to utilize quantitative reasoning.

Presenter: Peter Garrity, Adjunct Professor Teachers College, Columbia University

E-mail: Peter Garrity <jpg2@tc.columbia.edu>

10:15 – 10:45 Paper session

Designing a Quantitative Reasoning Based Module for Introductory Biology

Abstract: The lab instructors for the introductory Biology course at Wellesley identified some basic quantitative topics involving chemical concentrations and molarity that students with weaker backgrounds struggle with all semester long. The department believes that having difficulties with these types of problems is one of the primary reasons why biology students leave STEM majors. I am in the quantitative reasoning program at Wellesley, and collaborated with a group of Biology lab instructors to design a short online quiz and video based unit to help students gain comfort with these topics, incorporating best practice techniques such as pre-testing and self-assessment. I will describe the conceptual topics we developed to supplement the primarily formula-based approach that they had been using, and share preliminary data from the first semester the module has been used.

Presenter: Jessica Polito, Lecturer, Quantitative Reasoning Program, Wellesley College

10:15 – 10:45 AM Paper session

Visual Analogies for Teaching Statistics

ABSTRACT: Students in required statistics courses often have great difficulty with elementary statistical concepts. Many instructors have had the discouraging experience of realizing that their students can correctly compute a *P*-value but cannot explain what it is. This difficulty arises when students cannot connect novel statistical ideas to concepts that they are more familiar with, and instead rely upon rote learning to pass the course.

In this paper, we will demonstrate how carefully developed **analogies** help students build powerful conceptual bridges between new ideas and their existing knowledge. An analogy is a systematic comparison of the similarities between 2 concepts, one of them familiar (the “analog”) and one of them unfamiliar (the “target”). The paper will present a synthesis of research in education and cognitive psychology to demonstrate how analogies promote learning. It will also demonstrate ways in which (if poorly developed) analogies can backfire and hamper student learning. In particular, the paper will present a 5-point guideline derived from educator Shawn Glynn’s work in science education that can be used to help quantitative literacy instructors develop and apply analogies in teaching statistics.

Drawing upon several decades of experience teaching applied introductory statistics to medical students, journalists, and public health students, we will demonstrate worked-out examples of analogies that we have used for teaching statistics. (1) A fantasy trip to a science fiction planet can be used to help students understand the basic concepts behind hypothesis testing. (2) A weather map showing the risk of an upcoming hurricane can be used to help students understand confidence intervals. (3) A spinach recipe can be used to help students understand true and false positives, as well as more complex concepts such as posterior probability (also known as positive predictive value).

This paper will introduce quantitative literacy instructors to a framework they can use in developing their own courses, as well as teaching examples.

Presenter: Jessica S Ancker, MPH, PhD, Associate Professor, Weill Cornell Medical College

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10:45 – 11:15 AM Paper session

Reinforcing Empirical Reasoning in Introductory Chemistry and Physics Labs through Data Viz and Analysis Workshops

Abstract: The Barnard Physics and Chemistry departments have each introduced workshops run by the Empirical Reasoning Center (ERC) into introductory laboratory courses. The focus of these workshops has been on using Excel to create clear graphs from lab data, a task previously done by hand. In 2016, the ERC modified the workshop curriculum to incorporate more discussion of data analysis, including understanding the limitations of data, the impact of various choices about visual presentation (e.g., axis scale), and interpretation of results. The underlying assumption is that if students can more easily translate experimental data into crisp visual presentations, and are more familiar with data analysis tools in Excel, that this will support more sophisticated analysis of the data and understanding of the underlying concepts. The faculty responsible for these courses collaborated with Institutional Research and Assessment to adapt a rubric developed by Carleton College to assess lab reports on the appearance and accuracy of the graphs, quality of the uncertainty analysis, presentation of results, and interpretation of the experiment. This study utilizes lab assignments from both departments to assess shifts in proficiency, regarding these five assessment measures, among students over the fall 2016 semester. Our goal is for students in these courses to at least reach a minimum acceptable threshold of proficiency. Our expectation is that the Excel workshop, in addition to walk-in support from the ERC help desk throughout the semester, influences a shift, in particular, among students below an acceptable level of proficiency to at least a minimum acceptable level of proficiency across the five measures related to empirical reasoning. This paper reports on the results of this study.

Presenters: Barnard College: Jacob Alexander, Rebecca Friedkin, Alisa Rod and Stiliana Savin. Patricia Kirkland, Vanderbilt University.

10:45 – 11:15 Paper session

Developing Statistical Reasoning through Comparison Games

Abstract: Building on students' intuitions can be an extremely valuable means of developing statistical reasoning. In this presentation, we will show how comparison games can be used to reinforce fundamental concepts in statistics by engaging students in decision-making using data. Students already have a great deal of informal experience using statistical reasoning in making real-life decisions which can be used as a springboard to introduce more formal methods. According to the Guidelines for Assessment and Instruction in Statistics Education College Report (GAISE, 2016) a major objective of statistics education is to help students develop statistical thinking, which is also an important feature of quantitative literacy. In large part, students must deal with the omnipresence of variability as statistical problem solving and decision making depend on understanding, explaining, and quantifying the variability in the data. Furthermore, understanding the reasoning of statistical inference requires a basic understanding of some important ideas in probability. In particular students should be able understand how probability can be used in making decisions and drawing conclusions. The GAISE report (2016) recommends teaching statistics as an investigative process of problem solving and decision-making. Working on investigations with data is also an important feature of quantitative literacy. The comparison games introduced in this presentation aim to build on students' preexisting knowledge in order to develop the fundamental concepts of variation and probability.

Presenters: Audrey A. Nasar, Assistant Professor of Mathematics, Borough of Manhattan Community College, the City University of New York; Marla A. Sole, Assistant Professor of Mathematics, Guttman Community College, the City University of New York

11:30 – 12:30 Facilitated session

Are College Science Courses an Effective Venue for Quantitative Skill Improvement?

Abstract: Much of the dialogue surrounding college-level general education science courses in recent years has been focused on how best to engender "science literacy" among students, yet the phrase has many potential definitions, some of which rely on quantitative skills more than others. Is it possible to be scientifically literate but not quantitatively literate? Where do the two ideas intersect and where do they diverge? What are some of the sources of resistance among college science instructors to emphasizing and remediating quantitative skills in their courses, and what can QR centers do to help support those instructors?

Presenter: Kate Follette, Assistant Professor, Amherst College

11:30 – 12:00 Paper Session

Scientific Reasoning and Quantitative Reasoning in the Digital Age

Abstract: During our work over the past 5 years with spreadsheets to develop a 21st century problem solving curriculum, we found a powerful connection between scientific reasoning and quantitative reasoning. We call it "Functional Thinking". By bringing this standard method of creative problem solving, akin to design thinking, to spreadsheets, we found a common way for students to approach and solve a wide range of problems. They include most of the problems associated with QR, traditional story problems that proliferate in textbooks and tests, as well as today's rich and varied project/problem-based-learning ones.

Functional thinking, like spreadsheets, is based on functions. It starts by visualizing problems, then organizing data into inputs, outputs, and rules to build simple functions, which are linked together to develop models, iterated to test and revise those models, and finally explored by asking creative "What if...?" questions. This problem solving methodology has roots in the scientific method, engineering thinking, and coding tying it deeply into STEM preparation and education.

I will describe functional thinking by showing a variety of example spreadsheets from our library of Labs (of over 100 lessons available free on the Web), and look forward to an exciting and continuing discussion of this new approach to problem solving and the use of spreadsheets for Quantitative Reasoning.

Presenter: Art Bardige, CEO, What if Math (Sustainablelearning)

E-mail: Art Bardige <ArtBardige@gmail.com>

12:00 – 12:30

Creating the Simplest Possible Tools to Begin the Journey towards Numeracy

Abstract: In my close to forty year career as an engineer, energy industry analyst, and technology deployment consultant, I've witnessed whole business sectors collapse because of poor numerical literacy and standards (e.g., the Enron-led collapse of the energy industry in 2001 and the great global recession of 2007-2008 because of the abuse of financial engineering and forecasting models. I've sat through hundreds of presentations with faulty, questionable, and even fraudulent numerical analysis, yet no one in the audience challenges the results.

In my latest book, I argue that numerical literacy, at base, doesn't necessarily require knowledge of math (though it certainly helps), or at least not at first. Anyone, regardless of math training, or experience, can acquire the means to examine a numerical result under a magnifying glass. This is the premise of *Painting*

By Numbers: How to Sharpen Your BS Detector and Smoke Out the Experts, which I consciously modeled on *How to Lie with Statistics*, a 1950s classic by Darrell Huff. My goal with *Painting By Numbers* is that it ultimately be the first text that any student or adult can turn to in beginning the journey towards higher numerical literacy and quantitative reasoning, a window onto all of the other wonderful books, popular and academic, which instruct to greater depth. It's easy to read, entertaining, and one reader even said it could be the first book about numbers to be included on a beach or poolside reading list.

In this presentation, I will show how the twelve “commandments” I outline in *Painting By Numbers* can be used to examine virtually any numerical result for validity, accuracy, and relevance. I will add fresh, recent examples from the public sphere from around the time of the conference. At a time when less than 0.1% of the vote in four key states decided the recent presidential election, and a few people in the highest places eschew scientific principles and progress completely, improving numerical literacy, and information literacy generally, should be the paramount pursuit of everyone who cares about the future.

Presenter: Jason Makansi, Pearl Street President (www.pearlstreetinc.com)

Latest book: <https://www.amazon.com/Painting-Numbers-sharpen-detector-experts/dp/0998425907>

1:00 – 2:30 NNN Board Meeting. (Open to all)