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Abstract

This purpose of this mixed methods study was to examine the human activity of attendance at a mathematics teachers’ conference, TMathC 2017, which was mediated through Twitter and blogging. Tweets containing the hashtag #TMC17 were downloaded over a 53 day time period and were analyzed through social networking analysis software to understand the networking behaviors of the participants (Hansen, Shneiderman, & Smith, 2010; Hennig, Brandes, Pfeffer, & Mergel, 2012). Qualitative content analysis was used on the unique tweets and reflective blog posts to uncover the activity of the attending and remote conference participants. This qualitative analysis was done by using a framework of Engeström’s third generation Cultural-Historical Activity Theory (2015) to understand the complex nature of the human activity and relationships among the participants.

The social network analysis found a ‘tight crowd’ of network participants who were highly engaged, whether they were attending or remote participants. Evidence of the tight crowd network was found in the high centrality measures of the top 1% of the network. The network clusters also showed a large amount of both inter- and intra-cluster connections, with few clusters being isolated. The qualitative analysis uncovered the structure of a community which had rules of showing gratitude and support for others, developing relationships, encouraging a high level of engagement, and a commitment to the classroom and personal growth. The conference had effective use of hashtags as a communication tool, as well as other tools that reduced the difference between presenters and participants. Tensions which promoted learning included creating vulnerability in participants and focusing on classroom growth. Mixing the data revealed that first-time
attendees and experienced attendees had similar quantitative and qualitative behaviors. In addition, other differences in how hashtags and content was shared among the different groups of participants were uncovered.

This study of the TMathC 2017 conference showed how social media could be utilized in positive, constructive ways to benefit all groups of participants in future conferences. Specific recommendations on methodological implications, hashtag creation and use, virtual filing cabinets, and community building were created.

Keywords: Social Network Analysis, SNA, Cultural-Historical Activity Theory, CHAT, Engeström, NodeXL
Dedication

I dedicate this study to every person who has made me a better educator. Some I know without Twitter, but most I know only through Twitter. You have challenged and taught me, answered silly and good questions alike, and always told me I was enough. The #MTBoS community changed my classroom, my teaching, and my career. May the spirit of gratitude, sharing, and welcoming others never diminish in the math community. I ‘high five’ you all.

Abstract in tweet form (278 characters): Examined tweets and blog posts from #TMC17 w/ quantitative & qualitative methods. Found a tight community that encouraged gratitude, support & sharing and fostered personal and classroom growth for everyone. Moral: Be vulnerable, learn more, #pushsend, and be better! #MTBoS
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Chapter 1: Introduction

Participation in educational conferences has been a long-term staple in the professional development of teachers. Research on teacher attendance and learning through conference participation is a growing field (Akiba, 2012; Aramo-Immonen, Jussila, & Huhtamäki, 2015; Levin, 2012; Stanford University & CA. School Mathematics Study Group., 1970). However, conferences are short in duration typically not designed to facilitate ongoing communication between people. The learning trajectories of the participants in educational conferences may not include networking opportunities which facilitate learning (Fox & McCormick, 2009). The interactions between participants and the development of ideas tend to take second place behind keynotes and sessions which are essentially ‘stand and deliver’ lectures (Levin, 2012).

Technology integration can start breaking down the barriers to learning.

One such technology, Twitter, was developed in 2006, and teachers quickly found uses for it in their own practice and to facilitate communication (Alderton, Brunsell, & Bariexca, 2011; Hansen et al., 2010, p. 143; Holmes, Preston, Shaw, & Buchanan, 2013). Almost as soon as Twitter was adopted by teachers, it became part of their conference participation as well (Letierce, Passant, Breslin, & Decker, n.d.; Parra et al., 2015). Twitter was used as a ‘backchannel’ method of communication, where educators talked, and shared ideas, links, or more during a conference or even during a presentation (B. Chen, 2011; Kimmons & Veletsianos, 2016; Li & Greenhow, 2015). The backchannel allowed educators to expand the conversation of the conference to those who may not be in attendance.
Stepping up from using Twitter as a backchannel to educators integrating conference and online participation as a single entity is an evolving phenomenon. In this use, Twitter communication becomes a ‘frontchannel,’ where the presenters encourage the attendees in the room to tweet out the content of the discussion. This practice invites non-attendees into the room, to experience and learn from the presenter despite lack of attendance. This new category of conferences has one entry so far, TMathC. This conference is challenging the traditional models of conference attendance and activity, but this new modality has little research. There is little understanding of what the new patterns of communication are, or how this type of conference helps educators learn.

#Intro: Problem Statement and Significance

Educators engage in a variety of professional development (PD) during their careers, and most states require PD to renew a teaching license (Neville, Sherman, & Cohen, 2005, p. 17). Teachers may take courses through their district; they may attend classes offered through an institute of higher education, or they may attend conferences. Conferences are a regular feature of PD practices in education, with every mathematics education organization from national to local organizations offering conferences during the year. Specifically, the National Council of Teachers of Mathematics (NCTM) has both regional and national conferences each year. The NCTM considers conferences and PD to be similar enough to combine them under the same heading, “Conferences and Professional Development” on their webpage (“Conferences and Professional Development,” n.d.). State and local NCTM affiliates have their own conferences as well. Defining whether conferences are effective learning environments is problematic. One
definition of effective PD has six distinct features. Conferences can be an effective PD if they:

- Add to teachers’ knowledge of content and how to teach it to students;
- Help teachers understand how students learn specific content;
- Provide opportunities for active, hands-on learning;
- Enable teachers to acquire new knowledge, apply it to practice, and reflect on the results with colleagues;
- Are collaborative and collegial;
- Are intensive and sustained over time (Darling-Hammond & Richardson, 2009, p. 49).

Teachers who attend conferences can engage in these practices, provided the conference has opportunities for them. Typically, the national organizations are aware of the research, and attempt to create spaces which provide teachers the opportunity to choose their content, collaborate with others, and engage with their peers in productive fashion (“Conferences and Professional Development,” n.d.).

Matching teachers need to engage in professional learning with the variety of communication methods available to them becomes challenging in the current era of electronic messaging. Conferences have become only one way of participating in professional learning, and technology has created additional means of teachers speaking to one another and collaborating. The learning network of teachers has expanded beyond face to face conversation and entered the realm of electronic communications (Bauer, 2010). Among the technology teachers are using is wikis, a web platform which allows for quick and easy creating and editing of web pages; blogs, a longer form writing platform for the sharing of ideas; podcasts, audio recordings of interviews or ideas; or even the micro-blogging site, Twitter (Bauer, 2010). What all these platforms have in common is the active engagement of teachers on everyday topics.
Engaging in this way allows teachers to create a learning network for themselves. These networks, “facilitate lifelong learning with a focus on non-formal learning (intentional learning, without formal course)” (Fetter, Berlanga, & Sloep, 2011, p. 2). The learning network allows the individual to choose the context of their learning, at their own convenience, and in the style of their own choosing. One important way in which teachers have chosen to create networks of their own is through the use of Twitter (Bauer, 2010; Davis, 2015; Fetter et al., 2011). Twitter has emerged as a medium by which teachers are creating their own learning networks, which enables them to have instant access and concise communication with other teachers and experts in their fields (Davis, 2015). Teachers are creating communities through education-related chat groups and hashtags, which includes weekly asynchronous or synchronous chats, continuous discussions, and even classroom integrations (Brenneman, 2015; J. P. Carpenter & Krutka, 2014, 2015). Twitter has become a valuable tool for teachers to communicate with each other. As Carpenter and Krutka phrased it, “The question is not whether educators will use Twitter and other social media services, but how can they use such services most effectively and wisely” (2014, p. 431). That Twitter is being used by educators has become a foregone conclusion. In this context of conference PD and Twitter usage, in 2012, teachers combined the two and created a new type of conference with the name, TwitterMathCamp (TMathC).

#Intro: Origins of TMathC

In 2010 and 2011, a series of conversations on Twitter among mathematics teachers led to an open invitation in 2012 to any interested mathematics teachers to attend a free, four-day conference in St. Louis, MO (Shah, 2012). The Mary Institute and Saint
Louis Country Day School (MICDS) in St. Louis was selected as the location because it is in the central U.S., and they donated the classrooms and meeting space. The program was four days in duration. Each day consisted of exploring Exeter Mathematics problems (Phillips Exeter Academy, n.d.) in the morning for two hours, then lunch, followed by a half an hour of “My Favorites,” a keynote, and two sessions of presentations (“TMathC12 program,” 2012). The tagline of the conference was “Guerrilla PD for Math Teachers” (“Math Camp 2012,” 2012). The lack of corporate sponsorship was an essential characteristic of this event.

The two mathematics teachers who organized the first conference, Lisa Henry and Shelli Temple, did so with the intention of creating something different from the standard conferences. In an explanation of why she initiated the conference Temple stated,

> After finding the online blog/Twitter community, I’ve found myself increasingly dissatisfied with traditional professional development. I hate the idea of spending hundreds of dollars in registration fees when I can get much better PD for free through our Twitter discussions and online book clubs (“TmathC12: Who we are & why we’re doing this,” 2012)

The dichotomy between this user’s frustration with conference interactions and the engagement found in social media suggested a desire for a different type of professional development experience. One essential element of the new experience was a focus on the personal interaction between the attendees. Connected to the element of personal interaction was the idea of working together for a significant amount of time. The morning time working on Exeter math was as much about collaboration as it was about mathematics. The organization of the conference emphasized the construction of relationships among teachers in addition to content knowledge of mathematics (Shah, 2012).
Henry focused on the personal interactions she had while using Twitter and her desire to reciprocate. Organizing the conference was not just about gathering people together, but about giving back to people who had supported her.

When we first started kicking around the idea to meet, I was excited about the opportunity to meet in person several of the people who have influenced me to be the teacher I am today. Helping organize this “camp,” if you will, is a way I can give back to those who have freely shared with me over the last 2 ½ years (“TmathC12: Who we are & why we’re doing this,” 2012).

In both quotes from the different organizers, the focus was on people with whom they interacted online, the benefits of sharing, and the ability to share for minimal cost. The goals were to have a free conference, which mirrored the cost of social media use, that encouraged teachers to share quality materials, and create relationships. The focus on sharing ideas and content was essential to the makeup of the conference, and attendees were encouraged to share on Twitter. The use of Twitter as a backchannel to conferences is a common practice (B. Chen, 2011; Kimmons & Veletsianos, 2016; Li & Greenhow, 2015). A difference between TMathC and other conferences was the promotion of Twitter from backchannel status to a more central feature of the conference (Risser & Waddell, 2018). Using Twitter to disseminate what was occurring in conference sessions to those who were not in attendance and invite those individuals to participate actively in sessions was one new feature.

Researchers have examined music, reading, science, and library science teachers’ social media use as a learning tool, (Barone & Mallette, 2013; Bauer, 2010; Kist, Tollafield, & Dagistan, 2014; Mulatiningsih, Partridge, & Davis, 2013; Tekerek & Ercan, 2012), as well as K-12 mathematics teachers (Larsen, 2016; Larsen & Liljedahl, 2017;
While mathematics teachers’ use of social media has been researched, little research has been done to date on TMathC. One study examined the differences between the 2015 TMathC and the NCTM Annual conference (Risser & Waddell, 2018). Findings from this study indicated that while some practices of mathematics teachers’ social media use after each conference was similar, the sense of community was greater in the TMathC group based on the content of the tweets when compared to the NCTM group. The TMathC 2015 group also retweeted each other at a much higher proportion and had a shared emotional connection that was lacking in the NCTM Annual group (Risser & Waddell, 2018, p. 11).

The research on and use of Twitter by teachers is a growing field (J. Carpenter, 2015; Kimmons & Veletsianos, 2016; Knaub, Henderson, & Fisher, 2018; Kolleck, 2016). The mixing of Twitter into the mainstream of conference practice creates a new realm of learning network and PD integration. The creation of the TMathC conference occurred independently of the research, and out of this professional development, some mathematics teachers have moved beyond learning, and into the realm of creating resources (Milou, n.d.; “MTBoS.org,” n.d.). Mathematics teachers have created a virtual space by means of a Twitter hashtag using the acronym for ‘MathTwitterBlogosphere,’ or MTBoS. Like the conference, this growth has occurred organically on Twitter. Unlike the conference, there has not been an effort by the teachers to document when the growth has occurred. However, in this space, these mathematics teachers are creating websites, crowdsourcing problem sets, and building tools that allow them to share blog posts about the teaching and learning of mathematics (“Cool things we’ve done together,” n.d.; “MTBoS.org,” n.d.). The result is a created space on the internet which combines the
practices of blogging, Twitter usage, and mathematical pedagogy. TMathC also exists in this mathematics teacher space (“TmathC12: Who we are & why we’re doing this,” 2012). The purpose of this study is to examine one year of this conference, 2017, the tweets before, during, and after, and the accompanying blog archive.

The organizers of TMathC created something different than the typical conferences being offered by the national organizations. However, without an examination of the public behaviors, the activity, and the discussions of the attendees, it cannot be determined what social and learning activities, or networks are occurring. To determine the actual nature of this conference, I proposed an analysis of the public interactions of the participants in TMathC. I designed a mixed method study which explained and analyzed the activity of the participants. A mixed methods study might well be ideal for this analysis, because the quantitative portion of the study may uncover communications in behavior which could inform the qualitative analysis of the tweets and reflective blog posts of the participants.

#Intro: The Story Behind My Questions

In December of 2011, I was discussing advanced placement statistics with teachers on Twitter. While this discussion was occurring Shelli Temple suggested I attend a face to face meeting which was being planned for July in St. Louis, MO. Two individuals, Lisa Henry from Ohio and Shelli Temple from Oklahoma were planning an informal conference centered on teaching mathematics. None of the attendees or organizers in 2012 had ever met one another in person, and I was no exception. I made the decision to attend based on the value of the Twitter conversations I was having. The
benefits of attendance outweighed the risk of meeting people who were names behind a Twitter account.

The first face to face meeting in 2012, was a success, based upon the reflective blog posts the attendees wrote (“TMathC12 archive,” 2012). These blog posts had such titles as, “Best PD Ever,” “Providing Space to ask Questions in Class,” and “The Best Professional Experience of my Life” (“TMathC12 archive,” 2012). A total of 37 mathematics educators attended at the Mary Institute and Saint Louis Country Day School (MICDS) in St. Louis, MO. The attendees started a website, www.twittermathcamp.com, to archive the blog posts created after the event. In relation to national mathematics teacher conferences, the number of teachers was unimpressive. Many school districts might have more than this attend regular meetings or trainings as compared to the 2012 TMathC. The National Council of Supervisors of Mathematics (NCSM) attendance is typically 2000 at their annual meetings, and the National Council of Teachers of Mathematics have three to four times that number. The teachers attending TMathC came from across the U.S., as well as Canada and England. Other conferences also have an international attendance, so the attendance number and participants at TMathC was typical. What made this conference unique is the teachers involved organized the conference events, planned the sessions, and knew each other solely through Twitter. These teachers took the experience one step further, however, and were actively engaged on social media. The attendees tweeted the sessions and the conversations during and after the conference and blogged about the conference (“TMathC12 archive,” 2012). All attendees made an intentional effort to engage individuals not in attendance in the sessions.
This effort did not go unnoticed. Education Week published two articles about the conference, one each before and after the conference ended (Reich, 2012a, 2012b). In addition, in one of their bulletins, the U.S. Department of Education promoted the conference;

**ALL A TWITTER ABOUT MATH.** In 2012, 40 [sic] math teachers from 19 states and three countries met in St. Louis, Mo., to build relationships and create their own professional development strategies. Twitter Math Camp was born of their effort. Check out their Math Twitter Blogosphere, which helps mathematics professionals connect with one another (U.S. Department of Education, 2013).

The mathematics teachers, from three countries, blogged and tweeted sufficiently to generate interest from education news organizations and the U.S. Department of Education. As a singular get together, it would be uninteresting. However, Lisa and Shelli started a conference that in 2017 held its sixth gathering with 200 attendees.

At the end of the 2012 meeting, Lisa and Shelli committed to holding a second conference in 2013, and formed a committee of educators to plan and organize the future conference. This commitment has grown to become an ongoing annual conference. Each year a private or public high school, college, or university has donated space for the conference, which allowed the organizers to keep the event free or low cost. The second year, the conference had approximately 100 attendees in 2013 at Drexel University, Philadelphia, PA. At this conference I was invited to join the organizing committee to help plan the 2014 conference and beyond. The third year, 150 attendees participated in 2014 at Jenks High School, Jenks, OK, and the fourth year, 175 attendees in 2015 at Harvey Mudd College, Claremont, CA. The last three years had attendance capped at 200 attendees, in 2016 at Augsburg College, Minneapolis, MN, in 2017 at Holy Innocents’

In 2015 the committee realized a more formal organization was needed to pay insurance and request grants and the organizers started the process of forming a 501c3 charitable organization. In 2016, the non-profit educational charity TMathC was formed in Ohio ("TMathC," n.d.), and I was asked to be on the board of directors. As part of this process, the group formally changed the name and website to TMathC. Also, in 2016, the organizers instituted a $25 fee to reserve attendance at the conference because of the cap of 200 attendees.

The conference started small, as a way for K-12 mathematics teachers to informally share and learn from each other but created enough mentions on Twitter to draw the attention of the NCTM. In 2015 the NCTM sent their President to give a session, as well as other representatives in 2016, 2017, and 2018. ("TMathC15 program," 2015; "TMathC16 program," 2016; "TMathC17 program," 2017; "TMathC18 program," 2018). In the span of five years, the conference went from ‘Guerrilla PD for Math Teachers,’ an informal meeting of teachers teaching and learning from each other to an official, legally recognized organization giving an annual conference as PD and offering graduate credits through a university partnership. As an insider to the process of conference growth, I have observed the organic nature of the conference development.
#Intro: Research Context

My research questions were addressed through the sequential analysis of data, which were used to inform the next round of analysis. After a review of the literature on PD, learning networks, and social networks in chapter two, I will describe the mixed methodology used to analyze the data in detail in chapter three. The mixed methods will be a social network analysis for the quantitative and a qualitative, phenomenological analysis using an analytical framework of Engeström’s third generation of Cultural-Historical Activity Theory (CHAT).

The data collected were in two parts. The first part was the tweets from the public Twitter search from July 10 through August 31. This period included 17 days before, the four days of the conference, and the month after the conference, which occurred on July 27-30, 2017. In total the period tweets were collected totaled 53 days. While the most substantial proportion of the tweets were during the conference, the conversation prior to and after the conference might have been necessary to understanding the connections and conversation patterns of those engaging on Twitter. The second data set data were the public blog posts of individuals about their TMathC 2017 experience. These posts are linked from the TMathC archive (“TMathC17 archive,” 2017).

The quantitative analysis was a social network analysis (SNA) of the participants who used the #TMC17 hashtag for conference discussions. Because individuals who were not in attendance at TMathC used the hashtag, anyone who used the hashtag #TMC17 was considered a ‘participant’ regardless of their attendance. This created two groups within the category of participants, attendee participants and remote participants. The SNA created an understanding of the different learning networks participants created
through their conversation patterns. The SNA might inform other groupings of participants beyond attending and remote participants as well.

The qualitative analysis used the content of the tweets, as well as the blog posts, to explore and understand the quality and activity of the participants. It was recommended to use an analytical framework to avoid biases which arise from being an insider to conference participation (Hayfield & Huxley, 2015; Ross, 2017; Silverman, 2005). The framework chosen is Engeström’s third generation CHAT. This framework requires an analysis on a complex framework of seven elements: rules, subjects or individuals, community, division of labor, tools, objects, and outcomes of the system as well as the overarching tensions which facilitate learning (Engeström, 2006, 2006). The interplay of these seven elements and tensions create an understanding of the human activity of a complex system of learning (Engeström, 2015).

The mixing of the data occurred in the rounds of data analysis. The qualitative data were compared using the groupings suggested by the SNA, as well as the SNA was re-analyzed using information gathered from the qualitative analysis. Since the qualitative and quantitative analysis are using the same data set, it is appropriate to mix the data in the analysis stage (Creswell & Plano Clark, 2011).
Chapter 2: Literature Review

This literature review is divided into three parts: professional development (PD), social network analysis (SNA), and Cultural-Historical Activity Theory (CHAT). In the first section of part one, I review research and findings on the effective practice of PD. In the second section of part one, I examine the research on personal and professional learning networks as used by educators.

Part two of the review begins with an overview of the theory and concepts in the current SNA research field. Then I describe several types of SNA studies focusing on the field of education. Finally, I examine the literature found at the intersection of the fields of SNA and research on teachers’ professional networks.

Part three of the review starts with a brief history of activity theory leading up to Engeström’s third generation version of CHAT. Next, I describe the existing literature on the use of CHAT in the field of education and examine why CHAT is the appropriate analytical framework to use to examine educator learning networks. I also discuss research evidence that shapes the rationale of the study’s mixed methods design.

#LitReview #PD: Professional Development and Learning Networks

Few teachers would disagree with the idea, “educators should always be learning” (Kleine-Kracht, 1993). This learning may occur in the three categories of formal, informal, and independent learning, and is situated in the context of the culture of the subject or areas taught (Carter & Quinnell, 2012; Jones & Dexter, 2014; Lave & Wenger, 1991; Livingstone, 2001). However, most states require teachers to earn only a minimum number of documented hours of continuing education in order to renew a teaching license (Neville et al., 2005, p. 17). The practice of formal teacher learning is one way to earn the
credits necessary for renewal, but there is considerable discussion about what is ‘good’
PD. Further, the rise of the internet as a communication medium has created
opportunities for professional and personal learning networks (Baker-Doyle, 2011;
Baker-Doyle & Yoo, 2010). Exploring the similarities and differences between the three
types of learning opportunities, as well as how each type can extend teacher learning is
essential to understanding how conferences such as TMathC is situated as PD.

#LitReview #PD: Conferences and Professional Development

PD is an activity with variance depending on context and location. Some authors
assume that the reader will know what PD means and dive into the discussion about good
and bad types (Birman, Desimone, Porter, & Garet, 2000; Garet, Porter, Desimone,
Birman, & Yoon, 2001; Nelson, 2015). Other authors are clear on what they consider
good PD to be and frame it as, “a coherent part of a school reform effort” (Darling-
Hammond & Richardson, 2009). Other authors view PD through a pragmatic lens and
evaluate the quality based on the results the PD has on teacher learning of skills and
procedures (Roessger, 2015). This variance in definitions may create a perception that PD
is ill-defined, and given the flexibility in definitions, everything from Twitter, to
blogging, to classroom interactions, to workshops has been labeled as PD (Davis, 2015;
Garet et al., 2001; Hramiak, Boulton, & Irwin, 2009; Kabilan, Adlina, & Embi, 2011;
Scherer, 2012). A first step, then, should be clearly defining PD.

The practice of learning in PD can be categorized into three classes, formal,
informal, and independent (Jones & Dexter, 2014). Formal learning opportunities are
structured learning environments such as graduate courses or classes offered by school
districts with a defined curriculum (Richter, Kunter, Klusmann, Lüdtke, & Baumert,
These formal learning opportunities are where teachers often accrue the necessary hours for renewal of teaching licenses. The formal learning PD can occur in a workshop setting where everyone is working on a common task, or a classroom where a leader is informing the educators (Garet et al., 2001; Jones & Dexter, 2014). The context of teachers learning together on a formally defined curriculum is the common thread that makes the activity formal. In addition, the idea of formal PD has been codified into law.

*The No Child Left Behind Act (NCLB)* of 2001 codified into law a multi-part definition of professional development. (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). This definition was reorganized in 2015 in the *Every Student Succeeds Act (ESSA)*, but the text was not changed. There are two parts separated by an ‘and.’ Part A defines,

> The term ‘professional development’ means activities that—(A) are an integral part of school and local educational agency strategies for providing educators (including teachers, principals, other school leaders, specialized instructional support personnel, paraprofessionals, and, as applicable, early childhood educators) with the knowledge and skills necessary to enable students to succeed in a well-rounded education and to meet the challenging State academic standards; and (Every student succeeds act, 2015, p. § 8002(42)(A)).

Section B of the law follows with, “(B) are sustained (not stand-alone, 1-day, or short term workshops), intensive, collaborative, job-embedded, data-driven, and classroom-focused, and may include activities that—” (Every student succeeds act, 2015, p. § 8002(42)(B)) and has eighteen additional clauses that further define professional development (see Appendix A for the full text). The law does not give a justification for excluding one-day workshops, and this negative only excludes one type of workshop out of many other types available.
Informal PD learning environments are defined as those taking place outside the traditional university or classroom without a specified curriculum (Jackson, Mohr-Schroeder, & Little, 2014; Richter et al., 2011). Examples of this may be departmental or school book clubs, or engaging in a schools’ professional learning community (Kwakman, 2003; Livingstone, 2001). These learning environments may not be required for teachers in all cases, but still take place in the school or workplace, and are aligned with the goals of the school or department. These PD activities help teachers in gaining skills necessary to help their students succeed in the school.

Independent PD learning is also not required of teachers, and is separate from the informal because it is engaged, “in on their own initiative and accord, and which possess no connection to their organization” (Jones & Dexter, 2014, p. 371). The rise of social media use allows teachers to engage in self-directed learning environments which have no connection to their school or employer (Alderton et al., 2011). Teachers engage in this practice to satisfy their own professional or personal learning goals, without the demands of the formal structure of coursework or a connection to an employer. The practice of independent learning increases as teachers become more comfortable with social media use (Lohman, 2005; Tosato, Arranz, & Avi, 2014). The teacher engages in this learning because they have an independent desire or need to learn something and seek out others who share and support that need. A definition of PD can go beyond the categories of formal, informal, and independent, however.

Any definition of PD should include teacher learning, content or classroom skills, as these topics are found in all of the practices above (Birman et al., 2000; Buysse, Winton, & Rous, 2009; Garet et al., 2001). Buysse, Winton, and Rous (2009) attempted
to uncover a general definition in the education arena and did not find one. They did construct a definition for the National Professional Development Center on Inclusion that meets the demands of the ESSA, as well as communicates the idea of PD in a constructive manner.

Professional development is facilitated teaching and learning experiences that are transactional and designed to support the acquisition of professional knowledge, skills, and dispositions as well as the application of this knowledge in practice. The key components of professional development include (a) the characteristics and contexts of the learners, (b) content, and (c) the organization and facilitation of learning experiences (Buysse et al., 2009, p. 239).

This definition gives a clear vision of what PD should be. It also allows for a wide range of experiences while the educators work through the key components of PD, including who, what, and how. First, this definition requires that PD be facilitated learning and transactional. Second, the PD must allow the participant to acquire; professional knowledge, skills, and dispositions. Finally, there must be a way to apply knowledge in practice. The last three components speak to the ‘who,’ the ‘what,’ and the ‘how’ of PD. The last two points of the definition meets the expectations of PD found on the Association of Teacher Educators website (“ATE position framework,” n.d.) as well as other researchers (Darling-Hammond & Bransford, 2005; Darling-Hammond & Richardson, 2009; Garet et al., 2001; Scherer, 2012; Yoon et al., 2007). It is the first point of the definition where there is a discrepancy.

The condition that PD be transactional requires an exchange between people. Adding to this requirement the facilitated learning and the result is that PD should be bi-directional and active. A facilitator or expert who is leading the PD is an essential requirement of the idea of ‘facilitated learning.’ Having active learning may be more
important than requiring facilitated learning. Garet et al. (2001) uncovered that active learning was preferred; however, active learning could take the form of observing and being observed, a form of situated learning. Storandt, Dossin, and Lacher (2012) uncovered forms of computer-mediated active learning which were effective for the PBS Teacherline program. Although the above definition is limited to facilitated learning, there may be broader forms of learning which will accomplish the same goals. The common element in all forms of PD is active learning, allowing other forms of learning, and creating an opportunity for more forms of PD.

Mediated learning PD opportunities are becoming more available as electronic forms of communication also become common. Whether the communication is synchronous in real-time (Y. Chen, Chen, & Tsai, 2009) or asynchronous in the form of Twitter or blogging (Davis, 2015; Hramiak et al., 2009; Kao & Tsai, 2009), a crucial component is an active, engaged environment where teachers can learn from each other (Korthagen, 2017; Matherson & Windle, 2017). In the end, the form of learning is less important than the activity of learning.

Sustaining the activity of learning over time is also vital. In the literature of PD, the findings repeatedly demonstrate that one day, or short term PD, is less beneficial to teachers than long term, sustained PD (Birman et al., 2000; Garet et al., 2001; Matherson & Windle, 2017). In fact, there is evidence that,

…professional development lasting 14 or fewer hours showed no effects on learning, whereas other studies of programs offering more than 14 hours of sustained teacher learning opportunities showed significant positive effects. The largest effects were for programs offering 30-100 hours spread out over 6-12 months” (Darling-Hammond & Richardson, 2009, p. 49).
This research justifies the exclusion of the “stand-alone, 1-day, or short-term workshops” made in the ESSA definition earlier (Every student succeeds act, 2015, p. § 8002(42)(B)). Any definition of professional development in any form must require a long-term commitment to the learning of the participants.

#LitReview #PD: Professional and Personal Learning Networks

Within the discussion of the types of PD, there also emerges the idea of personal and professional learning networks. Authors often merge these two types of networks together in articles. For example, Scavitto (2013) titles a practitioner piece *How to get more out of your PLN using Twitter*, and yet never once explains what a PLN is. By using the initials, the author can completely avoid defining the term and leaves it open to the reader to define. Kist, Tollafield, and Dagistan (2014, p. 317) commit an even worse consolidation. In the abstract they write, “Exploring content of tweets of some adolescent literacy leaders suggests the need for careful scaffolding for those being introduced to Twitter as one possible component of a Professional Learning Network.” Three sentences into the article, they then write, “The class we teach, ‘Multi-Modal Literacies,’ is mandated for all students in our English Education program and using Twitter for developing a Personal Learning Network (PLN) was a required component of the class.” Two pages later, they state, “Even before the onset of social media, the social aspect of reflection (participating in a PLN) has been seen as a vital part of the professional life of a critically reflective practitioner” (2014, p. 319). These are not the only examples of the merging of the ideas of professional and personal. Visser, Evering, and Barrett (2014, p. 396) states, “A personal learning network (PLN) has been defined as a ‘system of interpersonal connections and resources’ that can be used for informal learning,
collaboration, and exchanging knowledge and ideas (Trust, 2012, p. 133).” Notice the citation for the definition of a personal learning network cites Trust, who authored the article entitled *Professional Learning Networks Designed for Teacher Learning*. Never once in Trust’s article do the words ‘personal learning network’ appear (Trust, 2012). There are more examples of this merging of the two ideas (Alderton et al., 2011).

There are several possibilities that can explain the imprecise use of the two phrases, professional learning network and personal learning network. One is that professional and personal learning networks are so similar in nature and initials that the authors do not distinguish between the two types of networks because there is no difference. In the online world, the distinction between professional identity and personal identity may be merged to the point where there is no difference between them. On the other hand, it could be that there is a distinction between the two types of usage, and there needs to be definitions established which would allow for a clear delineation.

It is possible there is no distinction between the two types of networks. The personal and the professional networks merge together to the point where educators are using online communication without regard for separation of identity. There are researchers who argue for this position. Alderton, Brunsell, and Bariexca (2011, p. 7) explicitly define a ‘PLN’ as a “[professional / personal learning network]” and use the two terms interchangeably throughout the article. In addition, in business, there is evidence that marketing professionals find a univocal approach to social media usage to be expedient (Fieseler, Meckel, & Ranzini, 2015). Also, in a study of established academics on Twitter, it was found the respondents shared both personal and professional
Information (Veletsianos, 2012). Sharing both types of information does not mean the users are sharing equally or with the same intent.

In a large scale study of Twitter usage, with a data sample of over 200 million tweets and 414 distinct groups, Tamburrini, Cinnirella, Jansen, and Bryden (2015) uncovered that the same users changed their word usage depending upon what group they were engaged with at the time. The linguistic behavior of the users demonstrated that they shifted their word choice and frequency depending on whether they were conversing inside or outside their group. This has implications for the creation of the users online identity as well as the boundaries they create for themselves (Ollier-Malaterre, Rothbard, & Berg, 2013). Most importantly, it also means the community of practice educators are engaging with and entering into may be different depending upon the needs of the person at the time (Lave & Wenger, 1991). Even if a user is sharing both personal and professional information, they may be sharing in different ways to the group or community they are engaged with at the time.

If there is a distinction created between the professional and the personal learning network, it may come down to the intentionality of usage, and the community of practice with which the user is engaging. In using Twitter, reasons for usage by educators ranged from the desire for real-time, on-demand question answering, to the flexibility of where access is allowed, to the conversations which develop (J. P. Carpenter & Krutka, 2014). The connecting of mediated online communication with PD is also a common link (J. Carpenter, 2016; J. P. Carpenter & Krutka, 2014; Greenhalgh & Koehler, 2017; Swanson, 2014; Trust, 2012). But not all Twitter, blogging, or other computer-mediated communication is for professional reasons. A large proportion of the activity on social
media is about ‘meforming,’ as opposed to ‘informing.’ Meforming statements are personal expressions which contribute to an online, social identity (Naaman, Boase, & Lai, 2010). The practice of meforming is common and does not lead to the practice of question answering, conversations, or PD. Meforming is purely social in nature. The act of being social still contributes to the community of practice and still contributes to a learning network (Aramo-Immonen et al., 2015).

The intention of the conversation is what distinguishes between a professional and personal learning network activity. J. P. Carpenter and Krutka noted that “Twitter thus appears to provide not just access to technical knowledge and professional resources for educators who might otherwise be isolated, but also important emotional support in some cases” (2014, p. 427). The professional and technical resources are professional; however, emotional support is personal. There is a distinction to be made between the two types of usage, even within the same users or community. As Visser et al. uncovered, “Equally important findings are that the culture of this Twitter-based community of teachers is welcoming and fosters collaboration and participation, and the meaningful interpersonal relations arise as a result of the friendly, participatory culture of the community” (2014, p. 409). Another study on why teachers participate in online communities found five distinct reasons, three of which are personal, two of which are professional. The personal reasons were sharing emotions, combating isolation, and a sense of camaraderie, while the professional were utilizing advantages of online communities, and exploring ideas (Hur & Brush, 2009, pp. 290–291). In both cases, the community of practice, which started professionally, also contained personal interactions. Other studies support this interpretation as well (Blanchard, 2008; Horn, 2008). In other
terms, the professional and personal learning network activity may be different depending upon the needs of the user.

**#LitReview #SNA: Social Network Analysis of Network Behaviors**

Analyzing social networks is a growing field along with the trend for users to engage with social media platforms such as Twitter, Facebook, and others (Hanneman & Riddle, 2005; Hennig et al., 2012; Song, 2009). The networks people build can be real but can also be constructed objects mediated through software and internet accounts. As such, the network can be modeled as a construct of the classifications used to define it (Hennig et al., 2012, p. 14). The process of constructing a model of a social network is then accomplished by, “gathering data about aspects of the phenomenon and organizing the data in a convenient form, by applying methods that produce additional derived data, and translating these back to the realm of phenomenon” (Hennig et al., 2012, p. 15). This process does not differ from other empirical methodology, except in the type of data collected and the methods used to represent the analysis. The type of data collected is the relationships between people. These relationships exist in communication behaviors or conversations between people. The network behaviors of people are the communication patterns, the connections among them, and their centrality with respect to the other members of the group.

**#LitReview #SNA: Network Introduction**

When two people, or vertices, have a relationship, they have a connection or edge between them. These vertices and edges form the basis for the data collection in networks (Hennig et al., 2012). Analyzing a network is the analysis of “the whole relation and interactions among the entities in the network” (Lee, Cho, & Gay, 2008, p. 26). A visual
representation of the relations and interactions between entities is a network diagram, which shows the relationships between vertices (see Figure 1).

Figure 1: A network diagram of the top 25 sites during a week (Lee et al., 2008, p. 27)

The terminology in this area of analysis varies among authors. In a network diagram, the first component of a diagram is the vertex. A vertex is an actor which originates a tweet, retweet, or like. A vertex may be a person, an organization or company, or even an automated account bot. For this reason, a vertex can also be called a node, agent, entity, or participant (Hansen et al., 2010, p. 34). When two vertices communicate, they create a connection.

A connection between two vertices is defined to be an edge, dyad, link, tie, or relationship and is, “the building block of networks” (Hansen et al., 2010, p. 34). These
connections have three distinct aspects: content, direction, and value (Hennig et al., 2012, p. 64). The content is the type of communication between the vertices, the direction depends on who is the initiator and who is the receiver, and the value is a measure of the proximity on the graph of the two vertices (Hansen et al., 2010; Hennig et al., 2012). For traditional networks, the content would be phone calls, texting, in person, or other types of communication. In a network analysis of Twitter communications, the content of connections is identical, and what varies is the direction and value. The connections between vertices identify who communicates with whom and how frequently. These patterns are categorized into types.

#LitReview #SNA: Connection Types

It is possible to use the connections between vertices to identify six different types of groups. (Smith, Rainie, Himelboim, & Shneiderman, 2014). From Figure 2, the six types of communication patterns are polarized or tight crowds, brand or community clusters, and broadcast or support networks. What defines these group types is the level of interconnectivity, the direction of the connections, and the number of isolated or unconnected vertices (Smith et al., 2014, p. 7). The fact there are a number of different communication patterns which can occur, is one reason it may not be possible to predict which pattern will emerge prior to collecting data (Hennig et al., 2012).
Using the connections between vertices to categorize the type of networking behavior of the group shows the size and structure of the vertices along with key factors.

The types of communication displayed at a conference would describe how the conference networking occurred. For example, a conference which was described by a polarized crowd graph would have several clusters which had little communication.

**Figure 2**: Six types of communications patterns on Twitter (Smith et al., 2014, p. 8).
between them. This type of conference network could possibly occur if a conference was composed only of elementary and secondary teachers, where they each had speakers and attendees and little interaction among the two groups of participants. The two clusters would end up isolated in the network. Contrasting to a polarized network is the unified, tight crowd. The tight crowd network could still have several different clusters, but there would be many edges connecting the vertices so that few of the clusters are isolated. In this case, the same conference of elementary and secondary teachers would be communicating with each other and creating connections between the clusters. Perhaps they shared common keynotes or sessions mixed into the elementary and secondary sessions.

The brand and community clusters are marked by many ‘self-loops’ and independent clusters. In both types of networks, there are many unconnected and isolated vertices, which creates a self-loop, a vertex who tweets only for themselves and includes no other vertex in their tweet. The difference between the brand and the community network is that in the latter there are a collection of clusters. If these two networks describe a conference, they both would be a conference with many individuals whose tweets contain no other mentions of other individuals. Most of the participants would be self-loops, and in the community clusters there would be small clusters with few connections.

The final two networks are broadcast and support, which feature a central vertex which either receives or sends tweets, respectively. A conference with broadcast features would be one where a single vertex plays the role of ‘distributor’ of information. A conference with a single speaker could fall into this category if a single vertex ‘live
tweets’ the speaker and engages with other vertices through answering questions. The support network would be the reverse situation, where vertices are directing questions to a single vertex. A question and answer network would have this type of pattern.

In addition to the group categorization, the vertices can also act in ways which can be categorized. A vertex may be just one member in a group of communicating participants, or can also be a hub or bridge (Hansen et al., 2010; Hennig et al., 2012; Smith et al., 2014). A hub vertex is one which has a high connection count and has a broad audience (Smith et al., 2014, p. 12), which makes a hub vertex an important because it connects a large number of other vertices together. A vertex in this role can be influential in the more extensive network, such as in Figure 1, the vertex MSN acts as a hub to other vertices.

Another type of vertex is a bridge vertex. This type of vertex may have fewer connections but might be highly influential in the network because it connects groups or hubs together, allowing for communication among vertices which may not communicate otherwise (Smith et al., 2014, p. 12). In Figure 1, a bridge vertex would be one which connected this network of the Top 25 Sites with another network. If, for example, the AbcNews vertex was the connection to a network of other sites, the removal of AbcNews would disrupt the communication between the two networks. In Figure 1, there are no apparent bridges, because the network is strongly connected. Finally, another way to measure a vertices’ importance in a group is by measuring how central they are to the network.
#LitReview #SNA: Measures of Centrality

The proximity of a vertex to other vertices in a graph can be measured in several separate ways. In Figure 3, the simple network has six nodes, connected to each other in different ways (Hennig et al., 2012, p. 128). This figure will be used to explain the differences between degree, closeness and betweenness centrality.

![Graph Image]

*Figure 3: Understanding different types of centrality calculations (Hennig et al., 2012, p. 128)*

The first and simplest, way to measure the centrality of a vertex is to sum the number of single or ‘one-hop’ connections (Ringe & Wilson, 2016, p. 745). The vertex with the largest number of one-hop edges is displayed in the middle of a cluster of vertices and is designated as having the largest degree centrality (Lee et al., 2008, p. 27). A vertex with a large degree centrality may be considered a hub and may have a considerable influence on the network. In Figure 3, the most central vertex by this calculation is vertex two with a degree centrality of four. A vertex with small or no degree centrality would be found on the outside of the cluster and have little influence,
such as vertex one. There are three different vertices which are tied in this centrality measure with a value of three; vertices three, four, and six. Table 1 lists the degree centrality values for each of the vertices found in Figure 3.

Table 1

*Calculations of types of centrality for Figure 3*

<table>
<thead>
<tr>
<th>Vertex</th>
<th>Degree</th>
<th>Closeness</th>
<th>Betweenness</th>
<th>Eigenvector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.1</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0.17</td>
<td>5</td>
<td>0.208</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.14</td>
<td>0.67</td>
<td>0.202</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0.14</td>
<td>0.67</td>
<td>0.202</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>0.13</td>
<td>0.67</td>
<td>0.13</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0.13</td>
<td>1</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Another descriptive calculation is the number of “steps” or distance from one vertex to another. This *closeness centrality* measurement finds the mean distance between a vertex and every other vertex in a network (Hansen et al., 2010, p. 41; Lee et al., 2008, p. 28). For this measurement, the smaller the value, the higher the influence of the vertex in the network, with a smaller closeness centrality value indicating the vertex is closely connected to most other vertices in the network (Hansen et al., 2010). To overcome the issue of a small value of closeness centrality indicating a high influence, Hennig et al. recommend the inverse of the value (2012, p. 125), which creates an alignment between large value and influence. It is essential to clarify which calculation is used when interpreting the value. NodeXL uses an inverse formula similar to Hennig et al. (2012) but simplifies the calculation to accommodate large data sets (Brandes, 2001). The algorithm in NodeXL sums the total number of unique paths between every vertex and
finds the inverse (Brandes, 2001). In the example of above in Figure 3, vertex 2 has a 
closeness centrality score which rounds to 0.17. There are a total of six edges connecting 
vertex 2 to the other five vertices, so the mean distance is 1/6. With different authors and 
software packages using different formulas for the same idea, understanding the methods 
of calculation is essential.

There are also medial centralities such as *betweenness centrality*. This measure is, 
“how often a given vertex lies on the shortest path between two other vertices” (Hansen 
et al., 2010, p. 40). This measure of centrality can also be thought of as a bridge score, 
which measures how much removing a vertex would disrupt the connection between 
other vertices (Hansen et al., 2010; Hennig et al., 2012). One way to calculate this 
measurement is to count the total number of connections between every vertex in the 
network and divide by the number of possible vertices (Hennig et al., 2012). However, 
the NodeXL algorithm simplifies the computation because it assumes large data sets 
(Brandes, 2001). In Figure 3, the value of five for vertex two is calculated through listing 
all vertex pairs and summing the number of pairs which require vertex two in the path. 
This method does not divide by the possible vertices, in order to streamline the algorithm 
(Brandes, 2001).

The calculation for this measurement yields larger values as a network grows 
because it is summing all possible paths between vertices. In the example of Figure 3, 
adding a seventh vertex which connects only to vertex two (in an analogous way vertex 
one is connected) doubles the betweenness score from five to ten. In more extensive data 
sets, a betweenness centrality can be in the thousands of connections.
In addition to radial and medial measures of centrality, there are also *feedback centralities*. This type refers to the dependence of a vertices’ centrality on the centrality of others (Hennig et al., 2012, p. 126). The most common of this type is the *eigenvector centrality*. In this case, a vertices’ centrality is proportional to the total centrality of its neighbors (Hennig et al., 2012, p. 127). A large eigenvector centrality value for a vertex indicates that it is connected to influential vertices. This measure of centrality is a value that supports the idea that it is quality, not quantity, of connections that matters, and the quality of a vertex is measured relative centrality of its neighbors (Hansen et al., 2010, p. 41; Hennig et al., 2012, p. 127).

Choosing which methods of measurement to use in any particular case may be difficult, as the relations among these measures are, “not fully understood” (Hennig et al., 2012, p. 128). It may be the case, depending on the data analysis, that one measure of centrality is more descriptive of the network over another method. It may also be the case that one centrality measure yields values for multiple vertices which are so similar little differentiation between vertices is possible. Therefore, depending on the purpose and context of analysis, one measurement may be more useful than another based upon the calculated values. The importance of one measure of centrality over another cannot be determined prior to the data collection and analysis, because the calculations are based on the relationships of the vertices.

**#LitReview #SNA: Twitter Specific Network Behaviors**

On Twitter, interpreting which type of network is being analyzed requires mapping multiple types of communication between the participants. The connections can occur in mentions, retweets, or ‘likes’ (Hansen et al., 2010, p. 146). Mentions occur when
one vertex names another vertex in a tweet. In Figure 1, a possible tweet could be CNN stating, ‘@eBay is a service to sell goods.’ A retweet happens when Netscape reads CNN’s tweet and retweets the original tweet, creating a triangular network of the three participants. Finally, it is possible (but there is no example of this in Figure 1) of a circular edge or self-tweet. If CNN tweets but does not mention another participant, and no other participant interacts with the tweet through liking or retweeting, the edge points back towards the original participant (Hansen et al., 2010, p. 160). An example of this would be CNN tweeting, ‘The news is very important to us.’ In Figure 2, the large grids of participants in the Fragmented and Clustered graphs are composed of self-tweets in which no other participant connects with the original participant.

These extra layers of network information complicate the ability to identify which centrality measures should be used, prior to collecting and analyzing the data. By calculating measures of centrality, graphing the communication patterns of the participants, and visualizing various aspects of the conversations, the quantitative question can be answered and used to inform the qualitative analysis.

#LitReview #CHAT: Cultural-Historical Activity Theory

Cultural-Historical Activity Theory (CHAT) has its roots in the work of Vygotsky and his belief in the cultural nature of learning. Learning, for Vygotsky, depends on both the way pupils and educators interact and learn to share cultural tools (van Oers, 2010, p. 8). In addition, he developed the theory in order to create a holistic approach to understanding intelligence and culture, and to explain how the two ideas worked together (Roth & Lee, 2007). As CHAT developed over time, there have been three generations. The first was written by Vygotsky, which privileged “sign or semiotic mediation,
especially in the form of speech” (Roth & Lee, 2007, p. 189). In the second generation, Leont’ev expanded the theory to include societal, cultural, and historical dimensions, where the fundamental unit of analysis and explanatory principle which determines the genesis, structure, and contents of the human mind is historically evolving object-practical activity (Roth & Lee, 2007, p. 189).

Engeström expanded the third generation of CHAT to a complete human activity system. In Engeström’s analysis, activity has a broader meaning than ‘action’ or ‘operation,’ but instead is the concept of linking ‘events’ to the contexts in which they occur (Aramo-Immonen et al., 2015, p. 1155). Engeström’s system is composed of seven connected elements, subject, object, instruments or tools, division of labor, community, rules, and the outcomes. In addition, there are four higher order processes, production, consumption, exchange, and distribution (Engeström, 2015, pp. 62–63; Roth & Lee, 2007, pp. 197–198). In organizing the activity system, there are connections between the elements, which leads to a useful diagram (see Figure 4).
Figure 4: The structure of human activity (Engeström, 2015, p. 62)

This diagram is useful, but not definitive. It should be used as a model to guide the understanding of the activity and not a definition (Engeström, 1999, pp. 30–31, 2015, p. 63). As a guide, the model allows the evolving, complex structure of a mediated human activity to be understood and described as a complex whole. One criticism regarding the complexity of the model is that it has too many components. “The idea of pairs or triplets of concepts which are mutually constitutive, being a differentiated unity, has a long pedigree, but a set of seven mutually constitutive concepts is not really tenable, and Engeström surely doesn’t mean it that way” (Blunden, 2010, p. 231). Engeström’s reply is simply, “Well, actually I do mean it just that way. Human activity is a complex systemic formulation. Why would three mutually constitutive components be allowed but not seven” (Engeström, 2015, p. xxx)? As a model, the complexity is a feature of CHAT,
and all the elements must be justified and used in the third generation of CHAT. However, understanding the smaller activities is a way to build an understanding of the larger system of human activity.

Engeström replied to Blunden that CHAT required analyzing the entire multi-part system. There are difficulties in the elements to the system which may complicate the creation of understanding. First, it is clear from Engeström’s description of CHAT that learning is considered a social and cultural endeavor (Engeström, 2015, p. 74). This firmly places a researcher who is using CHAT to gain an understanding of human activity in the constructivist tradition. However, using CHAT is not only constructivist but also simultaneously dialectic. The model allows for tensions between elements of the activity (Engeström, 2015, p. 66). In the case of the above learners, this means there can be group and individual production of knowledge, but the knowledge does not need to be aligned on the same topic. The dialectic continues throughout the model, whether the subjects are sense makers or grade makers, do the subjects create rules or do they rebel against the rules, is the division of labor cooperative, or do the subjects isolate themselves (Engeström, 2015, p. 90)? The data collection must be careful and thorough enough to allow the researcher to gain an understanding of the activity (Yamagata-Lynch, 2003b). The researcher must be able to shift the examination to “the motive–goal–instrumental conditions rather than the observable individual behaviors and use that information to understand the collective meaning-making process” (Yamagata-Lynch, 2003b, p. 104).

#LitReview: #CHAT, Educators, and Online Participation

The growth of CHAT has been trending higher since the 1980s and has grown to the point where the American Education Research Association (AREA) in 2001 created a
special interest group for researchers using CHAT (Roth, 2004, p. 1). Much of this growth has been driven by Engeström’s third generation additions to the theory (1987). Engeström has continued to develop and explain CHAT through applications in the private sector workplace as well as education settings (Engeström, 1999, 2006, 2007, 2015; Engeström & Young, 2001). The variety of applications of the theory may be one reason its use has increased. Another reason may be the focus of the theory on the idea of communities as learners (Engeström, 2016, p. 36). Essential to the theory of CHAT is the theory of expansive learning, which subsumes the idea of a community of practice (Lave & Wenger, 1991; Wenger, 1998) but allows for learning to be bidirectional. Whereas Wenger treats learning as unidirectional, where the learner moves from incompetence to competence, expansive learning allows for the idea that through learning, the learner is also able to transform the community (Engeström, 2016; Engeström, Engeström, & Suntio, 2002; Engeström & Young, 2001). As learners engage in the practice of learning, they gain competence, but also expand the subjects and topics they are studying. As a theory applied to educators, the dynamic and holistic nature of the theory allows for a more sophisticated understanding of the community of learners (Yamagata-Lynch & Haudenschild, 2009).

This flexibility has allowed CHAT to be used as a lens to understand the discussions of educators at the K-12 level and higher education settings. A meta-analysis of CHAT in education shows a variety of applications (Nussbaumer, 2012; Roth, 2004). At the higher education level, some of the research on how pre-service teachers learn skills utilizes CHAT (Ellis, Edwards, & Smagorinsky, 2010; Junor Clarke & Fournillier, 2012; McNicholl & Blake, 2013). Other research uses CHAT to understand how teachers
develop content, teaching, or other practices (Fuglestad, 2013; Ladel & Kortenkamp, 2013; Lerman, 2013; Meyers, 2007). Because a ‘community’ does not need to be physically in the same location, however, a large amount of research using CHAT has been on using technology as a mediating tool (Hattem, 2014; Mysirlaki & Paraskeva, 2012; Yamagata-Lynch, 2003b, 2003a).

Distance learning is a common way that technology is used as a mediating tool, whether the technology is using websites to monitor learning from home or school (Scanlon, Blake, Issroff, & Lewin, 2006) or using tools such as Blackboard, Second Life, or other online methods of teaching (Russell & Schneiderheinze, 2005; Yamagata-Lynch, Click, & Smaldino, 2013). There have also been a number of studies using online forums as a mediated learning environment (Barab, Schatz, & Scheckler, 2004; Ithindi, 2013; Russell & Schneiderheinze, 2005). All these mediating methods utilize technology designed for educational purposes. Social media was designed for purposes of communication, not specifically education, and yet educators and learners have adopted the use of these media constructs for learning.

Rambe (2012) used a CHAT lens to examine the use of Facebook in an academic setting. To accomplish this, the author collected Facebook posts from a class discussion group, which had long posts and replies. Twitter conversations, however, have character restrictions on the tweets, so the conversations are shorter in length. This restriction makes it more challenging to uncover meanings and context, but it is still possible to apply CHAT as a lens to uncover the learning relationships (Dissanayeke, Hewagamage, Ramberg, & Wikramanayake, 2013; Hattem, 2014; Potts & Jones, 2011). In these Twitter studies, the participants were dispersed across distances, so the community was defined
through their practice, not their living in proximity to one another. In this way, technology and social media are redefining how a community of practice can be viewed (Yamagata-Lynch, 2003a).

#LitReview: #CHAT as Analytical Framework

Researchers working in an area of insider knowledge recommend using an analytical framework to avoid biases in the analysis (Hayfield & Huxley, 2015; Ross, 2017; Silverman, 2005). Being an insider to the research area may bring several sources of bias. Presumptions of shared understandings of concepts, preexisting relationships causing friction, and complex issues of power are some of the issues which may influence the qualitative analysis (Ross, 2017, p. 327). As Tilley pointed out, “the researcher’s familiarity with the context does not always guarantee that the research conducted will be any less hazardous to the participants than the research directed by someone stepping in from the outside for a brief encounter” (1998, p. 327). A researcher can influence the analysis as an insider or outsider to the research. What matters most is the self-analysis and reflexivity to evaluate whether the analysis is representative of the participants (Savvides, Al-Youssef, Colin, & Garrido, 2014; Sutcliffe, Linfield, & Geldart, 2012).

To assist in analyzing the qualitative data a framework of Engeström’s third generation CHAT can be used. This framework requires an analysis on a complex framework of seven elements: rules, subjects or individuals, community, division of labor, tools, objects, and outcomes of the system (Engeström, 2006). The interplay of these seven elements creates an understanding of the human activity of a complex system of learning (Engeström, 2015). By examining the separate components of the framework
as well as the interactions yield a potentially rich analysis (Dissanayeke et al., 2013). In addition, the framework of CHAT is independent of whether the activity occurs in person or mediated by technology (Thoms, 2012). Therefore, for analyzing conference activity, this framework yields an opportunity for a rich analysis of complex activity without a reductionist perspective.

#LitReview #MixedMethods: Why Mixed Methods

Mathematics education research is a field in which mixed methods research (MMR) is frequently occurring (Hart, Smith, Swars, & Smith, 2009; O’Cathain, Murphy, & Nicholl, 2007). Hart et al. (2009, p. 34) examined three different journals of mathematics education between 1995 and 2005, the *Journal of Research in Mathematics Education*, the *Educational Studies in Mathematics*, and the *Journal of Mathematics Teacher Education*. The authors found that depending on the journal examined, between 24% and 36% of all mathematics education articles published were MMR studies using either inferential or descriptive statistics in addition to their qualitative components (Hart et al., 2009). When compared to the results of education journals in general at 24% (Alise & Teddlie, 2010, p. 115), mathematics education has a higher prevalence of MMR studies. The frequency of prior use should not determine what methodology of research should be used, however. The methodology chosen should be based on the questions asked and the type of answers expected (Creswell & Plano Clark, 2011).

Questions which explore a problem, describe experiences, or map the complexity of a situation are well suited for qualitative research methods (Creswell & Plano Clark, 2011; Onwuegbuzie & Leech, 2006). Questions which compare groups or determine relationships between groups are well suited for quantitative methods (Creswell & Plano Clark, 2011; Onwuegbuzie & Leech, 2006).
Clark, 2011). Having both types of questions is not sufficient to call a design mixed 
methods, however. The questions should be written in such a way as to require mixing at 
least once during the analysis (Creswell, 2010). Attempting an MMR design requires a 
careful approach starting with the research questions and continuing all the way through 
data collection and analysis, because it is not sufficient to do two studies, one qualitative 
and one quantitative, and report both sets of results (Creswell & Plano Clark, 2011; 
O’Cathain, 2010). The MMR design selected must be intentional with respect to the 
mixing and based upon the needs of the questions asked.
Chapter 3: Methodology

#Method: Overview

This chapter begins with the context of the research, the selection of participants, my involvement with TMathC, and the research questions. The quantitative and mixed methods with qualitative data sections which follow each include an explanation of the purpose, rationale, and analysis of the respective types of data. Finally, the limitations of the study are discussed, and the uniqueness of the method are explored.

I used a mixed-methods approach to investigate the three questions. The research was based on the network of mathematics educators who tweeted and blogged before, during, or after the 2017 TMathC conference, held annually in July. Every person or account who tweeted using the hashtag #TMC17 or had their blog post archived by TMathC in their 2017 archive was considered a participant. Attendees of the conference who did not tweet with the conference hashtag or blog about the experience were not included in the study.

A lens of Cultural-Historical Activity Theory (CHAT) was used to avoid insider perspective from interfering with the qualitative analysis. The primary data set was the tweets of the participants, which contain both qualitative and quantitative data. The qualitative data are the content of the tweets, while the quantitative data are comprised of the communication network between the participants. A secondary qualitative dataset is the longer form blogging activity of the participants. The purpose of collecting both tweets and full-length blogging is it will give a deeper understanding of the participants’ activity. The quantitative data set will provide a contextual frame for the description of the educators’ activity before, during, and after the conference.
#Method: Selection of Participants

Inclusion in both the quantitative and qualitative data sets will occur based on the individual’s public participation in the Twitter hashtag #TMC17. The data set will include anyone who tweets with the hashtag, replies to a tweet using the hashtag, likes, or retweets the initial tweet. By extending the data collection to the broader interaction with the initial tweet, networks of communication can be created. In addition, any individual who has a blog post in the TMathC 2017 archive was included in the qualitative data set.

For the purpose of clarity, the following definitions were used to identify the individuals who make up the participant pool. Individuals identified as participants were those individuals who either publicly tweeted using the hashtag #TMC17 or had a blog post included in the TMathC archive. These individuals may, or may not, have physically attended the conference in Atlanta, GA, but they engaged with the activity of TMathC in some way during the specified time. Individuals identified as attendee participants were physically present for the conference for at least some time during the period. These individuals are identified through their Twitter handle being listed in the public TMathC attendee list (“TMathC Twitter list of 2017 attendees,” n.d.). An individual who was a participant but not attendee was identified as a remote participant. It is possible there were attendees who choose not to tweet or blog about the conference. These attendees will not be considered participants in this study, as they made no public reflections, nor did they participate in public conversations during the study period.

While the attendee list was approximately 200, the participant pool size was unknown prior to collecting and analyzing the data. Because the hashtag use was public, and any user of Twitter could use the hashtag to connect with attendees, the potential
pool of participants is large. Further, the blog post archive was not limited to attendees, as
the link for inclusion was tweeted publicly as well.

**#Method #Participants: Context**

Data were collected from the Twitter search function from July 10 through
August 31. This period included 17 days before, the four days of the conference, and the
month after the conference, which occurred on July 27-30, 2017. In total the period
tweets were collected totaled 53 days. The blog posts were downloaded two months after
the conference at the end of September. This delay allowed the participants to reflect on
the presentations and activities of their conference attendance and post their reflections.
In addition, the activity of the conference was frequently tweeted about by participants,
and sessions were shared on the conference wiki site (“TmathC wiki,” n.d.), the
individuals who participated in the conference activity might not have been present at the
conference. It was expected the number of participants in the study was greater in number
than the attendance at the conference.

The study was constrained by the fact that the participants were all either social
media users or bloggers. It is possible that someone could have attended the conference
and not engaged on Twitter or a blogged about the experience. How frequently this
occurred is unknown in advance. The conference held a “first-time attendee” session to
introduce the practice of tweeting and blogging as well as to introduce first-time
attendees to each other. It was also possible that an attendee chose to either blog or tweet
about their experience, but not both. The study took place over the 2017 conference, held
annually in July.
**#Method: Data Collection**

The participant Twitter data were downloaded using a daily search of the hashtag #TMC17 by means of social networking software. The search pulled all necessary information necessary for the social network analysis from Twitter and stored the data in an Excel workbook. The downloaded data included, among other information, the initiator’s Twitter handle, the receiver’s Twitter handle, the date, time, unique Twitter identification number, hashtag or tags used, links tweeted, and the complete content of the tweets. Since the downloads were done daily, and the Twitter search function may return tweets within seven days prior to the search, it was possible the data set contained many duplicated entries after the files were merged. It is also the case that the Twitter standard search function does not return a census of tweets, but a sample whose methodology is not public (Twitter Documentation, n.d.). Downloading the tweets daily created a more exhaustive sample, however, the resulting sample contained many duplicate entries, which were removed using the three simultaneous values of the time stamp, person tweeting, and the unique tweet ID value. The content which matched all three values simultaneously were eliminated. The downloaded data included all the necessary information to complete the quantitative analysis.

In addition to the Twitter data, the blog archive was included in the data for the qualitative analysis. This data were collected by copying the text, photos, and links from each blog post linked from the TMathC 2017 blog archive. Each post was individually saved in a separate document for thematic analysis.
#Method #Collection: Researcher Involvement with TMathC

Since I have been involved with TMathC since its inception, it is important to understand how that may impact my biases in conducting this study. My involvement began in 2011 when I started engaging in discussions with the organizers of the first conference. I was a high school mathematics teacher who was struggling to discover new ways to think about teaching and learning mathematics and how to implement these ideas in my classroom. A group of people on Twitter was discussing how to increase cognitive demand in the mathematics classroom, as well as other topics relevant to mathematics teachers. I was active in these conversations, started implementing the ideas, and saw immediate benefits to my learners. I attended the first TMathC in 2012, and every TMathC since. I was asked to join the organizing committee in 2014 and joined the Board of Directors of the TMathC organization upon its founding in 2016. I have not only attended each TMathC but also presented at all but one conference. I gave a keynote presentation in 2018.

My personal involvement in the community predates my graduate school enrollment in Fall 2014. I will conduct the research as an insider observer. Being an insider can have benefits, such as “nuanced and responsible data collection” as well as, “richness in the interpretation of the data in light of deep knowledge of the social, political and historical context” (Ross, 2017, p. 327). It also comes with challenges as well. It is possible for the researcher to overlook parts of the data because of assumptions of shared understandings of essential concepts (Hayfield & Huxley, 2015; Ross, 2017). Further, it is possible the researcher may avoid difficult or sensitive topics because of
personal relationships or power differentials (Hayfield & Huxley, 2015; Ross, 2017; Sutcliffe et al., 2012).

One way to mitigate these concerns suggested by Silverman (2005, p. 236) is to, “move beyond ad hoc labels and redefine our data within a well-articulated analytic scheme.” This recommendation is why I propose the mixed methods procedures outlined below. The quantitative social network analysis (SNA) allows for an impersonal data collection and analysis, while the framework of CHAT is an analytic scheme which would meet Silverman’s suggestion.

#Method: Research Questions

RQ1: What were the network behaviors of participants in TMathC in 2017?

RQ2: What was the human activity of conference participation of TMathC in 2017?

RQ3: How were the network behaviors and human activity of the participants of TMathC in 2017 interrelated?

#Method: Quantitative Data

#Method #Quant: Purpose

The purpose of the SNA was to illustrate the range and type of connections found in the conference activity, which framed the communication patterns of the participants. This data analysis was not meant to generalize about participation at this or any other conference, but rather to describe the network patterns at this particular conference and reveal possible lines of inquiry in the qualitative data.
#Method #Quant: Rationale

SNA makes it possible to compare the communication networks among individuals who were participating in TMathC. The participants generated multiple networks through their tweeting behaviors, and SNA will allow for the discovery of trends across the different networks created. In addition, the number of participants in TMathC was greater than the number of attendees, and thus a methodology must be selected which captured this breadth of activity. By analyzing the tweeting behaviors through SNA, participants who were not in attendance, but who were members of the community, were included in the activity. The resulting maps were a thorough analysis of the public behavior of the participants with respect to the conference.

#Method #Quant: Social Network Analysis (SNA)

The SNA was done using software explicitly designed to work with large datasets of social networking data. NodeXL is one such software package and was used to calculate such measures of networking as the different types of centrality, as well as visualizations of the networks such as clusters, edges, and density. The types of calculations done may include the list:

- The different types of centrality measure the influence of participants on others in separate ways. The types are betweenness, eigenvector, and closeness.
- Density is a measure of the proportion of connections or edges a person or group has. The more connections between individuals, the higher the density of communication.
• Bridges are individuals who connect others to the conversation in the primary data set. For example, it is possible that an individual retweets to their own followers and those followers engage only with the individual, not the others who are starting the conversation. This person is a bridge who connects one group of participants to another.

• The different visualizations of the measures allow for distinct groups or clusters to be viewed, which may allow the qualitative analysis to be analyzed in different slices, later.

It is not possible to predict which measures or visualizations will be used prior to the analysis.

#Method: Mixed Methods with Qualitative Data

#Method #Mixed: Purpose

The purpose of the qualitative study was to contextualize the human activity, conference participation, of the participants of TMathC in 2017. Human activity is the understanding of all the various aspects of the conference participation as viewed through the multi-part lens of CHAT. By analyzing the content of the tweets and blog posts, I was able to explore the cultural activity of the participants beyond the network of connections. Networking was a substantial activity of conference attendees, but knowing what was said to others, not only to whom it was said, allowed for a stronger understanding of the activity.

#Method #Mixed: Rationale

A study which examined only the quantitative Twitter data of the conference would explain the ‘who’ of the activity, but it would miss the ‘what’ and ‘why’ found in
words and the reported experience of the participants. The choice of using the content of the tweets of the participants was aligned with a mixed methods parallel design, as the content of the tweets and the data used in the SNA above is the same data set. Tweets are a shorter form of blogging with character limitations, therefore adding the full-length blog posts expanded the ability of the researcher to understand the activity of conference attendance better.

The SNA identified members of the community who were high-frequency communicators, bridges, or other forms of influencers, as well as those who were lower frequency. The knowledge gained from the SNA influenced the analysis of the qualitative data and allowed overarching themes to be mixed onto the qualitative data. In addition, the findings of the qualitative analysis were used to do additional SNA.

#Method #Mixed: Analysis of Data

The qualitative data were analyzed using comparative thematic analysis, using the analytical framework of Engeström’s third generation CHAT. The purpose of imposing the framework on the data was to discourage any insider bias which may have occurred. By having the framework of rules, community, division of labor, subject, object, mediating artifacts, and outcomes as the structure of analysis, it allowed the central activity, tensions, and contradictions of the activity of conference participation to be examined.

While the thematic analysis occurred, the qualitative data was also analyzed through the lens of the quantitative data. A possible, but incomplete, list of lenses which could occur are bridges, high or low frequency, or influential or non-influential participants. Bridges are individuals who connect one cluster of participants to another.
High or low-frequency participants are individuals whose tweet counts are high or low compared to the data sets middle values. Similarly, influential, or non-influential participants are individuals who have a large or small number of connections when compared to the middle values of the data sets. Predicting the actual networking structure of the participants prior to the analysis cannot was not possible.

In addition, there was information in the qualitative analysis which influenced a second analysis of the quantitative data. Participants who mention they are first-time, veteran attendees, or non-attending participants could change the network maps and show the network in a different perspective. It is for these reasons a parallel, convergent design is chosen (Creswell & Plano Clark, 2011).

**Figure 5**: Parallel, convergent design of the study
**#Limitations of the Study**

One limitation of this design was that if an attendee did not blog or tweet about their experience, they would not be included in the search, and therefore not included in the data set. Tweeting or blogging was not required of any attendee. In this case, the attendees' experience, reflections, and activity were not present or taken into account in the analysis. It was also possible that an attendee who had a private Twitter account engaged with the participants throughout the data collection period. In this case, the participant might have been included in the quantitative data as a receiver of tweets but would have no qualitative Twitter data. These individuals might have data in the blog post data, however. In essence, the limitation was that while collecting data from many participants in the activity, there might have been individuals, influential or not, who were not represented for one reason or another.

Another limitation is that by searching only the main conference hashtag, public side conversations or replies were not included in the data set. When replying to a person’s tweet, the common practice is that not everyone includes the original hashtag in the reply, or they may drop the hashtag altogether (Bruns & Stieglitz, 2012, 2013; Sopan, Rey, Butler, & Shneiderman, 2012). The data set included the original tweet, but the resulting conversation might not have been captured in the data set. This limitation meant that in all cases, it was likely the data undercounts edges between vertices, and possibly vertices who replied to tweets without using the hashtag. The data did not include the content of the tweets for qualitative analysis as well. Capturing all conversations was not possible through a hashtag search.
A third limitation is the fact that I personally know many of the participants from previous TMathC conferences and interactions on Twitter. The relationship I have with the individuals spans years of interactions and conversations. This limitation is a reason interviews or other face to face data was not collected. By collecting data mediated through other communication technology, the data collection reduced the opportunity for biasing the data analysis.

A final limitation is the reliance on English as a communication language across all participants. Although participation in the conference is not limited to any specific language, and even though attendees travel from several different countries, English is the *de facto* language used to communicate. This limits the participation to only English speakers, and further limits the ability of the quantitative analysis from being generalizable.

**#Uniqueness of Method**

There is a paucity of research in the literature which mixes SNA and CHAT. Many studies have been published using SNA to analyze Twitter communication and conference participation (Bruns & Stieglitz, 2012, 2013; Gao & Li, 2017; Gao, Luo, & Zhang, 2012; Sopan et al., 2012; Zappavigna & Martin, 2018). Many studies have also been published using CHAT in academic settings or conference participation (Russell & Schneiderheinze, 2005; Sannino, Daniels, & Gutierrez, 2009; Schmittau, 2003; Vandebrouck et al., 2013; Yamagata-Lynch, 2003b; Yamagata-Lynch et al., 2013). The studies which claim to combine these two methodologies are harder to find, however.

One dissertation mixed SNA and the subset of CHAT focusing on the community of practice in examining new teachers and their struggle during induction (Baker-Doyle,
2011). However, the SNA in this dissertation was not from a social networking platform like Twitter. Instead, the study examined 14 different networks of first-year teachers. All the networks in this study were small, personal networks created by face to face interactions of the participants, and the largest network had fewer than 30 vertices. The qualitative data were participant interviews viewed through the lens of community of practice. While the abstract mentions both SNA and CHAT, the mixed methods analysis is a different category of SNA for the quantitative, and a subset of CHAT as the lens for the qualitative.

Another article claimed to combine SNA on Twitter data from a conference and CHAT (Aramo-Immonen et al., 2015). This article searched on the #cmadfi tag, representing the Community Manager Appreciate Day celebration in Finland in 2014. This study analyzed the Twitter data using SNA; however, CHAT was not used to analyze or interpret the data. CHAT was used only to establish the importance of community and motivation for the analysis. The article did not analyze individual tweets using CHAT and instead used the lens as a background for understanding research on community building in groups of individuals.

A search in the Journal of Mixed Methods Research found only four articles published in any edition which used SNA. However only one used the analysis on data from a social networking platform. None of the four used CHAT in the qualitative analysis. Tashakkori and Teddlie (2010) mention social networking analysis software twice in the 893 pages of the Sage Handbook of Mixed Methods in Social and Behavioral Research, 2nd edition, but none of the chapters provides an example of SNA and CHAT. Finally, Creswell (2009) in an editorial which mapped the field of research in mixed
methods found no methods which used the two approaches. This paucity of research using the two approaches of SNA and CHAT in the mixed methods suggests the method outlined in this paper has a unique approach.

#Methodology Summary

This study used a parallel, convergent mixed methods design using two different data sources. The first source was the public tweets of the TMathC hashtag #TMC17. The second data source was the public blog posts linked from the TMathC 2017 blog archive. The first data source served as both quantitative and qualitative data, as it contained all the necessary information to use social network analysis as the quantitative method. The first source also contains the text of the tweets, which served as one part of the qualitative data. The second source for the qualitative analysis was the blog posts linked from the archive.

The analysis was accomplished in multiple passes, where the quantitative analysis informed the qualitative analysis, and the qualitative analysis informed a secondary quantitative analysis. This process was the mixing of the data necessary in a parallel, convergent design and facilitated the understanding of the activity of conference participation and communication patterns of TMathC 2017 to answer the third research question.
Chapter 4: Mixed Methods Analysis of the Network

This chapter is divided into three sections and contains an analysis of the data collected from the mathematics teacher conference TMathC in July 2017. Each section focuses on one of the research questions and answers each question in order. The first section is an analysis of the quantitative data using social networking analysis (SNA). The analysis of Twitter data will show the networking behavior of remote and attending participants in the network as individuals and as a collective network. The research question which will be answered in this section is, RQ1: What were the network behaviors of participants in TMathC in 2017?

The second section is the analysis using Engeström’s third generation Cultural-Historical Activity Theory as a framework to investigate the content of the tweets and blog posts of all participants. This framework was used to examine each tweet and blog post in the data set and identify the type of activity. This framework developed the complexity of conference attendance activity using the statements, questions, and reflections of the participants to answer the research question, RQ2: What was the human activity of conference participation of TMathC in 2017?

Finally, the third section of the analysis section is a mixing of the two previous types of analyses. This mixed methods section used the SNA analysis to create new comparisons in CHAT analysis that could not be observed previously. Likewise, the CHAT analysis was used to create a comparison in the SNA which could not be identified beforehand. This section answered the question, RQ3: How were the network behaviors and human activity of the participants of TMathC in 2017 interrelated?
The Quantitative Analysis via #SNA

The research question specific to the quantitative social network analysis is, RQ1: what were the network behaviors of participants in TMathC? To answer this question, data were collected from July 10, 2017, through August 31, 2017, using the hashtag search #TMC17. This search resulted in a data set which was composed of 1,319 unique vertices, 5,278 unique edges between vertices, and 8,270 duplicate edges for a total of 13,548 edges. Some of these vertices were organizations, such as the National Council of Teachers of Mathematics (NCTM) or Creative Commons but the majority were individuals with their personal, public accounts. A single tweet could have multiple edges if the sender of the tweet included multiple people; therefore, the number of unique edges is not representative of the number of tweets. Duplicated edges occur when a participant retweets someone else’s tweet, and the same tweet can be retweeted by different participants. The 8,270 duplicate edges indicated many retweets by multiple participants. The most retweeted tweet was by Bourassa, “‘Math is about relationships but kids think math is about numbers.’ -@MFAnnie #TMC17” which was retweeted by 77 additional different vertices. Because of the retweeting, this tweet was responsible for one unique edge, and 154 duplicate edges.

It is a common practice among users of Twitter to not include hashtags in replies or continuing conversation with other individuals (Bruns & Stieglitz, 2012, 2013; Sopan et al., 2012). Any data collection using a hashtag search will under-represent and under-count the actual activity, which means that in all cases, this analysis under-represents the actual number of tweets, edges, and activity of the participants of TMathC.
Using NodeXL to analyze the collected activity on the hashtag TMC17 yielded Figure 6.

*Figure 6: Graph of TMC17 full data set*

This graph shows 26 different clusters of participants, ranging in sizes of clusters from 356 at the largest to seven individual clusters of two participants each. As an overall graph of the activity, it shows that the conference Twitter network aligns with the definition offered by Smith et al. (2014) on (see page 27) as a “tight crowd,” where the participants were highly connected with each other, despite being in different clusters. Almost every cluster had many connecting edges between the different clusters.

Adding labels for the top 10 clusters by the number of participants and omitting the bottom 11 clusters from the graph shows the range of sizes of each cluster. A vertex is assigned to a unique cluster by NodeXL based on the frequency of edges to other
participants. Therefore, if a vertex is in cluster one, it is assigned that cluster because the vertex had more edges to other vertices also in that cluster.

Figure 7: Top ten clusters by size in TMC17

The exception is cluster 10, with 39 vertices, as it had no connections to any other cluster or vertex in the data set (see Figure 7). It was composed entirely of self-loops. A self-loop is a vertex sending a tweet mentioning no other vertex. An example of a tweet from this group said simply, “#TMC17 Have fun everyone! I hope to get back there sometime.” This tweet mentions no other vertex, and if there were any replies to this tweet, they did not use the hashtag #TMC17 to create further edges. Because the cluster was isolated and added no edges to other clusters, omitting it from the top 10 graphs and adding cluster 11 in its place is reasonable (Schaeffer, 2007). However, omitting the cluster from the graph does not remove the cluster from any other analysis. The NodeXL software creates a
common cluster for this type of vertices, however, it fails to meet a definition of a cluster, as any vertex in the cluster cannot connect to any other vertex in the data set (Schaeffer, 2007, p. 33). Cluster 10 did not add to the pattern of communication among the other clusters.

![Graph](image)

**Figure 8:** Top 11 clusters, omitting cluster 10

In Figure 8, Cluster 11 does have edges within (intra-cluster) and among other clusters (inter-cluster), which adds to the network. The remaining clusters, 12 through 26 had a total of 48 vertices, with the largest having six vertices total, and the bottom six clusters having two vertices each. Since those clusters were small omitting them from future graphs as well as cluster 10 will not change any understanding of the behaviors of the community (Ding, and, & Simon, 2001; Flake, Tarjan, & Tsioutsiouliklis, 2004; Schaeffer, 2007).
#SNA: Four #Types of Edges

Of the 1,319 vertices in the data set, some were attending, and some were remote participants. There were 189 participants listed in the TMathC public Twitter list as attending the conference, representing 16.7% of all participants (“TMathC Twitter list of 2017 attendees,” n.d.). These attending participants (AP) may have had different activity than the remote participants (RP) who were engaged in the community through Twitter. By identifying the attending participants and remote participants, the vertices and edges were further identified based on who originated the edge and who received the edge. In this identification, there are four distinct types of edges, listed in Table 2.

Table 2

Types and Number of Edges in #TMC17 Activity

<table>
<thead>
<tr>
<th>Types of edges</th>
<th>Total number of edges</th>
<th>Percent of edges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending to Attending</td>
<td>7591</td>
<td>56%</td>
</tr>
<tr>
<td>Remote to Remote</td>
<td>1620</td>
<td>12%</td>
</tr>
<tr>
<td>Remote to Attending</td>
<td>2778</td>
<td>21%</td>
</tr>
<tr>
<td>Attending to Remote</td>
<td>1559</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13548</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The attending to attending participants composed 56% of all edges, while 88% of the total edges included at least one vertex which attended the conference. Further examining the 88%, there were 32% which had an attending participant as only one half of the communication pair. The other half of the pair, whether initiating or receiving the tweet, was a remote participant. The remote participants were actively engaged with the
attending participants, with slightly more of the connections being of the remote to attending participant type.

The remote to remote participant communication was a small percentage of the overall edge activity, comprising only 12.0%, however by separating the four types of edges, it was observed that the remote participants in the conference communicated with each other in a manner similar to the network as a whole (see Figure 9).

![Figure 9: RPRP edges only in the TMathC network](image)

Figure 9 shows fewer edges among the clusters, but each cluster has edges running both intra- and inter-cluster. From this figure, it is determined that the remote participants of TMC17 engage with each other on related topics as the attending participants. Furthermore, in C1, C2, and C3, fan shapes occurred, which indicate that a remote participant served as a bridge to other remote participants. The implication is that one
remote participant shared content with a group of remote participants either together or separately, spreading the activity to more vertices.

In addition to remote participants communicating with other remote participants, the remote participants also communicated with attending participants. If the edges that show APRP and RPAP communication are added into the graph, the full engagement of remote participants with the conference is observed in Figure 10.

Figure 10: All RPRP, RPAP, APRP edges shown and APAP edges excluded

This graph shows the level of RPAP, APRP, and RPRP communication to be active during the period. By adding in the APAP communication in red in Figure 11, it is observed that the remote participant activity in the data set follows a similar pattern for both intra- and inter-cluster communication.
A prominent difference is the red APAP edges, typically flow to the center of the clusters, while the blue remote participant edges are distributed to the outside. From Table 2, the quantity of the four different edge types showed a difference in activity level, with the range between APAP to APRP being 6032. This wide variety of activity indicates that for the qualitative analysis, analyzing differences among the four types of activity may be necessary. Only through a qualitative analysis can the nature of the variety of activity be understood.

**#SNA: Intra and Inter Cluster #Edges**

Besides the four distinct types of edges based on participants, each cluster had both inter- and intra-edges. In examining the quantities of intra-cluster edges, the cluster
with the greatest number of participants was not the cluster with the most edges (see Table 3).

Table 3

*Intra-cluster edges for all clusters*

<table>
<thead>
<tr>
<th>Intra-cluster</th>
<th>Number of Edges</th>
<th>Number of Vertices</th>
<th>Ratio of Edges to Vertices</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 to C1</td>
<td>1701</td>
<td>356</td>
<td>4.78</td>
</tr>
<tr>
<td>C2 to C2</td>
<td>4899</td>
<td>328</td>
<td>14.94</td>
</tr>
<tr>
<td>C3 to C3</td>
<td>568</td>
<td>138</td>
<td>4.12</td>
</tr>
<tr>
<td>C4 to C4</td>
<td>255</td>
<td>95</td>
<td>2.68</td>
</tr>
<tr>
<td>C5 to C5</td>
<td>169</td>
<td>73</td>
<td>2.32</td>
</tr>
<tr>
<td>C6 to C6</td>
<td>137</td>
<td>59</td>
<td>2.32</td>
</tr>
<tr>
<td>C7 to C7</td>
<td>90</td>
<td>59</td>
<td>1.53</td>
</tr>
<tr>
<td>C8 to C8</td>
<td>127</td>
<td>51</td>
<td>2.49</td>
</tr>
<tr>
<td>C9 to C9</td>
<td>107</td>
<td>49</td>
<td>2.18</td>
</tr>
<tr>
<td>C10 to C10</td>
<td>45</td>
<td>39</td>
<td>1.15</td>
</tr>
<tr>
<td>C11 to C11</td>
<td>44</td>
<td>24</td>
<td>1.83</td>
</tr>
<tr>
<td>C12 to C12</td>
<td>5</td>
<td>6</td>
<td>0.83</td>
</tr>
<tr>
<td>C13 to C13</td>
<td>11</td>
<td>6</td>
<td>1.83</td>
</tr>
<tr>
<td>C14 to C14</td>
<td>25</td>
<td>5</td>
<td>5.00</td>
</tr>
<tr>
<td>C15 to C15</td>
<td>6</td>
<td>4</td>
<td>1.50</td>
</tr>
<tr>
<td>C16 to C16</td>
<td>3</td>
<td>4</td>
<td>0.75</td>
</tr>
<tr>
<td>C17 to C17</td>
<td>3</td>
<td>3</td>
<td>1.00</td>
</tr>
<tr>
<td>C18 to C18</td>
<td>2</td>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>C19 to C19</td>
<td>2</td>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>C20 to C20</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C21 to C21</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C22 to C22</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C23 to C23</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C24 to C24</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C25 to C25</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>C26 to C26</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Even though cluster 1 was the largest cluster in the number of vertices, it was not the most active cluster. Cluster 2 had almost three times as many edges as cluster 1, with a slightly smaller number of vertices. The number of intra-cluster edges typically also fell as the cluster size diminished, as seen in the ratio of edges to vertices in Table 3. From
the ratio calculation, there was more activity in the first three clusters than in the smaller clusters, although the ratio stayed relatively stable between approximately one and two. In addition, the inter-cluster communication for the largest clusters also differed. For example, cluster 2 sent 962 edges to cluster 1, while cluster 1 reciprocated with only 862 in response.

Table 4

*Inter-cluster edge count for largest 11 clusters*

<table>
<thead>
<tr>
<th>Sending Cluster</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C9</th>
<th>C10</th>
<th>C11</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1701</td>
<td>862</td>
<td>167</td>
<td>73</td>
<td>110</td>
<td>19</td>
<td>69</td>
<td>19</td>
<td>53</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>C2</td>
<td>962</td>
<td>4899</td>
<td>396</td>
<td>165</td>
<td>368</td>
<td>78</td>
<td>139</td>
<td>54</td>
<td>101</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C3</td>
<td>168</td>
<td>373</td>
<td>568</td>
<td>32</td>
<td>54</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C4</td>
<td>79</td>
<td>140</td>
<td>18</td>
<td>255</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>2</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C5</td>
<td>51</td>
<td>113</td>
<td>28</td>
<td>2</td>
<td>169</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C6</td>
<td>20</td>
<td>98</td>
<td>12</td>
<td>4</td>
<td>1</td>
<td>137</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C7</td>
<td>42</td>
<td>98</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>90</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C8</td>
<td>20</td>
<td>77</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>127</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C9</td>
<td>26</td>
<td>47</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>107</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>C11</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>44</td>
</tr>
</tbody>
</table>

The difference in edge direction for these clusters does indicate a different level of activity of the participants. Cluster two was more active in both inter and intra-cluster activity towards both cluster one and cluster three. That behavior was consistent for the other inter-cluster pairs as well, although not universally. For example, Cluster 6 to cluster two had 98 edges, but the reverse was only 78, and cluster eight to cluster two had 77, while the reverse was 54.
#SNA: #Content of the Clusters

The differences in activity among the clusters could be explained by the content of the tweets. The analysis software counted the hashtags present in every tweet and every cluster and reported the top 10 tags for each (see Table 5). The hashtag #TMC17 was excluded from the table because it was included in every tweet in the data set. A more detailed and thorough discussion of hashtags occurs later in the qualitative section of this study; however, the counts are relevant to the quantitative discussion.
### Table 5

**Top hashtags in cluster excluding tmc17**

<table>
<thead>
<tr>
<th>Cluster number</th>
<th>Total vertex count</th>
<th>Top 9 hashtags in cluster excluding tmc17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>356</td>
<td>mtbos descon17 sketchnote coachtmc pushsend mathchat tmcequity mathandell 1tmcthing</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>328</td>
<td>mtbos pushsend tmcequity talklessam 1tmcthing clotheslinemath tmcplans descon17 iteachmath</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>138</td>
<td>mtbos tmcequity iteachmath cheezyexeter pushsend descon17 statchat sketchnote fbf</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>95</td>
<td>mtbos elemmathchat descon17 pushsend smudgedmath tmcequity coachtmc mathchat mathart</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>73</td>
<td>mtbos tmcequity makeitreal iteachmath pushsend njed weelead satchat tmcjealousycamp</td>
</tr>
<tr>
<td>Cluster 6</td>
<td>59</td>
<td>movingmath mathyarns mathart mtbos mctmmath hyperbolic crochet scaleup lines</td>
</tr>
<tr>
<td>Cluster 7</td>
<td>59</td>
<td>talklessam iowamath mtbos sketchnote elemmathchat iteachmath tmc18 coachtmc pushsend</td>
</tr>
<tr>
<td>Cluster 8</td>
<td>51</td>
<td>mtbos iteachmath observe me tmc fakemathnews gcdsfaculty clotheslinemath descon17 sketchnoting</td>
</tr>
<tr>
<td>Cluster 9</td>
<td>49</td>
<td>mtbos trivianight connectingreps tmc16 tmcsavengerhunt rehearsalsareawesome 1tmcthing pushsend genderidentity</td>
</tr>
<tr>
<td>Cluster 10</td>
<td>39</td>
<td>mtbos tmcjealousycamp tmc15</td>
</tr>
<tr>
<td>Cluster 11</td>
<td>24</td>
<td>oer  tcrwp</td>
</tr>
<tr>
<td>Cluster 12</td>
<td>6</td>
<td>coachtmc</td>
</tr>
<tr>
<td>Cluster 13</td>
<td>6</td>
<td>mtbos</td>
</tr>
<tr>
<td>Cluster 14</td>
<td>5</td>
<td>wvctm</td>
</tr>
<tr>
<td>Cluster 15</td>
<td>4</td>
<td>mtbos</td>
</tr>
<tr>
<td>Cluster 16</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Cluster 17</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cluster 18</td>
<td>3</td>
<td>mtbos</td>
</tr>
<tr>
<td>Cluster 19</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cluster 20</td>
<td>2</td>
<td>tmcnyc17</td>
</tr>
<tr>
<td>Cluster 21</td>
<td>2</td>
<td>mtbos</td>
</tr>
<tr>
<td>Cluster 22</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cluster 23</td>
<td>2</td>
<td>stem</td>
</tr>
<tr>
<td>Cluster 24</td>
<td>2</td>
<td>tmcjealousycamp</td>
</tr>
<tr>
<td>Cluster 25</td>
<td>2</td>
<td>programmed</td>
</tr>
<tr>
<td>Cluster 26</td>
<td>2</td>
<td>mtbos tg2chat</td>
</tr>
</tbody>
</table>
Not every cluster in the data set had hashtags present, and with a cluster size below six vertices, it may have taken only one instance of using a hashtag to make it ‘top 9’ for the cluster. By counting the top hashtags in each cluster, there are some similarities which become apparent, for example, cluster 6 was almost exclusively devoted to the discussion of math art, with seven of the nine hashtags relating to the math art discussion. The only two which did not relate to math art was “#mtbos,” and “#mctmmath.” The #mtbos tag represents the acronym MathTwitterBlogO’Sphere, a hashtag used for the broader community, and #mctmmath is a regional math council affiliate tag. The fact that #mtbos was ranked fourth in this cluster but first in most of the others showed the frequency of math art conversations was high.

Cluster 2, the most active cluster, also included hashtags for two keynotes, “#pushsend” and “#tmcequity,” two morning sessions, “#talklessam” and “#clotheslinemath,” as well as the social connection tag, “#tmcplans.” The “#1tmcthing” hashtag was also used by both attending and remote participants to share the ‘one thing’ they were planning to implement after the conference was over. Compared to cluster 1, which had as its second most used hashtag “#descon17,” a conference which occurred prior to TMathC, and sketchnotes as its third most used hashtag, and the reason for a lower edge count is observed. The fact that the keynotes were fifth and seventh most used, while topics of “#coachmc,” “#sketchnote,” and “#mathchat” were ranked higher explains the lower activity. This cluster, although larger, was not engaged in the broader topics of the TMathC conference as much as it was engaged in topics relating to smaller groups of vertices.
The overlap between groups on topics ranging from #tmcequity (top five clusters) to #pushsend (clusters 1 through 5, 7 and 9) further reinforces the assignment of the tight crowd label as well. Each cluster had contributions from the attending and remote participants which crossed topics across cluster boundaries. While there may have been consistent usage of hashtags within clusters, few hashtags were exclusive to any one cluster.

#SNA: #Activity During the Day

The individuals who participated in TMathC did so at all hours but had times during the day when their activity was greater which matched the hours of the conference. In Figure 12, the tweets per hour are shown. The graph labels show the beginning of the hour, so a label of 6 AM with a bar below 200, indicates that between the hour of 6 AM and 6:59 AM there were less than 200 tweets during this time. A typical day at the conference started at 9:00 a.m. with the opening session each day, followed by morning sessions until 11:30 a.m. Lunch was ‘on your own’ from 11:30 a.m. to 1:00 p.m. each day, with the conference resuming at 1:00 p.m. and ending at 5:00 p.m. All times are in Eastern Time, the time zone of the conference.

Figure 12: Tweets by hour of the day (Eastern Time)
If the graph is divided into the morning and afternoon times to match the schedule, the highest count of tweets was from 8:00 to 8:59 a.m. and 12:00 to 12:59 p.m., coinciding with meal times. This indicates that having free time allowed participants to tweet outside of session times. The conference session of My Favorites occurred at 9:00 to 9:30 a.m. and 1:00 to 1:30 p.m., which also contributed to the second highest level of tweeting activity in the morning and afternoon. In both the morning and afternoon there were declines in the amount of tweeting once sessions were underway. While the largest activity in tweeting patterns is during the conference hours, the off-conference times, starting at 5 p.m. through 9 a.m. have activity. There was not a single hour where there was no tweeting activity.

**#SNA: #Individuals Tweeting Activity**

In examining the vertices’ activity, determining which vertices are most influential in the network produced different outcomes depending upon which measure of centrality was examined. For example, a simple way to determine a vertices activity is to count the number of edges the vertex initiated in the data set. Jruelbach produced the largest number of edges with 412 edges, but of these 412 edges, 108 of them were self-loops. Only counting edges will not be enough to determine the influence a vertex had on others in the network. It is for this reason that measures of centrality were developed as indicators for the influence a vertex has on a network.

One measure of centrality is the betweenness centrality, which is a measure of how central a vertex is to the graph. Recall that betweenness centrality is the total number of steps between every vertex in the network divided by the total of the number of connected vertices. Because of this definition large values of this measure of centrality
are possible. In this data set, the vertex with the greatest betweenness centrality was also jreulbach with a value of 215,883.1. The smallest betweenness centrality score was zero, which applied to 829 vertices. Only 420 or 31.8% of the vertices in the network had enough centrality to measure, which mirrors the finding above that a minority of the vertices contributed to most of the activity.

A betweenness centrality of 215,883.1 may be large or small, depending upon the network in which that number resides. If that vertex was removed, it would eliminate that number of shortest paths of sharing information. Since the betweenness centrality measure is relative to the network, comparing the ratio of measures explains the impact of the vertex on the network. This analysis used a model which separates the vertices with a 1-9-90 distribution of users where the 1% was the most active vertices, the next 9% of highly active vertices, and the remaining 90% of vertices (Bruns & Stieglitz, 2013; Tedjamulia, Dean, Olsen, & Albrecht, 2005). For this network, using the betweenness centrality as the ranking measurement, the 1% was the top 13 vertices, the next 9% was the next 119 vertices, followed by the 1,187 remaining vertices. Comparing the betweenness centrality within the top 1% in Table 6 by calculating the ratio of largest to smallest showed the relative roles each vertex had in networking with others.
Table 6

*Betweenness centrality and ratios of top 1% of vertices*

<table>
<thead>
<tr>
<th>Vertex</th>
<th>Betweenness centrality</th>
<th>Betweenness ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jreulbach</td>
<td>215,883.10</td>
<td>3.5</td>
</tr>
<tr>
<td>Mfannie</td>
<td>139,677.20</td>
<td>2.3</td>
</tr>
<tr>
<td>heather_kohn</td>
<td>86,266.30</td>
<td>1.4</td>
</tr>
<tr>
<td>Graceachsen</td>
<td>82,643.40</td>
<td>1.3</td>
</tr>
<tr>
<td>Gfletchy</td>
<td>77,538.30</td>
<td>1.3</td>
</tr>
<tr>
<td>Mathhombre</td>
<td>76,284.50</td>
<td>1.2</td>
</tr>
<tr>
<td>approx_normal</td>
<td>70,797.30</td>
<td>1.1</td>
</tr>
<tr>
<td>Davidkbutleruoa</td>
<td>70,564.80</td>
<td>1.1</td>
</tr>
<tr>
<td>Jgough</td>
<td>70,180.90</td>
<td>1.1</td>
</tr>
<tr>
<td>Marybourassa</td>
<td>67,656.10</td>
<td>1.1</td>
</tr>
<tr>
<td>Anniekerkins</td>
<td>66,189.20</td>
<td>1.1</td>
</tr>
<tr>
<td>Mrsjenisesexton</td>
<td>66,188.60</td>
<td>1.1</td>
</tr>
<tr>
<td>Desmos</td>
<td>61,985.70</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The ratio shows that the vertex jreulbach had 3.5 times the number of connections as the smallest of the top 1%, whereas all but the top two were less than 1.5 times the lowest.

Jreulbach was a vertex which communicated and passed through information to many vertices, far greater than any other vertex.

Using this ranking of the top 1% of the network also allows further comparisons to be made in Table 7.
Table 7

*Top 1% of vertices as measured by betweenness centrality*

<table>
<thead>
<tr>
<th>Vertex</th>
<th>Cluster</th>
<th>Betweenness centrality</th>
<th>In-Degree count</th>
<th>Out-Degree count</th>
<th>Reciprocated Vertex Pair Ratio</th>
<th>Self-loop count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jreulbach</td>
<td>1</td>
<td>215,883.1</td>
<td>198</td>
<td>99</td>
<td>0.23</td>
<td>108</td>
</tr>
<tr>
<td>Mfannie</td>
<td>4</td>
<td>139,677.2</td>
<td>161</td>
<td>54</td>
<td>0.19</td>
<td>6</td>
</tr>
<tr>
<td>heather_kohn</td>
<td>1</td>
<td>86,266.3</td>
<td>100</td>
<td>66</td>
<td>0.19</td>
<td>53</td>
</tr>
<tr>
<td>Graceachen</td>
<td>5</td>
<td>82,643.4</td>
<td>152</td>
<td>38</td>
<td>0.20</td>
<td>17</td>
</tr>
<tr>
<td>Gfletchy</td>
<td>7</td>
<td>77,538.3</td>
<td>149</td>
<td>17</td>
<td>0.06</td>
<td>1</td>
</tr>
<tr>
<td>Mathhombre</td>
<td>2</td>
<td>76,284.5</td>
<td>83</td>
<td>79</td>
<td>0.20</td>
<td>18</td>
</tr>
<tr>
<td>approx_normal</td>
<td>3</td>
<td>70,797.3</td>
<td>69</td>
<td>76</td>
<td>0.24</td>
<td>19</td>
</tr>
<tr>
<td>Davidkbutleruo</td>
<td>2</td>
<td>70,564.8</td>
<td>103</td>
<td>88</td>
<td>0.35</td>
<td>90</td>
</tr>
<tr>
<td>Jgough</td>
<td>1</td>
<td>70,180.9</td>
<td>110</td>
<td>48</td>
<td>0.14</td>
<td>3</td>
</tr>
<tr>
<td>Marybourassa</td>
<td>4</td>
<td>67,656.1</td>
<td>113</td>
<td>39</td>
<td>0.09</td>
<td>13</td>
</tr>
<tr>
<td>Anniekperkins</td>
<td>2</td>
<td>66,189.2</td>
<td>91</td>
<td>61</td>
<td>0.20</td>
<td>38</td>
</tr>
<tr>
<td>Mrsjenisesexton</td>
<td>1</td>
<td>66,188.6</td>
<td>86</td>
<td>31</td>
<td>0.17</td>
<td>32</td>
</tr>
<tr>
<td>Desmos</td>
<td>1</td>
<td>61,985.7</td>
<td>131</td>
<td>2</td>
<td>0.01</td>
<td>1</td>
</tr>
</tbody>
</table>

The top 1% of vertices in the network had a vertex with largest number of self-loops in the network, 108, which is surprising. Self-loops alone resulted in a betweenness centrality score of zero because they connected to no other vertices. This group also had the largest number of in-degree edges in the network at 198, as well as out-degree, 99. The in and out-degree counts indicate the direction of the edges, whether they point towards or away from the vertex. Not every vertex in this group had high numbers of either, however. In addition, the Reciprocated Vertex Pair Ratio described the vertices’ in and out-degree ratio after self-loops and retweets have been removed. The group had a wide range on this statistic as well. The activity of this group of vertices demonstrated that it was not the cluster or number of tweets received or sent which scored them a high
centrality score, but it was the frequency and with whom they exchanged tweets. This finding further reinforced the tight crowd designation observed above in Figure 2, because each of the top five clusters by size had at least one of the top 1% active vertices. There were many connections among the clusters through the activity of the vertices.

Since the calculated statistics did not clarify why these vertices had the highest betweenness centrality score, looking at other elements may do so. One aspect of the network statistics was the top words used in the tweets. NodeXL counted the instance of each word, hashtag, and vertex used by each vertex independently, and reported the most frequently used words by each vertex. This count did not distinguish between the use of hashtags, vertices, or words, however. For example, for the vertex jreulbach, the hashtags used repeatedly were tmc17 and mtbos, while the vertices were hpicciotto and samjshah and the words were love, 3, math, its, and thank. Collecting these top words used allowed for patterns to emerge (see Table 8).
### Table 8

**Top words in tweet by count by top 1% of participants**

<table>
<thead>
<tr>
<th>Vertex</th>
<th>Cluster</th>
<th>Top Words in Tweet by Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jreulbach</td>
<td>1</td>
<td>tmc17 mtbos hpicciotto love 3 samjshah math its thank</td>
</tr>
<tr>
<td>Mfannie</td>
<td>4</td>
<td>tmc17 descon17 gwaddellnvhs session geonz mathillustrated hey see ethan_midpen folks</td>
</tr>
<tr>
<td>heather_kohn</td>
<td>1</td>
<td>tmc17 coachtmc session need mathprojects clotheslinemath mtbos math great calculus</td>
</tr>
<tr>
<td>Graceachchen</td>
<td>5</td>
<td>tmc17 graceachchen tell talk out 2 yes brettegarner math keynote</td>
</tr>
<tr>
<td>Gfletchy</td>
<td>7</td>
<td>tmc17 5 much k more math sharing desmos mathgeek76 mtbos</td>
</tr>
<tr>
<td>Mathhombre</td>
<td>2</td>
<td>tmc17 math tmcequity mtbos jschwartz10a need gfletchy session out teachers</td>
</tr>
<tr>
<td>approx_normal</td>
<td>3</td>
<td>tmc17 graceachchen cheesemonkeysf out great session jreulbach more here math</td>
</tr>
<tr>
<td>Davidkbutleruoa</td>
<td>2</td>
<td>tmc17 mathyarns session travel crochet mathinyourfeet out teachbarefoot being thank</td>
</tr>
<tr>
<td>Jgough</td>
<td>1</td>
<td>tmc17 sharing sketchnote day cheesemonkeysf descon17 graceachchen session lessons desmos</td>
</tr>
<tr>
<td>Marybourassa</td>
<td>4</td>
<td>tmc17 thanks math mtbos sheriwalker72 pamjwilson samjshah calcdave part tmathc</td>
</tr>
<tr>
<td>Anniekperkins</td>
<td>2</td>
<td>tmc17 graceachchen mtbos up justinaion math curvahedra hyperdodecahedron 5 hey</td>
</tr>
<tr>
<td>Mrsjenisesexton</td>
<td>1</td>
<td>tmc17 tmcequity math gfletchy mathhombre equity love more dingleteach one</td>
</tr>
<tr>
<td>Desmos</td>
<td>1</td>
<td>descon17 tmc17 jgough sharing sketchnote desmos pre conference opening excited</td>
</tr>
</tbody>
</table>

In Table 8, other vertices were frequently mentioned and used in the tweets. Mentioning other vertices increased the number of edges for each tweet, which in turn increased the likelihood of a reply.

Another element of this activity is the use of descriptive hashtags and words. For example, davidkbutleruoa used the hashtags “#tmc17” and “#mathyarns,” as well as
included the vertices “#mathinyourfeet” and teachbarefoot regularly in their tweets. By also including the words session, travel, crochet, and thank the perception of his tweets as having elements of travel, sessions on creating items, and being grateful were observed. This practice of using descriptive words such as math, curvahedra, and sharing showed a clear focus of their communication. Further, using words with connotations of inclusiveness such as equity, love, and thank created an overall group language which could encourage others to engage with the author. This practice should be followed up in the qualitative analysis to determine if it was only the 1% group, the 9% group, or other clusters which participated in this language structure.

#SNA: Answering Research Question One

The research question posed in this section was, RQ1: What were the network behaviors of participants in TMathC in 2017? The remote and attending participants in TMathC in 2017 created a tight crowd network of 26 different clusters. Not all clusters participated in the tight crowd. For example, cluster 10 was composed of 39 participants who had no edges with any other participant in the network. The largest three clusters contained 822 attending and remote participants, which accounted for 62% of the overall network activity. The smallest 15 clusters contained 49 attending or remote participants combined and ranged in size from six to two members. The clusters were identified through the edges between the vertices, or participants, and ended up having common hashtags. For example, cluster 6, with 59 participants, engaged in conversations related to the #movingmath and #mathyarns hashtags. This cluster communicated with each other about math art with a high enough frequency to create a cluster, however, they were not
isolated in the network. This cluster had many connections with other clusters, which is indicative of a tight crowd designation.

The only difference uncovered in the activity of attending or remote participants was frequency. The attending and remote participants were distributed across the clusters and exhibited similar tight crowd engagement. The correspondence of activity suggests the remote participants were engaged in related topics as the attending participants. The remote participants also engaged with attending participants, other remote participants, and the attending participants engaged back to the remote participants in large numbers. The frequency of all three types of edges which contained remote attendees implied they were welcomed into the network with few barriers other than space and time.

The network was also active at all hours of the day and night, with a bimodal distribution of tweets centered around the hours before the conference started at 9:00 am and restarted after lunch at 1:00 pm. This indicates the attending participants used the breakfast and lunch social time to increase their tweeting activity. The activity decreased steadily during the morning sessions and afternoon sessions. The decreasing activity could suggest that as attending participants became engaged in the session content; they tweeted with less frequency.

The individual participants’ network behaviors mirrored the network as a whole. The top 1% of the network, as defined by their betweenness centrality scores, were found in clusters 1, 2, 3, 4, 5, and 7. Five of the 13 participants in the 1% were located in cluster 1, which positioned them centrally in the network, and the remaining eight participants were spread through the listed clusters. These participants were not all high-frequency tweeters, nor high-frequency receivers of tweets. The 1% was a group whose network
activity did not share a common set of behaviors except for their attending participant status and relatively large betweenness centrality. They were active participants but spread out among the network. The 9% and 90% groups of participants had similar patterns of networking as the 1%. The similarities among the groups were the most important feature of the comparison. To summarize, the networking behaviors of all participants in TMathC 2017 exhibited a tight crowd pattern, showed patterns which indicated remote participants were welcomed and engaged and were most active during time periods when conference activity was lower.

**The Qualitative Analysis via #CHAT**

The research question related to the qualitative analysis in this study was: RQ2: What was the human activity of conference participation of TMathC in 2017? This analysis will answer that question. The data set for this analysis was composed of 4,844 unique tweets and 126 blog posts. Each of the tweets contained #tmc17, but there were many tweets in threads or conversations which did not contain the hashtag. Those tweets not containing the hashtag were ignored for the purpose of this study because the Twitter search function could not find them. The blog posts were linked from the TMathC.com website and were copied into documents two months after the conference ended.

In answering the question, what was the human activity of conference participation of TMathC in 2017, the framework of Engeström’s third generation of Cultural-Historical Activity Theory (CHAT) was used. This theory has seven structural elements found in Figure 13.
Figure 13: Engeström's third-generation model of CHAT

The complex structure of human activity can be decomposed into individual elements and then reconstructed to understand how humans engage and learn by using this model. One additional component of the theory that is not pictured in the diagram is the idea of ‘tensions.’ Tension is a description for a function in the examined activity which leads subjects to be in their Zone of Proximal Development (ZPD) (Engeström, 2015; Vygotsky, 1981; Vygotsky, Hanfmann, & Vakar, 1962). With the addition of possible tensions, a CHAT analysis of the data must examine seven elements and the tensions which may create opportunities for learning.

For the purpose of analyzing the TmathC data, the relabeled elements of the diagram are found in Figure 14.
In the analysis of the TMathC data, each of the seven elements of the triangle was examined independently, as well as the tension or tensions which promote learning. There was no predetermined order to the analysis found in the literature.

Because there is no predetermined order to the analysis, the order used is the participants first, then how the participants divided the labor of the conference, the tools they used, and followed by the rules. These elements lead into the community, and finally the object and outcome of the conference, followed by a discussion of the tensions found which promote learning. This order allowed the analysis to focus on the participants first, followed by the community, and finally the overarching tensions which facilitated learning.

*Figure 14: Elements of CHAT for TMathC*
#CHAT #Participants of TMathC17

There were two groups of participants found to be active in TMathC17. The first group was participants who were attending the conference in person, referred to as attending participants. The second group was participants attending remotely through Twitter, referred to as remote participants. The use of the term ‘participant’ without a modifier will mean the person has membership in any one of these groups. Among the remote participants, there was a small sub-group who had a unique practice where they used the conference hashtag but did not engage with other participants. These participants tried to use the hashtag to pull participants into their separate conversations. Since this group was small but influential enough to create their own cluster, as will be seen later in the mixing of the data, it is worth discussing them first.

#CHAT #Participants: Leveraging Participants

This group of participants, the leveragers, were the smallest group in number with six participants, but they had a consistent practice. They used the #TMC17 hashtag to gain the attention of the attending and remote participants, gave their message about the mathematics curricula or professional development they were advertising, and they provided a link for more information. One particular vertex, Vertex A in Table 9, was so active in this behavior they were the central vertex in cluster 11 the network maps in Figures 8 through 11 above. Their tweeting behavior was to include the #TMC17 hashtag, a link, and a message for the attending or remote participant. None of those
included individuals engaged with the other participants in TMathC. However, by including them in the original tweet, they also became part of the participant pool of TMathC when downloading data.

Table 9

*Leveraging participant tweet practices*

<table>
<thead>
<tr>
<th>Leveraging Participant</th>
<th>Tweet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertex A</td>
<td>Miss Standards author Bill McCallum on coherence + his new #OER math curriculum? Catch it here: <a href="http://buff.ly/2uzLvbd">http://buff.ly/2uzLvbd</a></td>
</tr>
<tr>
<td>Vertex A</td>
<td>Episodes feat. @wgmccallum, Malcolm Swan and @jamesgrime now available at <a href="https://t.co/wNXuuoeNOu">https://t.co/wNXuuoeNOu</a> &amp; <a href="https://t.co/reUvO4mA78">https://t.co/reUvO4mA78</a> #MTBoS #tmc17</td>
</tr>
<tr>
<td>Vertex B</td>
<td>Not able to attend #TMC17? Interested in learning more about instructional routines? Check this out: <a href="https://t.co/ybiHw2Lvoe">https://t.co/ybiHw2Lvoe</a> #CthenC</td>
</tr>
<tr>
<td>Vertex C</td>
<td>Are you at #TMCJealousyCamp and looking for an alternative? Maybe learning about an instructional routine? <a href="https://t.co/ybiHw2Lvoe">https://t.co/ybiHw2Lvoe</a> #tmc17</td>
</tr>
<tr>
<td>Vertex D</td>
<td>DO NOT MISS THIS! This could be the best summer math PD you get! <a href="http://buildmathminds.com/virtual-math-summit/">http://buildmathminds.com/virtual-math-summit/</a> … #MakeItReal #MTBoS #TMC17 #mathchat #elemmathchat</td>
</tr>
<tr>
<td>Vertex E</td>
<td>All attendees at #tmc17 check out @watertankmath to help ur Ss w/ their + and - especially w/ those negative integers! #math #mtbos #txed</td>
</tr>
<tr>
<td>Vertex F</td>
<td>We'd love for some secondary math teachers to help us pilot a short, anonymous survey! <a href="https://t.co/81fLi4x9Vq">https://t.co/81fLi4x9Vq</a> #MTBoS #TMC17</td>
</tr>
</tbody>
</table>

Vertices B, C, and D were targeting the remote participant of TMathC to see if they could engage some of them in a different conference or professional development activity. The use of the hashtag #TMCJealousyCamp identified individuals who were not attending with humor, but still following TMathC. Finally, Vertices E and F were offering a product or asking for opinions. These participants were using the popularity of the
hashtag to attempt to sell their product or pass along their message to possibly interested parties.

#CHAT #Participants: Remote Participants

The remote participant engaged with the entire TMathC participant pool in diverse ways. A common behavior was ‘jealousycamp,’ where participants expressed their emotions at not attending. These tweets ranged from the sad, “Sad news for me... no #TMC17 for this mama. I'll miss you all so much! (And the learning opportunities too!)” to the humorous, “Game on #tmc17! WE the #TMCjealousycamp will be with you for 3 days in our pyjamas [sic] !!” and ended in the excited registers, “When oh when am I going to be lucky enough to attend this!! #mtbos #tmc17.” This group freely used the hashtag TMCjealousycamp to express their feelings at not attending. The use of the tag did not keep them from exhibiting other behaviors, for example, the vertex who tweeted the ‘sad news for me’ also later tweeted, “If you’re in the morning Exeter math session at #tmc17, feel free to tweet me about any Math 2 stuff.” The use simply communicated in a short number of characters the emotion that they were not present and wished they could have been.

Another behavior in which the remote participants engaged was they followed threads of hashtags or conversation. These remote participants made mention that they were not at the conference and encouraged attending participants to continue to tweet. Complex statements such as, “Ok really wish I was at #tmc17 now. #CoachTMC looks
like an amazing session. Keep tweeting! I'm stalking hardcore!! #tmcjealousycamp.”

Other remote participants were more direct in their request, “Thanks to everyone sharing from #tmc17, getting lots of great ideas!” These statements encouraged the attending participant to tweet content ideas out to the remote participant. The first statement is sophisticated because it made personal statements about the remote participant’s emotional state, identified a particular strand of conversation, the CoachTMC sessions, and encouraged the attending participants to continue their communication behavior. The second example of general encouragement was more common among this group.

Some remote participants asked questions such as “Total FOMO going on right now. Can someone tell me what is #tmc17?” These remote participants had the ‘Fear of Missing Out’ on math conversations and asked for more information. The individuals who responded fell into both the remote and attending participant groups. There was also one example of a remote participant who has made a practice out of being a remote participant at multiple years of TMathC, “New to the math twitter world? #tmc17 stands for Twitter Math Camp. I have never been but it's my 3rd year following the tweets. Join me!” This remote participant was communicating more with other remote participants, educating them on the acronym use, and inviting them also to become remote participants. This type of behavior was also observed in tweets such as, “I love seeing math teachers getting together to raise their math game. Have a great #tmc17 everyone who's lucky enough to be there.” The tweet’s first sentence creates interest for anyone who is a math teacher, regardless of their awareness of the hashtag or conference. Invitations like these possibly attract additional remote participants during the conference.
The final general activity of remote participants was engaging, which had a wide range. Some remote participants asked questions of participants, “Are the wiki and other materials available for those of use not lucky enough to be at #tmc17?” Other remote participants reminded the attending participants that the TMaThC attendance list is small, “I look forward to seeing @graceachen's keynote. Please understand most #mtbos and most math teachers are not at #tmc17.” This behavior was a constant reminder to share resources, links, and slides to the larger participant pool. In most cases, the focus of the remote participant was on learning and resource gathering, “Any chance posts will be accessible to #MTBoS? I couldn't go to #TMC17 this year but dying to learn new stuff.” These remote participants saw the value in the information presented at TMaThC and leveraged the sharing of resources to their benefit.

A second aspect of the engaging activity was sharing back to the attending participant. One remote participant tweeted with a morning session regularly, including on the first day saying, “If you’re in the morning Exeter math session at #tmc17, feel free to tweet me about any Math 2 stuff.” This same remote participant said later, “Yes!!! I’m around if folks want to tweet about Math2! <3 #TMC17.” The back and forth engagement occurred in more than one session throughout the conference. The remote participants' participation ranged from the passive, ‘wish I was there’ to the highly active ‘asking and answering questions.’ While remote participants may not have had the same activity level of conversation as attending participants, there was an amount of conversation which facilitated learning.
#CHAT #Participants: Attending Participants

Attending participants had the widest types of communication activity. The attending participants communication included social or humorous tweets before and during the conference, “I heard @[deletedname] was doing a morning session on waffle fractions #tmc17.” Waffle House as a reoccurring theme was common because of the proximity of a location to the conference hotel. More generic social tweets were similar to, “Any plans for dinner? #tmc17 my roomie @[namedeleted] is here, too.” Food and social sharing played a role before the conference started, during the afternoons when sessions were over, and after the conference ended. These included sharing self-photos with or without other attending participants. Many of these tweets included dining photos, where large numbers of attending participants dined together. In addition, there were 184 tweets about attending participants traveling to or from the conference. These travel tweets frequently included self-photos of the attending participant in front of signs, or landmarks, or photos of scenery. The final social or humorous type of tweeting pattern was the tweeting of memes, funny videos, or photos, which occurred 192 times.

Another activity found in the tweeting patterns of the attending participants was the sharing of resources or content. This sharing included quotes from keynotes or session leaders which communicated both math content and the participants’ enthusiasm, “‘Using math to solve problems instead of problems to learn math.’ Wow! @classroomchef #tmc17.” Other tweets were focused on sharing of content through
photos of slide presentations or session notes, or links from the session, “‘As the step changes, ______ changes” #tmc17 [linked photo]” where a photo linked from the tweet explained the text. In this tweet ‘As the step changes, _____ changes,’ the photo of a linear representation of a problem encouraged the reader to think about how to reframe their questioning strategies to create classroom conversation. This behavior was more common than sharing of self-photos. The attending participants shared 508 photos of content and 622 links to websites, compared to 411 tweets which contained self-photos with no mathematical content. Many tweets included both a link and photo, or a quote and a photo which made the tweet information dense. This practice also created tweets which had overlapping codes. This overlap was not present in the social tweets but was common in the content tweets. Similarly, in the blog posts, which were all written by attending participants, they included both social and content sharing. Further examples of the attending participant tweets will be developed in the next sections.

#CHAT #DivOfLabor: Keynotes, Sessions, My Favorites, and Social Events

In the division of labor at TMC17, there were four distinct types of events or work in which the attending participants engaged. These are ordered by the number of individuals leading each of the categories. Keynotes and sessions are common types of conference activities. Keynotes are a presentation by a single person to a large audience, whereas sessions are smaller and focus on specific topics. My Favorites were a unique type of mini-presentation, which occurred in the morning, before the afternoon keynotes,
and on Sunday morning. The My Favorite sessions were prepared on a topic of the presenters’ favorite classroom practice but were not scheduled until the conference was underway and lasted for no more than 10 minutes. Finally, there were social events, which included a first-timer’s dinner, a trivia, and a game night each on a separate evening.

#CHAT #DivOfLabor #Keynote1 - Equity

There were three keynotes at TMC17. The first was by Grace Chen, who shared an equity focused keynote entitled “The politics (?) of mathematics teaching.” This keynote was centered on the histories of Grace and her family as immigrants to the United States. The tweets from attending participants during the keynote communicated essential elements to remote participants and followed both the pacing and story of the presentation. Starting with, “‘Is teaching necessarily political?’ @gracechen answering yes. #tmc17” Tweets like this set the tone for the rest of the hour talk. Many other people tweeted a version of the same question. Some of the other tweets were factual, “Is teaching necessarily political? -@gracechen #TMC17.” Other tweets were more enthusiastic and added content to the message, “Word up, @gracechen! “Teaching is *necessarily* political. Paulo Freire would love this. #tmc17”

During the hour of the keynote, the attending participants tweeted quotes from Grace and images from the screen, with each message tweeted and retweeted by multiple people. In addition, there were tweets such as, “Thank you for all your honesty and
vulnerability to share your family’s story @graceachen. #tmc17.” The attending participants were adding personal contexts while the keynote was occurring. This included not just feelings, but also connections they were making, “@graceachen speaking brutal, important truths about politics inherent in education. The parallels b/w Taiwan & Southern Rural US! #tmc17.”

Finally, the attending participants also tweeted plans and ideas for changing practices based upon the keynote, “Incredibly compelling keynote @graceachen at #tmc17. But what can I do? I think I can start by allowing my Ss to tell their stories.” The Twitter shorthand ‘Ss’ was used to contract the word ‘students.’ The person tweeting this had moved beyond thinking of their feelings about the keynote, into the realm of finding ways to put the ideas into practice in their classroom.

The Twitter feed during this keynote gave any remote participants a reasonable understanding of the keynote, and the many blog post descriptions gave a complete picture of the presentation. Whereas the Twitter feed captured individual quotes and ideas. The presenter, later, offered a stronger understanding to all participants with respect to her keynote through a blog post with video and text.

#CHAT #DivOfLabor #Keynote2 – Learning From Each Other

The second keynote was by Graham Fletcher, an elementary school educator, with a title of, “All I really need to know I learned from the MTBoS…Not really, but close.” The acronym MTBoS stands for the Math Twitter Blog o’Sphere and was a
common hashtag throughout the conference. This hashtag was intended to identify a community which exists online. This keynote was different, as it combined mathematics with humor, “.@gfletchy hilariously point out the flaws in cookie cutter problem-solving strategies. #TMC17” What he actually said about cookie cutter problem-solving strategies was not tweeted, just that it was funny, and the strategies had flaws.

The audience was also asked to be actively involved in the presentation, “.@gfletchy Making us get out actual paper and pencil? #TMC17.” The participants were asked to do mathematics, but again, the problems were not tweeted. There were quotes from Graham’s keynote which were tweeted. “‘Elementary school teachers consider themselves generalists, but if you teach math then you are a math teacher.’ @gfletchy #tmc17.” Centering all teachers as mathematics teachers led to the quote, “Surround yourself with people smarter than you, outside your circle, people that will push you to adapt and not stay static @gfletchy #tmc17.” One message of Graham’s keynote was to find those who can create and inspire growth. A second message, which connected to Grace’s keynote was, “‘Vulnerability is the birthplace of professional growth.’ Is this a hurdle to getting elementary Ts to a math conference? @glfetchy #TMC17.”

While there were fewer quotes of Graham repeated by the attendees on Twitter, the messaging still allowed remote participants to understand the message of the presenter. There were also fewer tweets in general during Graham’s keynote, which can be explained by the fact that many participants were engaged in doing math instead of tweeting. The active components of the keynote took the place of using electronic devices. Graham did not blog about the keynote, but videos were linked on the blog
archive page, which, again, provided remote participants a way to watch the keynote after the fact.

#CHAT #DivOfLabor #Keynote3 – Push Send

The third keynote was by Carl Oliver, who presented on, “Hitting the darn ‘send’ button.” The message from Carl was not to allow fears and self-doubt to get in the way of asking for help, offering help, or sharing of resources or ideas. Carl also did something different during his presentation, which was to start the hashtag of “#pushsend” specifically for his keynote. Carl also structured the keynote after a Twitter chat, where the chat leader posts a question with a “Q1” and the participants reply with “A1” as an organizational system. Carl invited Twitter participation in the keynote.

The first question was, “#PushSend #Q1 Think of a time when you shared and something good happened #TMC17.” The variety of responses showed the elevated level of engagement of the participants outside of the conference, “Shared a lesson idea and got lots of helpful feedback from the #MTBoS! #Q1 #pushsend #TMC17.” Some responses took the idea of other people and pushed to the idea of community, “#Q1 #pushsend Helping me find this amazing community #tmc17.” This idea of community was communicated in other ways as well, “Shared my love of the #MTBoS with teachers at @MathforAmerica and they grabbed so many materials #pushsend #Q1 #TMC17.” Other typical responses were about personal relationships created over Twitter, “A1:
Whatever it was I tweeted that connected me to @JustinAion aka my twitter twin #q1 #pushsend #tmc17.”

The second question was “Q2 Why is it so hard to #pushsend?” The responses to this question had related trends. One trend was the learning curve of the technology, “#Q2 #PushSend I still struggle with the language & use of the language #tmc17 @carlolitwitter.” Another trend was navigating the technology for professional use, “#Q2 #pushsend Still navigating pushing boundaries of ‘professionalism’ on Twitter… #tmc17.” These two trends demonstrated some participants were engaged in the process of learning or adapting the technology to their own practices. The barriers to adopting technology as a mediating practice were at least twofold. Learning the vocabulary, practice, and method of communication was a barrier, as well as learning how to fit those elements into their professional life. Other trends were more personal, such as the time required or the fear of being public.

The time required to use the technology was an additional barrier. One participant clarified this barrier clearly, “time… there isn’t enough time… for all or some of it. blogging, keeping up with twitter, etc. #Q2 #pushsend #tmc17.” The barrier of time was one theme which resonated with multiple participants, in multiple ways. Using Twitter was not always the focus, however. The practice of blogging and sharing of lessons or classroom practices also takes time, “Also, not enough time. I have so many ideas I want to blog, but I have a full-time job and a full time family. #Q2 #MTBoS #TMC17.”

The final trend which came out of the question, ‘what keeps you from pushing send’ was a personal vulnerability. There were several different threads of vulnerability which occurred during the keynote. One was the lack of anonymity which occurs when a
participant publishes their ideas, “Q2: not being able to be anonymous anymore. #pushsend #TMC17.” This participant did not explain why they wished to remain anonymous. The reasons could be personal or professional for that single participant. Other participants were clearer in their reasons for remaining anonymous, “my biggest barrier to blogging regularly is anonymity & the fear of putting my job in jeopardy for telling hard truths #Q2 #pushsend #tmc17.”

In addition to the fear of being public, is a fear of not being ‘good enough’ to be public, “As a first year teacher, I struggle with thinking I have anything valuable to contribute to people who know more #Q2 #pushsend #tmc17.” This participant expressed their fear of not knowing enough to contribute, but this fear was not limited to only early career teachers. This theme was repeated by many, in different ways, “It’s intimidating. I’m afraid it’s not good enough. I’m not a great writer. #Q2 #pushsend #MTBoS #TMC17.” Other participants shared their fear, and expressed ways they overcame it, “#PushSend Q2: Thinking that no one will care what I have to say but then just deciding to blog for myself #TMC17.” What all these participants had in common was the idea that in order to engage in the practice of #pushsend they had to become aware of a vulnerability they had. Several participants framed their response to the original question in that way, “#Q2 #pushsend Overcame barrier of sharing vulnerability… ‘am I good enough? Help me be better.’ #tmc17.”

The final two questions of the keynote had an agreement in the responses. The third question was, “What are the benefits that occur when you #PushSend?” The responses to this question were similar across all participants. The answer to the third question about benefits was to mention resources, support, or assistance the participant
received, or, about self-improvement, “#Q3 #pushsend #tmc17 @carlolitwitter We only expand and improve our world by connecting to others.” The message of improvement, whether personal or classroom focused, was the consistent response by the participants.

The responses to the final question, “How can we encourage others to #PushSend?” had similar statements, which centered on the idea of connecting ‘new’ users or individuals with low follower counts with more experienced users, “#q4 #pushsend @carlolitwitter #tmc17 connect a veteran to a newbie as a follower/message/commenter; frequent Intro Chats; use multiple #’s.” This participant packed many different ideas into one tweet. Other tweets on this question mirrored some or all the suggestions. Connecting people with other people was the dominant theme to come out of the question.

While the keynotes gathered a sizable proportion of tweets because the attending participant pool was present for all of them, the keynotes also were blogged in reflective posts. A representative post on the third keynote summarized the presentation and reflection afterward.

The final keynote came next, which was given by Carl Oliver and basically asked us to be brave and vulnerable and to just push send on our blog posts and tweets. There was also some fascinating analysis of when various people first used the hashtag #MTBoS. This made me reflect on what it was that brought me into the #MTBoS and I went trawling through my old twitter to see how I had thought about it at the time. It was most interesting to reflect on my persistence with the #MTBoS despite varying levels of engagement at the beginning.

Not all the blog posts mentioned the keynotes. While the blog posts featured photos, quotations, and references to all three keynotes, only twelve of the 126 blog posts
discussed the keynotes. What the blog posts discussed more frequently were morning and afternoon sessions.

#CHAT #DivOfLabor: Morning and Afternoon Sessions

On the program, there were 75 sessions listed. Thirteen were morning sessions, and the remaining 62 were afternoon sessions. This distinction is vital because the morning sessions had a unique characteristic that the same participants worked together for two hours each morning for three days. The afternoon sessions were traditional sessions, of either an hour or half an hour each day, on Thursday, Friday, and Saturday. A full list of all sessions can be found in Appendix 2.

The thirteen morning sessions included a group of participants creating math art by crocheting hyperbolic geometric shapes, another group discussing the intersection of equity and the Common Core mathematics standards, and two different sessions which used the Exeter Mathematics curriculum in separate ways. The number of tweets and blog posts on the morning sessions was large. One participant blogged about the art session, “I also love that there was so much art getting passed around. People were showing off crochet and sculpture and patterns they’d discovered and it was just excellent.” Many the tweets about the morning sessions included photos of work at a whiteboard or photos of notebooks, such as the tweet about Clothes Line math, “Group starting to place then space fractions on the number line #clotheslinemath @MathProjects
#tmc17 [linked image].” These tweets and blog posts clearly communicated the energy and the mathematical activities in the sessions.

The variety found in the 62 afternoon sessions was large, with several elementary and secondary content topics, sessions on pedagogy, questioning, lesson ideas or construction, and teacher leadership and advocacy. In the afternoon sessions, it was less frequent to have a dedicated hashtag, so searching for content became more difficult.

Some participants referenced the title, “In our ‘Teacher as activist’ session with [name deleted], this is a legit privilege of math that we can leverage to help others! #tmc17 [link to tweet].” Others shared the resources from their own session, “Here is the resource from my session on strategies to transform problems from Rote to Rich #TMC17 [link].” Other tweets were vague enough not to be readily identifiable to any particular session, “The def’ns of math we are discussing are fascinating. Do parents impose it? What appears naturally? Do parents have that language? #TMC17.”

In addition to the lack of afternoon hashtags, there was also no record of who or how many attended each morning or afternoon session. The only record was tweets which referenced the sessions, the blog posts on the site archive, and information uploaded to the conference wiki site. An index of the conference wiki site can be found in Appendix 3.

The last session time slot on Saturday was reserved for “Flex Sessions” which were sessions with no presenter or topic on the schedule. The flex sessions were announced Saturday at lunch and were created by participants suggesting topics or leaders for a session. Some of the sessions were a repeat of topics from a morning session or other session. Other flex sessions were created by recruiting someone to offer and
facilitate a session. Sunday had no sessions or keynotes and was composed entirely of the My Favorites.

#CHAT #DivOfLabor: My Favorites

My Favorites were another feature of TMathC. My Favorites were offered Thursday afternoon, twice each day Friday and Saturday, once in the morning before morning sessions, and once in the afternoon before the keynotes, and on Sunday morning. Each time slot for the My Favorites was thirty minutes long except for Sunday which was two hours long. Each participant presented for five to ten minutes to the collected audience of attending participants on something they considered to be their ‘Favorite’ topic. This was the only requirement for the presentation. The presentations could be on the presenters’ favorite classroom activity, practice, or any other topic the presenter chose to share. One attending participant described these sessions in a blog post as, “great little 5 minute presentations anyone can present about some super cool tool or aspect of their teaching, and they’re great, but not all that unusual—they’re a staple of edCamp.”

The variety of topics presented during the My Favorites was large. Classroom engagement or other strategies were typical. These ranged from one participant’s “Two Nice Things,” where anytime someone in her classroom said anything negative about another learner, the original speaker had to say two nice things about the person, to the “Math Joy Bell,” where anytime anyone in the classroom felt a moment of joy, they
quietly went up and rang the bell. These presentations were about the large or small practices the participants created for their classrooms.

Other presentations were about broader topics. One topic was about how a teacher travels to Africa each summer to teach math, and how that experience influenced her classroom practice. Other My Favorite presentations were on technology use, technology distractions, or reframing the language used in a classroom with respect to failing learners. The variety of topics presented during these periods was remarkably diverse.

The participants giving My Favorites were all attending participants, however one remote participant tweeted, “Can people do ‘My Favourites” via Google Hangout? Asking for a friend. #tmc17 #tmc17jealousycamp.” Not all the presenters of My Favorites were experienced attendees. Many of the My Favorite presenters were first-time attendees, who presented to the entire group their favorite thing. This practice of My Favorites allowed all attending participants the ability to become presenters, with the same audience as the keynotes.

#CHAT #DivOfLabor: Social Events

The final element to the division of labor were the social events on the TMathC calendar. These included “Speed Dating” on Thursday evening, followed by the first-timer’s dinner, a trivia contest on Friday night, and game night on Saturday. The Speed Dating event was a 45-minute long session where all attending participants were invited to the large presentation room and were divided by categories sequentially such as
regions where they live, grade levels taught, favorite shoe style, or preferred vacation.

The goal was to encourage attending participants to meet other people they have not met before through multiple rotations of mixing the groups. These social events were written about in blog posts and were tweeted frequently during the events. Figure 12 on page 71 shows the hourly tweets, and while the conference ran from 8 am to 4:30 pm each day, the tweeting pattern showed an elevated level of engagement from 5pm to 10 pm. The first social event was the speed dating, to encourage attending participants to meet. One attending participant blogged about the experience, “during the ‘speed dating’ end of the day, someone mentioned that while they make notes during the sessions, they also make an action list – ideas to try, things to read, etc.” Meeting and getting to know other attendees was the goal but learning also occurred.

The first-timer dinner provided an opportunity for first-time attendees to go out to dinner with speakers or other experienced attendees. Tweets like, “Great company, great food, great spirits! Loving my #TMC17 family! [link to image of people around restaurant table]” dominated this period. Many photos of attending participants at a restaurant were shared. During the trivia night, attending participants tweeted about their teams, “Join us Friday PM as the #TMC16 team defends their title at #TMC17 2nd Annual Trivia Night! Don’t have a team? Show up, make some new peeps. [image of participants].” The final night of the conference was a game night, and similar tweets dominated the evening. The attending participants shared photos of themselves playing games, whether they were math games like Prime Climb or social games like Ticket to Ride. The activity of sharing the social elements of the evening is what accounted for many tweets during the evening.
#CHAT #Tools: Mediating Artifacts used by Participants

The tools the attendees used during the period were focused on communication and sharing of information. The most frequently used tool was Twitter, which served to facilitate communication between participants. Twitter allows for short, microblogging communications called tweets and can be accessed through a free account on the site Twitter.com. Twitter may have been the communication medium, but a more complex software called Tweetdeck served as a tool for some to keep track of the conversations. Tweetdeck is accessed through the website Tweetdeck.Twitter.com. Both tools access Twitter and create tweets on the main Twitter site and can be used interchangeably. In addition, other tools used by the participants were blogs, hashtags, the conference wiki site, and Google documents.

#CHAT #Tools: Software used to Interact with Twitter and Tweetdeck

The use of Twitter was ubiquitous during the conference period. Not everyone used the basic Twitter software, however. A different web-based interface called Tweetdeck was frequently used by attending participants. One participant tweeted, “My #1TMCThing use tweetdeck so that I can be more connected and #PushSend more frequently. #TMC17.” Another tweet at the beginning of a My Favorites session was, “This weekend has taught me a new meaning to ‘all hands on deck’ #tmc17 [image].”
The attached image showed eight attending participants from the back and their computer screens, all with the recognizable columns of Tweetdeck running as the Twitter interface. None of the visible screens were showing the Twitter interface. It was not only attending participants using Tweetdeck, however. One remote participant tweeted, “#TMC17 Even from my seat on the train, the warmth and brilliance keeps on coming through my tweetdeck.”

What made Tweetdeck useful was the amount of information it allows to be seen at once. The basic Twitter software allows for only one column of information at a time. Tweetdeck, however, allows for multiple columns to be used to organize hashtags and conversations simultaneously. For example, one column could have been a search for #TMC17, while another could have been #TMCPlans or multiple session hashtags in different columns. This flexibility is what participants found to be useful, “Tweetdeck is awesome!! Today was the first day I really used it (another first for me). Definitely has enhanced #tmc17.” On the Sunday of the conference, one attending participant tweeted, “Guess it’s time to add a #TMC18 tweetdeck column to follow the speculation #TMC17.” Another participant replied with another way to use the platform, “Make it worse, have #TMC17 OR #TMC18 in your tweetdeck. 150 mph at that point.” The attending participant indicated using the Boolean operator “OR” to connect multiple hashtags together into a single column. Tweetdeck made the use of hashtags easier and more efficient.
#CHAT #Tools: Hashtags - a Tool Within a Tool

Hashtags were an essential tool for connecting participants during the period in question. Hashtags were a tool that lived within a tool and identified sessions, keynotes, and more. The main hashtag was #TMC17, and it was included in tweets before, during, and after the conference. This hashtag was the primary way of identifying a tweet as connected to the event. During the conference, 52 other hashtags also were used to connect attending participants. For example, attending participants used the hashtag #TMCPlans to connect with others who were looking for a variety of connections. This hashtag was included in 61 different tweets. In each, the usage was to find other participants who wanted to connect and meet for a purpose, such as going out for coffee, “#tmc17 #TMCPlans Can we do good coffee again tomorrow, fellow coffee enthusiasts? If you have a car, that’s helpful! Love me some java!” The first hashtag connects to the large group of participants, and the second hashtag narrows the scope of the tweet to only those looking for a connection. When this practice was combined with Tweetdeck, one column of the software monitored the #TMC17 tag, while a second monitored only the #TMCPlans tag. This allowed a participant to find relevant information or requests quickly.

There were many other hashtags in use. Several morning and afternoon sessions created their own hashtag, and the third keynote by Carl Oliver had the #pushsend tag. Having a hashtag to identify the session also appeared to influence the quantity of
participation with the content. For example, one morning session was named “Hinge Questions.” This morning session had no hashtag in the data set, and a search for the term “hinge” yielded only seven tweets and two blog posts. The “Mathematical Yarns” morning session also had only two blog post mentions, but the #MathYarns tag has 40 uses in tweets. Having a hashtag was an encouragement to tweeting the activity of the morning session as seen in Table 10. There were approximately equal numbers of attending participants in each morning session and having a single hashtag to represent the session appeared to encourage participants to engage with the session on Twitter. There were two morning sessions without a hashtag and finding tweets that arose out of those sessions was difficult, even after coding.
There was a rough association between hashtag use and quantity of tweets, although the ‘Playing with Exeter Math’ session ended up with three different hashtags and only nine tweets. All these 12 hashtags were used simultaneously with the #TMC17 tag, and any remote participants would see all of these together in a search. The consistent use of hashtags was important to allow others to find desired content in the larger stream of #TMC17 tweets. Having three different hashtags for the ‘Playing with Exeter Math’ could have been problematic. As a further example, if the phrase ‘rich tasks’ was

Table 10

*Hashtags and tweet count for morning sessions*

<table>
<thead>
<tr>
<th>Morning session title</th>
<th>Hashtag</th>
<th>Number of tweets</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the relationship between the Standards for Mathematical Practice and Equity</td>
<td>TMCEquity</td>
<td>80</td>
</tr>
<tr>
<td>Talk Less, Smile More: Discussion in math class</td>
<td>TalkLessAM</td>
<td>66</td>
</tr>
<tr>
<td>Math Coaches Huddle</td>
<td>CoachTMC</td>
<td>48</td>
</tr>
<tr>
<td>Mathematical Yarns</td>
<td>MathYarns</td>
<td>39</td>
</tr>
<tr>
<td>Differentiating CCSS Algebra 1 -- From Drab to Fab using Exeter Math 1 &amp; Exploratory Talk</td>
<td>CheezyExeter</td>
<td>31</td>
</tr>
<tr>
<td>Become a Classroom Chef</td>
<td>ClassroomChef</td>
<td>20</td>
</tr>
<tr>
<td>The Co-Teaching Tango</td>
<td>CoTeachChat</td>
<td>11</td>
</tr>
<tr>
<td>Playing with Exeter Math</td>
<td>Exeter, TMC17Exeter, ExeterTMC</td>
<td>9</td>
</tr>
<tr>
<td>Unpacking and Creating Connecting Representations Tasks</td>
<td>ConnectingReps</td>
<td>8</td>
</tr>
<tr>
<td>Hinge Questions</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Rich Tasks Demand Rich Implementation to Maximize Student Learning</td>
<td>RichTasks</td>
<td>2</td>
</tr>
<tr>
<td>Use Cooperative Learning Strategies to Incorporate Group Work in the Math Classroom</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
searched for instead of the hashtag, an additional six tweets were found, and if the presenter’s names were searched for, an addition 22 tweets were found. A participant searching for only the hashtag would not discover these. Hashtags served as a tool to help identify and find tweets from specific sessions.

A final use of the hashtag as a tool was the use of #1TMCthing. This hashtag’s purpose was to encourage all participants to identify one thing they learned or experienced at the conference and implement during the next school year. For example, one attending participant tweeted, “Picked my #1tmcthing! I’m going to post my lesson plans in a shared google doc so coteachers and my algebra 2 team can see & comment #TMC17.” This was used 100 times in both tweets and blogposts to share the participants focus on one thing they want to implement. It is possible the participants tweeted after implementing their one thing, but those tweets were outside the data collection range and could not be collected. It was also possible that no follow-up occurred, and the participants forgot about their 1TMCThing.

#CHAT #Tools: Blogs as a Reflective Tool

Blogs, a longer form of communication than Twitter, were used before, during, and after the conference. Most of the use was after, however. There were two blog posts about anticipation and fears before the conference, approximately 15 posts during, and approximately 109 after the conference. The posts were of three main types. The first type was a summary, ‘this is what happened during the session.’ One attending
participant did sketchnotes of each session attended and posted them on their blog during the conference. A sketchnote is a form of notetaking whereby the note taker creates an artistic visual depiction of what occurred during the session using images, color, and words. One prolific blogger posted 11 separate times, with one post dedicated to the morning session, one post to a summary of My Favorites, one post each to the attended sessions, and one post to the keynotes. This blogger posted all but two of the 11 posts during the conference.

The second type of blog post was the reflective summarizer. This type of post went beyond the bullet point, and the participant engaged in critical self-reflection based on the session. For example, one attending participant during the week after the conference reflected on the third keynote,

Two things he mentioned really stuck out to me. The first is that blogging is reflection. For myself. A nerdy version of #treatyoself. Actually formalizing my thoughts not only makes me a reflective practitioner, but it’s also a great way for me to document my own professional growth. … Also I like the idea of blogging as a form of leadership. Perhaps no one will read this. But perhaps they will. As a teacher with access to the interwebs, I do a lot of taking. Lesson plans, practice problems, open ended tasks. I want it all. However, the day might come when perhaps something I say will help someone else. I may spark someone else in the same way that others have done for me, and I’m all about sharing the love!

This attending participant went beyond the words of the presentation and added their own thoughts about the content. This was a typical practice for the reflective summary blog posts. Take something that was said during a session or keynote, describe it, and then expand upon it, and make connections for a reflection.

The last type of post was a purely reflective post. Frequently, this was a second or third post by the participant posted after the conference. These posts varied in their topics
and format because they were personal in nature. One post in this category was on the idea that the participant ‘Learned Nothing.’

As I am back home and reflecting on Twitter Math Camp 2017, I feel like I have learned a whole lot of nothing.

- I learned nothing but friendly and amazing people attend this conference to make a first timer feel welcomed
- I learned nothing but amazing things from Desmos and have inspired me to use the software even more
- I learned nothing can change how I feel about incorporating more student voice into my classroom
- I learned nothing will change in my classroom unless I take more risks
- I learned nothing but being vulnerable will help me grow even more
- I learned nothing will keep me away from the MTBoS and all the wonderful people involved in it
- I learned nothing was gained except an amazing new group of friends and an overload of ideas
- I learned nothing will stop me from attending as many TMC’s as possible
- I learned a whole lot of nothing and I couldn’t be happier.

This was not the only poem written about TMathC; there were two others. Not every post in this category was a poem, however. Most were in a more standard format. All were reflections on the experience of attending or the people they met at the conference. One attendee said it this way, “Some PD experiences are almost designed to be about an expert handing down their product or policy and you don’t hope or expect to think. At TMC you almost always go in with an active attitude.” All three of these types of reflections on the conference could only occur in the blog format where there is no limit on the number of characters.
#CHAT #Tools: Sharing with a Wiki & Google Documents

The final type of tool of the conference was the use of a wiki site and Google documents to share materials. The conference maintained pages on the free wiki site, http://twittermathcamp.pbworks.com for all sessions, keynotes, and My Favorites. It was up to the presenters to update their materials, which occurred regularly. Presenters tweeted when they updated their materials, along with links, “I’ve updated the #TMC17 wiki with resources from my #BreakoutEDU session [link].” Sharing of resources on the wiki and tweeting the link allowed all participants to see and use the resources.

Another method of sharing resources from sessions was the use of Google documents. Google documents were shared 94 times throughout the conference. The ability to collaborate in a session on the content was a key feature that drove this use. The attending participants in a session could use the collaborative features of the platform to add multiple perspectives to one document. The participants then shared the resource they built, “Fun #talkingpoints for the beginning of the year! [link] #TalkLessAM #TMC17.” Sharing resources through the conference wiki or Google allowed remote participants to access the same session materials as the attending participants, leveling the difference between them.
# Rules of the Community and How They are Communicated

Every community has rules, and the community built around the TMathC conference is no different. The two levels of rules which apply to TMathC are organizational and inter-personal rules (Engeström, 2015, p. 122). There is a third level of rules, according to Engeström, the societal rules composed of state and local laws. This level does not affect the conference, and the conference had no impact on those laws.

There were organizational rules that were essential in the operation of the conference. These included starting on time, the process of selecting a morning session, and who was eligible for presenting a My Favorite. Other organizational rules included the showing of gratitude, the active engagement in sessions, the sharing of content, encouraging self-care, and the retweeting or amplifying of others. Each of these will be explained.

# Rules: Essential Organizational Rules of the Conference

There were few organizational rules for the conference, but the organizers communicated these rules thoughtfully. First, no one needed to blog or have a Twitter account to participate. Participants repeated this rule at the first-timer session, held before the conference officially started. One experienced participant phrased it in their blog post.
to first-time attendees as encouraged, but not required, “You don’t have to have a blog and you don’t have to tweet – although we HIGHLY recommend it.” The organizers did not make this statement, but this rule was so well adopted by the participants that they communicated it on their own.

The next rule, as stated by Lisa Henry, the lead organizer, was tweeted by a participant on the first morning, “speakers have to start and end on time OR ELSE #TMC17.” This rule may seem unnecessary, but the act of stating it raised the courtesy of timeliness to an official rule of how the conference operates. This rule was tweeted positively several times by participants. A typical tweet was, “#tmc17 starts on time. Awesome!” Being courteous of others’ time was a policy, not simply a consideration.

Another essential rule of the conference was to put your own learning needs first. Most educators would not need a rule similar to this when they are attending a conference; however, the conference made it clear. The statement was made to all first-time attendees explicitly and tweeted, “TMC17 newcomers – Please put your own learning needs FIRST! ‘Make it worth your time.’” The ‘it’ in the sentence is presumed to refer to the time and energy of attending the conference.

The next official rule of the conference was that everyone is worthy. A demonstration of the rule was that every participant was worthy of presenting. One first-time attendee phrased it this way on their blog,

Everyone is worthy: I love the fact that anyone at TMC can do a My Favourite [sic] and everyone is welcome to. Anyone can become a conference presenter by simply having something to say and asking to say it, and you get to do it in front of the whole conference. At TMC17 I said one of the remarkable wonderful things about TMC is that everyone is worthy to present. My Favourites [sic] is one of the ways the TMC organisers [sic] really make that real.
This idea that everyone was worthy of presenting permeated the conference and filled up to 45 five-minute time slots with unscheduled, unplanned presentations. Whereas the rest of the sessions were planned and scheduled in advance, none of the My Favorites were, and every attendee was welcomed and encouraged to sign up to present.

The final rule for the conference was how the various time slots were used to develop diverse levels of engagement or understanding. A participant described the overall time structure on their blog,

There are 3 morning sessions that are 2 hours each, for a total of 6 hours so you can really dive deep into the subject. Then, there are afternoon sessions that are an hour. There are “My Favorites” that can be 5 or 10 minutes. And, finally, we end with a Flex session for anything you might have come up with last minute depending on conversations along the way and this is an hour long. It is so well designed.

The rule that went along with morning sessions was that participants should remain in the same morning session the entire conference. This rule was not obvious as indicated by the questions asked. One first-time attendee asked, “#tmc17 newbie here!! Do we pick one morning session to focus on for 3 days or different one each day?” The response, from both attending and remote attendees, was to attend the same morning session for three days so they could “deep dive” into the topic. The participants considered this six-hour session during the conference successful as well. Another first-time attendee said, “#tmc17 I like this 3 day session format as I see the presenters talklessAM modify based on our thoughts from yesterday!”

When this rule of ‘remain in the morning session’ was combined with the earlier rule of ‘put your own learning first,’ there could be a conflict between them. The resolution between conflicts was that the individuals’ learning came first. As another
participant put it on their blog, “Participants select a morning session which runs for 2 hours each for the three full mornings (although the Law of Two Feet prevails).” The ‘Law of Two Feet’ phrase was linked to an online article which describes the law as, “any time you're in a meeting where you're not contributing nor adding value--you are encouraged to use your two feet and find a place where you can” (Opp, 2010). The ‘law of two feet’ allowed for the conference rules listed above to work together to maximize the participants’ benefit.

#CHAT #Rules: Showing Gratitude and Supporting Others

In addition to the explicit rules of conference operation, there were rules the community created for themselves. These rules were not stated by organizers or anyone else but must be inferred from the practice and activity of the participants. One such rule was the rule of showing gratitude and supporting others. One first-time presenter tweeted before the conference started, “Just finished my presentation for #TMC17 and I’m having heart palpitations. #firsttimenerves.” Responding to this tweet, other participants tweeted statements such as, “You’ve got this. I look forward to learning what you are passionate about at #tmc17.” This same attending participant later wrote in their reflective blog post, “Days leading to the conference, I received messages of encouragement from other #TMC17 participants when I expressed presentation jitters.”

This attending participant’s experience was not unique. Another attending participant wrote in their blog,
So many people at TMC came up to me and told me things that they see in me and admire about me. WHO DOES THAT? I mean where in the world can you go and have people honor your gifts and speak life into you, personally, and professionally, who don’t even live near you or work in your building?

The personal or Twitter mediated act of gratitude was an expectation of participation, even though the recipients of the appreciation were surprised by the activity. Tweets suggest that the community set this activity as an expectation practicing it daily.

After each keynote, tweets of thanks to the presenter were sent by many participants, as well as tweets of appreciation after sessions. These tweets were sent by all types of participants as well. One representative remote participant tweet was, “@TMathC @samjshah Thanks!! So much stuff coming out of #tmc17 it’s hard to keep up!” Another remote participant tweeted, “Thanks to everyone sharing from #tmc17, getting lots of great ideas!” That both remote and attending participants engaged in the activity of gratitude demonstrates how this community wide rule was received. It was not a ‘top down’ rule which originated in the conference from the organizers. Instead, it was a ‘bottom up’ rule. The act of gratitude was so prevalent, in fact, that a search using the term ‘thank you’ found 494 instances across all blogs and tweets.

#CHAT #Rules: Active Engagement with a Caveat

The reflective blog posts suggest another inter-personal rule of the community that each person was expected to be actively engaged in the activity. Each participant, whether remote or attending, was present because the person was actively seeking to learn something. One attending participant phrased it in a blog post as, “The first aspect
of this TMC attitude is that everyone in every face-to-face session is there ready to learn something. Not just expecting it, but *looking out for it* – they are actively seeking something to learn.” This expectation of active learning by all participants was an unwritten inter-personal rule of the community. The participants all engaged with each other in a way to foster and develop learning. This rule applied to all participants whether they were presenters, attending, or remote. The same participant above later in their post said, “Even more remarkable, *the presenters themselves* all seemed to expect to learn something in the sessions that they themselves were presenting. … At TMC you almost always go in with an active attitude.” Another participant phrased this idea differently, “At TMC I am sharing what I have and hoping my audience will contribute and teach me as well. And, that happens! It is more of a conversation than a lecture.” In the end, whether the active engagement rule was framed as a conversation with all participants, or as simply engagement, the resulting activity was the same.

Tweets during the conference suggested an important caveat to this rule. Incorporating the rule above of ‘put your own learning first’ also implies that each participant put themselves first. Several attending participants tweeted along these lines. One attending participant tweeted prior to the start of the conference, “It is ok to need some time by yourself. You don’t have to go to every session or every activity or every meal. #tmc17” Another attending participant tweeted during the conference, “#TMC17 reminder – self care – if you need time, take it!!” Other attending participants framed their suggestions for self-care differently by just informing others of their plans, “Bummed to miss out on speed dating, but I needed a nap #TMC17.” Whether by telling
participants to take care of themselves, or by demonstrating self-care, the caveat to the active engagement rule was made clear during the conference.

#CHAT #Rules: Sharing Time and Content

Blog posts and tweets showed that the combination of the gratitude rule and the active engagement rule worked together to create two additional rules for the community. The first rule is the rule of sharing. This rule is broad and had at least two parts. The first part is that participants in the community were willing to share their time to help others. There are multiple examples of this occurring in the blog posts or on Twitter. One of these examples was created out of a My Favorite, “During my talk about the Mathematicians Project, one person volunteered themselves and two others to make an AwesomeTable for it! Sessions ended, and the two of them sat down for an hour or so and started building it. Unbelievable. So generous.” One participant had an idea and project, and before the conference was over, other participants took the idea and created a searchable database. This sharing of time and knowledge was repeated several times during the conference. One participant created an artistic representation of a mathematical idea for another and brought the materials necessary to construct it. One participant from Australia brought foods from their home country to share with others. Another participant gave away math art objects they created during the conference. The practice of sharing time, products, or ideas with others was a cultural norm; a rule followed by all participants. Even remote participants tweeted their willingness to help
attending participants with questions as was seen previously, “If you’re in the morning Exeter math sessions at #TMC17, feel free to tweet me about any Math 2 stuff.” Another remote participant was asked if they would Skype in to help a session, and replied, “Perfect. Can’t wait! I wasn’t expecting the opportunity to participate in #TMC17!”

Another addition to this rule was the ideal of sharing the content of the sessions to remote participants. The sharing of ideas from sessions took several forms. One form was the sharing of quotes from sessions. The format of this sharing was repeated and consistent across sessions, “‘Efficiency only works when you have understanding…It’s a very poor substitute for good pedagogy.’ @pegcagle at #tmc17.” A version of this tweet was sent out five additional times within three minutes by separate attending participants and was followed by additional quotes from the speaker, @pegcagle. A remote participant following this thread would be able to understand the points the presenter was making.

Another form of the sharing was to include photos with the tweet. For example, in the tweet, “‘Number of adjoining squares’ #tmc17 ‘I first starting [sic] counting them, then I realized …’ [photo]” there was an explanatory photo attached. This photo was of a large poster size paper with a progression of five drawings, and two people’s hands with markers. The focus of the photo was on the math, with no faces or identifying features shown in the image. A remote participant seeing this tweet would be able to view the photo, and through the prompt come to their own conclusion about what was ‘realized.’ In the data set, there were 508 photos or videos identified as having a subject matter of mathematical or presentation content. This practice was so prevalent, that one attending participant tweeted during a session, “Don’t have to take a picture of the slide because I
know I’ll be able to retweet someone. Haha. #tmc17.” Photos were not the only thing shared, however. Links to websites, wiki pages, google documents, and other forms of content were also shared regularly. There were an additional 522 links identified as some form of content sharing which were not photos of content. Combined, there were 1,030 links to photos, websites, or other documents about sessions, keynotes, My Favorites, or other mathematical content. When the tweets with reflective blogpost links were included in this count, the number increased to 1130. The quantity of topical sharing through Twitter and blogs was large, and all of it was available to remote participants.

The sharing was not all business. There was also an amount of social sharing outside the conference hours. The participants shared 411 photos of people, often selfie photos, and 192 memes, or other non-content, non-participant photos. Most of this sharing was from attending participants. The tweets during the first-timer dinner regularly had photos of people, as did the tweets during the trivia and game night. Remote participants likewise practiced this. One remote participant tweeted, “Aww man! Following #TMC17 this week from afar. Experience FOMO, but the view here is nice, too! Travel Safe, share often #MTBoS ☺ [link to photo]. The photo in this tweet was a photo of a newborn infant, which contextually explained why the participant was remote.

Social sharing was not the largest type, though. Topical sharing of content exceeded social by a large amount. One thing that spurred the high degree of topical sharing was the gratitude expressed by the remote participant group. The interplay of rules reinforced the sharing rule.
#CHAT #Rules: Retweeting and Amplifying Others

The last inter-personal rule suggested by the tweets was the practice of retweeting or amplifying others. There are two separate activities in this rule. The act of retweeting someone is built into the Twitter platform and requires at most two button presses. If a participant reads a tweet they like and want to spread it to their own followers, they can push the ‘retweet’ button, and send it for more people to read. The software indicates that the original tweet was ‘retweeted by,’ but the tweet is identical to the original. In addition, a retweet can be retweeted, further spreading the original tweet to additional followers.

The tweet with the most retweets was, “‘Math is about relationships but kids think math is about numbers.’ - @MFAnnie #TMC17.” This tweet was retweeted 60 times, each time by a different participant. In addition, there were 50 tweets that were retweeted 10 or more times and a total of 2,540 tweets which were retweeted at least one time. This tweeting pattern shows an active practice of spreading other people’s tweets. Amplifying tweets was taking a simple button push to an additional level. Amplifying a tweet was a retweet with the addition of a hashtag, text, or comment to the original tweet.

The practice of amplifying had two separate practices, a basic, and an advanced. The basic practice of amplifying was to quote a tweet from another person and add the hashtag of the conference. For example, the tweet, “#TMC17 [link to original tweet]” takes the original tweet and adds the hashtag. In this case, the original tweet did not
include the hashtag, so the original tweet was then brought into the #TMC17 group for all to read. If someone was only following the hashtag, they would have missed seeing the original tweet, and therefore the retweeting participant amplified the original by appending the hashtag. This basic level of amplifying occurred 14 times in the data.

The advanced level of amplifying required adding information to the retweet, which expands upon the original tweet. The most active amplifier was @jreulbach, who chained the following two tweets together using this practice, “Questions to think about when you listen to your phone pocket 10 min audio recording (from @pegcagle) #tmc17 [link to tweet]” with the link to tweet taking the reader to, “Phone pocket: 1) Every question you ask. 2) How many times did I let students finish their thought 3) Track who speaks in which order #tmc17.” The amplifying tweet quotes and names a speaker, and then duplicates the first tweet as a subset to the amplifying tweet so that the first was seen twice. This practice of amplifying expands the notion of retweeting significantly.

Not all the advanced level amplifying tweets were this well planned. Some were simply adding a message to someone else’s tweet. For example, a participant @tweeted, “Awesome activity on ‘adulting’ #tmc17 #mtbos @rawrdimus [link to tweet]” where the link was sharing a My Favorite topic @rawrdimus presented. The amplifying tweet by @jfinneyfrock commented on the original tweet by @rawrdimus and gave followers an additional reason to read the original tweet. This amplified the original message more than a retweet or even just adding a hashtag. This practice occurred frequently in the Twitter data, which elevated the practice to a rule. There were 184 separate instances of amplification of tweets by 70 unique participants, above and beyond basic retweets. In addition, @jreulbach, the participant with the largest number of
connections was also the most prolific amplifier in the data with 46 or 25% of the amplifications.

#CHAT: Who was the TMathC #Community

Online community boundaries may be difficult to define. There is no physical boundary which can be drawn on a map which provides a structure to an online community, and even if there were, the data does not provide a physical location of each of the participants. Based on the activity of the all participants, it is clear the community is greater in number than only the attending participants. That the combined participants felt there was a community is evidenced by the frequency with which the words ‘community’ or ‘communities’ were used. These two words occurred 251 times in blog posts and 47 times tweets. How this community was constructed is unclear until it is described. Engeström (2015, p. 122) provides three different levels to consider when describing a community; the immediate primary group, the collective organization, and the societal network of activities.

#CHAT #Community: The Immediate Primary Group

The immediate primary group of TMathC were the attending participants and their activity. This group formed the core of the community and set the tone for interactions in person and online. That this group of individuals, along with the rules they
operated under, developed a sense of community and belonging was evident by the statements of the attending participants. One person, in their blog, wrote,

Other conferences I have been to don’t have the same community feel. Some have been close, but not nearly at the same level. Certainly it’s rare for the presenter of a keynote to be around at the rest of the conference to be part of the community and discuss other people’s ideas, and rare for the audience to act like they are there to support them! It’s certainly true that no compulsory PD I’ve ever been to has had this attitude of community-building! At TMC community-building is always in the background.

This attending participant noted that community was a constant current of activity throughout the conference. Events such as the first-time dinner, trivia night, and game night also contributed to the sense of community for the attending participants.

The rule of active engagement shaped the participation in the community for attending participants as well. Some attending participants entered the conference with questions about their activity in the community but changed their perception as they participated.

I often feel like I’m not whatever enough in this community, but I think from the feedback of my sessions and conversations throughout TMC, I’ve started to feel as though I do have useful ideas to contribute. … I left this year feeling like I really can become part of this community if I’m willing to put myself out there a bit more via both this blog and Twitter.

This attending participant felt like they could become part of the community, but they would have to do something first. The decision to do something was repeated by other attending participants, “I am officially declaring myself as a #MTBoS Rockstar because I am always trying to improve so I just decided I can be a Rockstar. See how easy that was? Now you can be part of us too, just by deciding you are.” The only barrier to entry in the community was the choice by the participant.
#CHAT #Community: The Collective Organization

The organization is the collection of remote and attending participants together as a whole. This group of individuals is spread out over space and time, and participate in the conference each in their own way. This collective group had similar conditions as the immediate, primary group. The participants had to be willing to make the decision to engage, and the engagement went both ways, remote participants engaging with attending, and the attending engaging with remote. A remote participant tweeted, “#MTBoS is truly an inspiring collective. If you aren’t already, follow #TMC17 to see more of what drives this ‘autonomous organism’” as a way to encourage other remote participants to reach into the community. An attending participant deliberately acknowledged the remote participants and their engagement as well, “My biggest takeaway from the experience is the overwhelming love and support and cheerleading I felt from the #TMC17 and #MTBoS communities, both people who were present and those who were not.” The community was recognized as the collective by all participants.

#CHAT #Community: The Societal Network of Activities

The largest view of community activity is found through examining the network of activities of the community. By following the rules outlined above, a community was created around the hashtag #TMC17. This community had a clear set of activities
centered on mathematics teaching, as well as the inclusion and invitation of new voices. One attending participant said in their blog, “This family thrives on new additions. New voices. New opinions. We need you in our family, our community, our conversations, and our classrooms.” The openness to new voices created the opportunity for constant additions to the network that helped others grow as an educator. One participant framed it in their blog as a constant work to improve,

I think most of all what I want for more teachers are what I found at Twitter Math Camp. I want them to have experiences that continually enrich their vision of what mathematics and mathematics teaching can be. And I want them to have the support they need to recognize that no one is perfect but it’s worth working to get better.

By having a center on mathematics and mathematics teaching, the community had a wide focus which invited anyone who shares that interest to participate. One participant described the communities’ composition on their blog as, “people who are looking for ways to be better in the classroom in order to help our learners. We want to learn from each other.” The only barrier to entry was the willingness to participate or the level to which the participant was interested in participating.

#CHAT: Objects of #Growth

The objects of growth for the conference were twofold. The first object was the personal and professional growth of the participant, and the second object of growth was techniques which focused on learner growth in the classroom. Each of these objects of growth had strands in the conference, as well as discussion in blogs and on Twitter.
#CHAT #Growth: Personal

Sessions at the conference supported all participant’s desire for personal growth in their career, as well as the community and participants. Attending participants attended for their own, personal reasons, and while many had aligned objects of their focus, they were not always the same. One attending participant stated in their blog, “I value the learning and growth that this collective inspires me to pursue.” Another first-time attending participant blogged, “I know that #TMC17 has made me a better math educator with one conference. I can only image how I will continue to evolve as I attend more TMCs in the future.” Even though each participant had their own goals and focus, tweets and blog posts showed there was a commonality of developing skills and techniques that made them grow as a person or educator.

One of the tools of the conference was the use of #1TMCThing for attending or remote participants to focus on their own goals after the conference. The #1TMCthing was used as a way to focus the participant on one thing they would take away from the conference and implement. Examining this hashtag showed that many participants engaged in the practice of personal career growth. One attending participant said, “I think my #1TMCthing is to actively engage in this community more and not suffer in silence #tmc17 #mtbos.” Another attending participant wanted to bring the TMathC spirit to their local school district and share it, “#1tmcthing I need to bring more #mtbos/@tmathc
spirit & ways to my local teacher community #miched.” None of these objects of growth focused on explicit classroom practices to implement with learners.

One participant who had attended multiple TMathC conferences noticed this pattern of growth and summed up what they saw over time in this way on their blog:

The real fascinating part has been watching the careers evolve [of] all of the amazing people I have met through this conference, convention, family reunion, whatever you want to call it. On the surface it was professional development for teachers by teachers. Now you look around the room and you see people who write professional curriculum, work for Desmos, have written books, have won the biggest award in math education, have become math specialists, have risen in the ranks of NCTM committees, and on and on.

Professional growth is not always about growing out of the classroom, although clearly many had. One experienced teacher of over 20 years said that they, “came away from this joyous gathering burn-out free and ready to re-engage with my professional pedagogical self.” Growing personally or professionally sometimes meant that the participant left the conference more motivated and ready to be productive in the classroom.

#CHAT #Growth: Classroom

Another object of growth for the participants was a focus on their classroom and learner growth. The number of morning and afternoon sessions focused on learner growth was large. Sessions such as Talk Less, Smile More: Discussion in Math Class, Rich Tasks Demand Rich Implementation to Maximize Student Learning, and Become a Classroom Chef were entirely focused on improving learning outcomes in the classroom. The participants blogging and tweeting about these and other sessions had a clear focus
on their classroom implementation and expressed as their #1TMCthing, “So, my #1TMCThing is to incorporate more rich tasks into my classroom this year. I plan to start by using some of the prompts given to us on the last day and see where things go from there.” Another participant framed their goal for the classroom as an exercise in risk taking, “I need to and want to have the courage to take risks in my classroom to help my learners learn.” The range of different statements regarding the focus of the participants with respect to their classrooms was wide. Each teacher taught in a different classroom, with different learners, and different requirements from their district. That each of them found something they could act on in their classroom, which they believed would positively change learning outcomes, was valuable.

#CHAT #Outcome of TMathC

The outcome of TMathC is the sum and interactions of the seven elements of the activity system triangle described above: Rules, Community, Division of Labor of sessions, Individual participants, the Mediating Tools, Objects, and Outcomes of Learning. The six connected elements together make up the activity system of TMathC, and all lead to the seventh, the Outcome. The outcome of TMathC is the professional development of educators who participate in the activity. Each of the seven elements of the activity system was aligned to promote the professional development of the participants, whether they were remote or attending.
The final component of Cultural-Historical Activity Theory (CHAT) is the tension or tensions which allow or facilitate learning. Engeström is clear in his explanation of CHAT that no learning can occur in a system without some tension which puts the participants in a Zone of Proximal Development (ZPD) (2015, pp. 134–139). However, while being in the ZPD is a necessary condition, it is not a sufficient condition for learning. The individuals’ learning must have other activities which promote learning once the ZPD has been reached. In the activity of TMathC, the tensions which promote learning were defined by the participants through keynotes, sessions, and activities. Many of the quotes in the explanation of each element of activity above mention the largest tension of learning, vulnerability. The second tension of learning was cooperation. The activity which bound the social community of learning to the participants’ actualization of learning was asking for #1tmcthing, an implementable action step taken after the conference. This last step required reflection and consolidation into the final stage of learning.

Tweets and blog posts indicate that all three keynotes, independently, emphasized the role vulnerability plays in learning for participants. Graham Fletcher’s keynote even
summed up, explicitly, “Vulnerability is the birthplace of professional growth.” One participant went so far as to title their reflective blog post on the conference, “Vulnerability = ZPD for teachers.” This same participant closed their reflection with, “Take risks. I see vulnerability as a teacher’s Zone of Proximal Development. Learning and progress happen for teachers when they open up and take chances and then reflect and refine. May you learn and grow exponentially!”

This theme of participants opening themselves to vulnerability played out throughout the blogs and tweets. The participants centered themselves in the idea that taking risks in their practice was equal to being vulnerable, and that both would lead to greater personal career growth. One participant wrote in their blog, “How much time I am [sic] willing to spend being open, honest, myself, and vulnerable? How much time am I willing to spend to understand those I am with? When I take the time to understand, ask, share, and take risks, my community improves.” The desire for improvement was also connected to the relationships with other educators, “What is great about #TMC17 is that taking the risk to put yourself out there socially here reaps great rewards of human connection.” The human connection was seen as a reward in and of itself, separate from personal growth.

Personal career growth was not always the attending or remote participants’ explicit goal for learning. As educators, they engaged in the practice of risk taking to facilitate learning to make their classrooms more conducive to learning, “I need to and want to have the courage to take risks in my classroom to help my learners learn.” As classrooms change and become more of a risk taking environment, the learners in the classroom would hopefully become more vulnerable, and willing to take risks
themselves. One participant had this as an explicit goal, “My #1TMCthing is to take more risks and encourage my students to do the same. We can be brave together. #TMC17 #MTBoS.” Spreading this message of vulnerability and risk taking went beyond the classroom for some, “Hey @gfletchy! I shared your #tmc17 quote about vulnerability with my admin, and she used it to lead into our faculty goals [this] year. Thanks!!” The goals of these participants showed the practice of being vulnerable and taking risks in the classroom were a unit of engaging them in learning. Taking risks or being uncomfortable is never without tension or stress.

#CHAT #Tensions: Putting Learning into Practice

The second unit of learning in the TMathC community comes from the tension of wanting to do better and putting the desire into practice. One participant admitted in their blog that, “While intellectually I liked or wanted to implement many concepts over the years, I honestly felt that when I left TMC17 that my mind was ready for the seeds of these sessions.” Working with others during a session, and learning about ideas, projects, or concepts is not enough to push the participant into implementation. Implementation occurs when the participant examines their practice, reflects on the ideas learned, and finds an opportunity gap which they can fill. This same participant said, “I am open to trying these things in my classes this year. I feel ready to do so. The seeds are planted. Let’s see how well they grow this year.” This pressure between practice and learned ideas is the second tension which creates learning. To this participant, the decision to ‘grow the seed’ relieved the tension present in the earlier statement about not being ready.

The second tension was visible in the statements from the participants on their #1TMCthing. The statement, “My #1TMCthing is to use Talking Points to build
classroom norms for discussion and, therefore, support my classroom community.

#tmc17,” showed a narrow focus on a specific goal which was possible to implement and measure. This statement can be compared to, “#1tmething actually #3tmctnings Going to engage more with #mtbos, share my blog, and implement at least three ideas that I learned at #tmc17.” Whereas the first statement could build out of a tension of ‘struggling to create classroom norms’ and therefore finding a solution, the second statement is of the ‘planting a seed not ready to grow’ version found above. The second statement of implementing three ideas is vague, and ill defined. It is not a response to a specific tension in the participant.

This distinction is essential to framing the statements which the participants put forward as their ‘thing.’ The specificity of the statements demonstrated the growth of the participant through the collaboration and learning which occurred during sessions. For example, “My #1TMCthing is to begin new concepts with an active, engaging activity using #classroomchef #tmc17,” described what types of lessons would be the focus, and how the lessons would be changed. Another participant chose a different session as their focus with similar construction, “My #1TMCthing is to add at least one clothesline activity to every unit #tmc17 #clotheslinemath.”

Not every participant chose one thing to implement. One first-time participant wrote about how they implemented four different practices into their school year and planned to implement additional elements in the second semester. Some participants did not choose a ‘thing’ at all, or at least did not publish their thing. The purpose of the hashtag was to facilitate being held accountable, “use #1TMCthing #tmc17 to get your learning on. In October someone will hunt you down.”
participants did not feel the tension of vulnerability nor an opportunity gap, and did not fully engage in the learning activity.

**#CHAT: Answering the Second Research Question**

The second research question which this section answered is, RQ2: What was the human activity of *conference participation* of TMathC in 2017? The analysis divided the data into the different elements of the activity system, and the answer will reintegrate the analysis using Figure 14 as a guide. The data found in the rules, community, and individuals sub-triangle of the activity worked together to form a community which taught the rules to new attendee by modeling behaviors. These rules included gratitude for other individuals, being actively engaged in the community, and being willing to share time and knowledge with others. The community benefited from the rules because the rules aligned the individuals activity to support other individuals and the community as a whole. This support included remote and attending participants in equal measure. One way the rules supported all attendees was the use of retweeting and amplifying others. This rule enhanced individuals’ participation, and also built a sense of community and belonging.

The data in the sub-triangle of tools, individuals, and objects contributed to the overall activity through the active development and sharing of content. Individuals adding files and content to the wiki site and sharing the links on Twitter encouraged individuals to be active contributors to the learning objectives of personal or learner centered growth. The additional tools of hashtags and Tweetdeck contributed to remote and attending participants communication about session content and links. These tools were used to make communication efficient and contribute to participants finding
information. These tools also played a role in finding the longer reflective blog posts when participants posted them.

The data found in the final sub-triangle of objects, division of labor, and community demonstrated how the multiple types of sessions contributed to the forming of a sense of community and the objects of learning. The morning sessions where attending participants worked together for two hours each day for three days allowed them to form relationships which contributed to community. The different types of sessions allowed participants to become an active members of the community, contributing to everyone’s’ learning through the My Favorites and Flex sessions. The alignment of sessions and community contributed to the learning objects. The data also showed a focus on the outcome of the conference aligned to learning in general.

Engeström was clear that learning could not be accomplished without tensions, and the data showed two different types in the TMathC community. The first tension found was the concept of vulnerability. The participants were asked to engage actively in activities that created a sense of vulnerability through tweeting, reflecting, and responding to others. The second tension found in the data was the stress between practice and learned activity. The participants were learning processes, activities, and ideas that they could implement in their classroom, but there was stress between knowing and implementing. This stress was a tension that created opportunity for participants to learn.

#Mixed Methods Analysis

The third research question in this study was the mixing of the quantitative and qualitative analysis; RQ3: how were the network behaviors and human activity of the
participants interrelated? To answer this question, the data was mixed using the qualitative to interpret the qualitative, as well as the reverse. One way to mix the data was to project the 1-9-90% separation onto the activity theory analysis to find differences among the three groups in their activity. Another mixing using the quantitative on qualitative was separating the data according to the attending or remote participants and seeing if there was a difference in the activity between the two groups. Finally, the quantitative analysis could be reexamined using the first-time attendee and experienced attendee identification. Did the first-time attendees create their own subnetwork within the larger network, and how were the first-time attendees incorporated into the larger network?

**#Mixed: Differences Among the 1-9-90 Participants.**

Of 1,319 participants, 13 were categorized as the top 1%, 119 were in the middle 9%, and the remaining 1,187 were in the bottom 90% based on their betweenness centrality scores attained from their Twitter participation. The thirteen 1% participants, were all attending participants. Six of them submitted at least one blog post to the archive. Of the six who submitted blog posts, four were first-time attendees to the conference, meaning all four first-time attendees who were in the 1% category submitted blog posts about their experience. Table 1 summarizes the blogging activity of the categories of participants.
Table 11

*Blogging activity of the 1-9-90% categories of participants*

<table>
<thead>
<tr>
<th>Betweenness category</th>
<th>Count of participants</th>
<th>Count of participant bloggers</th>
<th>Count of 1st time attendees</th>
<th>Count of 1st time bloggers</th>
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<td>36</td>
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<td>11</td>
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<td>90%</td>
<td>1187</td>
<td>13</td>
<td>21</td>
<td>3</td>
</tr>
</tbody>
</table>

All three groups of participants had first-time attendees, as well as individuals who submitted blog posts to the archive. The most prolific blogger in the data set, misscalcul8, had twelve blog posts and was located in the 90% category. The second most prolific blogger, jgough, had ten posts and was in the 1%, with all of the posts were images of the sketch notes she produced. The third most prolific blogger, hhsmath, had nine posts and was in the 9% category. The tweeting activity based on betweenness centrality did not indicate the activity of the participants in the practice of reflective blogging. The trend in percentage of participants who blogged decreased from the 1% to the 90%, but all three groups had bloggers, first-time attendees, and individuals who were both first-time attendees and bloggers. While all three groups of participants did engage in similar activities, this does not shed light on whether the different groups had different things to say in their activity.

#Mixed: Math Spam Found in the 90% Group

Two types of activity, which expanded the numbers in the 90% group of participants, were targeted math spam, and the use of the hashtag #jealousycamp or #tmcjealousycamp. Targeted math spam comprised the entirety of Cluster 11 of the
network, and was composed of retweets of two specific tweets, “A clear, helpful guide to #OER licenses from http://creativecommons.org. @creativecommons #tcrwp #tmc17.” The second tweet was, “9 @DigitalPromise Superintendents say #OER raises the bar for instructional materials. EDITORIAL [link] #tmc17.” These two tweets created the subnetwork found in Figure 10.

![Figure 10](image_url)

**Figure 15:** Cluster 11, a subnetwork of targeted math spam

This subnetwork is an example of targeted math spam. The original tweet from @K12oer was intended for participants of TMathC based on the hashtag use and context. However, none of the 22 participants who retweeted either of the two tweets were attending participants or engaged with any other participants. These remote participants had two entries in the data set, both of which were retweets of the two tweets. This practice of retweeting remote participants by other remote participants created additional participants in the 90% group. This activity of remote participants simply retweeting other remote participants without any additional engagement was not observed in the 9% group.
Another version of math spam, which occurred on the conference hashtag, was other mathematics educators who were trying to get attention for their own professional deployment offerings. These took the form of tweets like, “Are you at #TMCJealousyCamp and looking for an alternative? Maybe learning about an instructional routine? [link] #tmc17.” There was no discussion of events at TMathC, nor engagement with participants on topics of TMathC, only the call for those not attending to shift their attention to a different mathematics teaching professional development opportunity.

#Mixed: The 1-9-90% Were More Similar than Different

While there were some differences in tweeting behaviors among the three groups of participants, there were more similarities than differences. Each of the three groups contained first-time attendees and participants who blogged. The top 1% did not contain any remote participants, but the 9% and 90% both did. Of the 119 participants who were in the 9%, 14 were remote participants, and the majority of the 1187 participants in the 90% were remote. The tweeting and blogging behaviors of the 1-9-90% were similar, however.

All three groups had participants who blogged about each session they attended, the keynotes, and My Favorites. The most prolific blogger was found in the 90% group, where the participant wrote a different blog post for each session and keynote, one at a time, and day-by-day account of the My Favorites. While this participant was not as active on Twitter as the participants in the other two groups, they were a highly active blogger. The second most active blogger emerged from the 1% group with 10 posts, and the third most active blogger was in the 9% group with nine. Each of these three
participants posted reflections on their TMathC experience and explicitly mentioned #1TMCthings in their blogs that they wanted to accomplish in their classrooms.

Each of the three groups of participants participated in the #1TMCthing hashtag proportional to their numbers, with participants selecting goals to accomplish in the next school year. In addition, participants in each group actively engaged with each other and were involved in the conversations, discussed above concerning rules, community, and the division of labor through sessions. Several of the participants in the 90% group were session presenters. Not being as active on Twitter as other participants did not reduce their activity in the conference, or the community.

#Mixed: Differences Between Attending and Remote Participants

One major difference between attending and remote participants occurred in the use of the #TMCJealousyCamp hashtag. #TMCJealousyCamp expressed a theme found common only in the remote participant group. Some remote participants used the #TMCJealousyCamp hashtag explicitly, while others expressed ideas that were themed with those using the hashtag. To keep the analysis simple, whether the participant used the tag or not, all tweets expressing similar ideas were coded similarly using the code ‘JealousyCamp.’

#Mixed: #JealousyCamp Tweets in the RemoteParticipants

Remote participants connected with other remote participants using the #TMCJealousyCamp tag, and requested information from the attending participants. For example, one remote participant tweeted, “For everyone at #tmc17 (or #TMCJealousyCamp like me), how can I save some of these great tweets/resources to refer back to them later? #mtbos.” This use of the hashtag by participants in this remote
participant group was a way to request information or to express their emotional state at not attending. The requests for information were very specific at times, “Where are you in the agenda? #tmc17 #tmcjealousycamp.” Other times, instead of requesting information, the tweet acknowledged that information was coming, “Better start catching up on blog reading now since I know the #tmc17 ones will start soon! #tmcjealousycamp #schoolstartsnextrweek #notready.” Other tweets encouraged attending participants to continue their tweeting behaviors, “Ok really wish I was at #tmc17 now. #CoachTMC looks like an amazing session. Keep tweeting! I’m stalking hardcore!! #tmcjealousycamp.” These types of tweets all engaged with attending participants to boost continued tweeting and blogging by letting them know their tweets or blogs were being read. Other participants did not use the hashtag, but expressed similar ideas, “Are the wiki and other materials available for those of us not lucky enough to be at #tmc17?”

The larger theme found in the #TMCJealousyCamp was the expressing of emotions. Many tweets expressed sadness or jealousy at not attending, “This is the week I want to watch my Twitter feed the most for #TMC17 details, but I also want to avoid it for all the jealous feelings.” Others expressed the sentiment differently, “Every single post on my feed is about @desmos and #tmc17. Keep it coming! I’m totally not bitter that I’m missing out … #tmcjealousycamp.” The desire for information framed the jealousy or bitterness. Other remote participants were less clear on why others should follow the hashtag; they simply encouraged following, “Got 10 mins. Follow #tmc17 (twitter math camp)… live vicariously from those in attendance!” It was unclear from the context of this tweet if the ‘live vicariously’ meant the social or the content tweeting, or both. Other participants in the remote group were clear on why they were expressing
emotion, “I’m not gonna lie. My heart hurts a little (a lot) that I’m not catching up with everyone at #TMC17. Have the best time y’all.” For this participant and others, the content was secondary to personal connections.

The rule described of showing gratitude extended to the participants in the remote group as well, “As always, thanks to the #tmc17 people that have allowed the at-home folks to live vicariously through your tweets for the past 3 days! ☺.” The theme of jealousy camp applied to the tweet because of the ‘live vicariously’ statement. That the participant also thanked the attending participants also showed the connections between the 1-9-90% and the attending and remote participant groups.

#Mixed: #JealousyCamp Tweets in the Attending Participants

Not all of the #TMCJealousyCamp tweeting was done by participants in the remote group. The attending participants who used the hashtag were sharing links to the remote participants, “For everyone at #tmc17 and even more for everyone at #tmcjealousycamp, check the links! [link to Google document].” Several attending participants in the attending group shared the links to the wiki site and other pages using the hashtag to connect explicitly with remote participants. Intentional inclusion was a practice only attending participants could undertake, and it occurred with no prompting from remote participants. It was a practice of sharing with those who were not present.

#Mixed: Using First-time Attendee Status to Examine the Network

In the coding of the tweets and blog posts, any mention by or of an attendee as a first-time attendee was marked, and the username was documented. Since no list of first-time attendees was kept publicly, this was the only way to determine who was attending their first TMathC conference. The purpose in examining the first-time attendees
compared to the experienced attendees was to determine if the first-time attendees created their own subnetwork within the larger network, if they were fully integrated into the larger network, or if the reality was some middle ground in between the extremes.

Through the coding process of examining tweets and blog posts for self-identifying content, 47 attending participants were identified as first-time attendees. It is possible this was an undercount because some first-time participants may not have identified themselves as such on Twitter or in a blog post. As stated previously, the undercount is always an issue when working with social media analysis. However, 47 is a reasonable number, given that there were 189 attending participants listed on the official TMathC list. The 47 counted participants made up 25\% of the attending participants.

There were approximately 95 presenters during the conference, of which ten were first-time attendees. After subtracting the 85 presenters who attended a previous TMathC, there were 104 spots left, of which the 47 first-time attendees filled just under half. Given that the number of first-time attendees is a reasonable count, the following analysis is also reasonable. For the purpose of the analysis, an attendee who attended a TMathC prior to 2017 was labeled as an ‘experienced’ attendee as compared to the first-time attendee.

The quantitative analysis of the data showed that there were four different types of edges possible in the analysis using attending and remote attendees. For the experienced and first-time attendees, there are also four types possible, with the type listed first as the initiating vertex. In this case, there were experienced to experienced, experienced to first-time, first-time to experienced, and first-time to first-time edges. By
categorizing the types of edges in this way, the number and proportion of edges, which contain a first-time attendee, was counted in Table 12.

Table 12

*Count and proportion of edges comparing first-time and experienced attendees*

<table>
<thead>
<tr>
<th>Types of edges</th>
<th>Total edges</th>
<th>Percent of edges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced to experienced</td>
<td>9361</td>
<td>69%</td>
</tr>
<tr>
<td>Experienced to first-time</td>
<td>1689</td>
<td>13%</td>
</tr>
<tr>
<td>First-time to experienced</td>
<td>1528</td>
<td>11%</td>
</tr>
<tr>
<td>First-time to first-time</td>
<td>944</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13522</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The first-time attendees comprised 25% of the population of attending participants, and they were engaged in 31% of the edges of the network, with only 7% of the edges composed of first-time to first-time attendees. The large majority of first-time attendee communication was with experienced attendees on an equal basis, at 23%. From this data, it appears the first-time attendees had a network, which was similar to their proportions at the conference.

The network the first-time attendees participated in was similar to the network of the participants in general as well. In Figure 16, the ‘N’ is the total number of vertices, and the ‘n’ is the number of first-time attendees in the clusters. Each line is an edge between either a first-time and experienced or between a first-time and first-time attendee. The number of edges is only approximately 30% of the overall network graph (see Figure 6 for the full network graph), but the shape of the edges for the first-time attendees is similar to the pattern of the network as a whole.
First-time attendees’ network map.

First-time attendees were members of most of the top 10 network clusters, with the exception of clusters four and seven (see Table 13 for a summary). The clusters not listed had zero first-time attendees and were not in the top 10 in size. The first-time attendees were integrated into the main discussions in the data set, with the majority of them in the two largest clusters.
Table 13

*First-time attendee count by cluster*

<table>
<thead>
<tr>
<th>Cluster number</th>
<th>Total vertex count</th>
<th>First-time attendee count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>356</td>
<td>14</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>328</td>
<td>22</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>138</td>
<td>2</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>73</td>
<td>3</td>
</tr>
<tr>
<td>Cluster 6</td>
<td>59</td>
<td>2</td>
</tr>
<tr>
<td>Cluster 7</td>
<td>59</td>
<td>0</td>
</tr>
<tr>
<td>Cluster 8</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Cluster 9</td>
<td>49</td>
<td>1</td>
</tr>
<tr>
<td>Cluster 10</td>
<td>39</td>
<td>1</td>
</tr>
<tr>
<td>Cluster 19</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 16 shows three different types of communication patterns, so it is possible the experienced attendees are dominating the edges. Restricting the network to only the 7% of the edges, which were first-time to first-time attendee, would clearly show where those attendees were located in the clusters.
**Figure 17**: First-time attendee to first-time attendee edges only.

Figure 17 shows that these first-time attendees were not limited to the edges, but many were integrated into the center of a cluster, where they had a large number of connections to other participants. Figure 17 shows that many first-time attendees had a degree of influence in the cluster, and were essential to the network as a whole. It is also possible that Figure 17 does not include all the first-time attendees, as some may not have tweeted only with other first-time attendees, as this figure excludes the two types of edges comprised of first-time to experienced or experienced to first-time attendees. Despite this potential undercount, the first-time attendees had a network that was composed of a proportionate number of edges, and many of those edges were central to the overall network.
The third research question to be answered was the mixed method question, RQ3: how were the network behaviors and human activity of the participants interrelated? This question was answered by analyzing the data in two different methods of mixing. The first method was to use the quantitative to inform a second qualitative analysis, and the second was to use the qualitative to inform a quantitative analysis.

The first finding was that there were more similarities than differences among the 1-9-90% groups. When the qualitative analysis was reexamined with the data divided into the 1-9-90% groups based on betweenness centrality, similar themes were found in each of the three groups. While the leveraging remote attendees were found only in the 90% group, each of the three groups had bloggers whose reflections had similar themes. Each of the three groups had vertices who tweeted about similar topics. Each of the three groups had remote and attending participants. The qualitative similarities among the three groups were surprising. The one thing that was different about them was their centrality to the activity of the conference, but the content of their tweets and blogs was similar.

Likewise, when the qualitative analysis was used to identify first-time attendees and examine the network they created, the first-time attendees’ network was similar to the experienced attendee network. The first-time attendees showed up in all three groups of the 1-9-90%, and they were also active bloggers. The first-time attendees were in all clusters, including the top 10, and the network they created emulated the network as a whole.
If they had not self-identified as first-time attendees in the qualitative analysis, there would be no way from either analysis method to distinguish them from the experienced attendees.
Chapter 5: Conclusions, Implications, and Questions

#Introduction

Through this dissertation, I have described the communication patterns of the whole group, subgroups, attending and remote, first-time and experienced attendees of the 2017 TMahtC conference. The conference was an activity of participants spanning four days in July 2017 in Atlanta, GA. Participation was not limited to the physical location by the activity of the participants using Twitter, blogs, and websites. Data collection extended prior to and after the conference, spanning a total of 53 days. The activity of these participants created a complex community aligned with the goals of outcomes of learning, both personal and classroom focused. In this final chapter, I discuss the implementation and conclusions of the study, and propose implications and questions for the future.

In reviewing the implementation of the study, I describe ways in which the literature shaped the study. Further, I consider how the focus of the study shaped the findings, and how limitations were addressed by the analysis. Next, a) I summarize the findings of the study, b) discuss how they speak to current research and draw conclusions, and c) suggest possible implications for conferences in connecting remote to attending participants, promoting community in the participants, and use of hashtags. Finally, I propose questions that the findings raise for future studies.

The #Implementation of the Study

This study addressed the activity of professional development (PD) that occurred at a conference that used social media as an essential element of its communication. This conference, TMahtC, used Twitter as its main communication device and encouraged
attending participants to use Twitter to post pedagogical ideas, session content, and documents so the remote participants could also learn. This type of learning is informal PD because the conference was not tied to any school, district, or state standards documents, and the educators who engaged did so at their own direction. The collection and analysis of the data from the conference created a variety of challenges.

Data collection took place over 53 days, by using the Twitter search network and downloading all activity on #TMC17 for the TMathC conference in 2017 from July 10th to August 31st. This created multiple different files that were combined, and resulted in a document which had many duplicates because the search function returns records from the previous seven days. The Twitter search function, however, does not return a census of tweets, only a sample. Downloading tweets daily created a more complete sample, although it is unknown if this sampling method approaches a census. The document was sorted and duplicate entries removed to create the final data set for the social network analysis (SNA). The data set was composed of vertices, edges, tweets, and blog posts. A vertex is an account, which creates an original tweet, replies to or retweets a tweet, and can be a person or an organization. When one vertex mentions another vertex or retweets another vertices tweet, they create an edge. This data set was large, with 13,548 edges between vertices, 4,844 unique tweets, and 1,319 unique vertices. In addition, the 126 reflective blog posts submitted to the TMathC archive were downloaded at the end of September.

Analyzing this data using SNA provided a quantitative picture of the networking and communication trends at the whole network, cluster, and individual level. The SNA examination categorized and quantized the interactions among individuals into edges.
between pairs of vertices. These edges, with a vertex at each end, form the basis for the quantitative analysis. The analysis consisted of calculating the cluster and individual vertex communication for the entire network of all participants.

In the quantitative analysis, the network was found to have a tight crowd structure, in which there were several large clusters that were connected to other clusters through multiple edges. The large number of edges between clusters is essential to the tight crowd label. Further, the betweenness centrality measure divided the 1,319 unique vertices into three categories of the top 1%, the next 9%, and the bottom 90% scores for comparisons. The 13 vertices in the 1% group existed in six different clusters, and shared characteristics with the 9% and 90% groups like blogging activity. Only 420 or 31.8% of the participants had a betweenness centrality above zero, which indicated that only about one third of all participants contributed to most of the network communication. The quantitative analysis did not address what was actually said in the communication, however, which led to the need for qualitative analysis.

The method chosen for qualitative analysis was Cultural-Historical Activity Theory (CHAT) as an analytical framework. CHAT was chosen to be a framework, and not a qualitative lens, in order to mitigate the limitation of being an insider to the community. CHAT provides a rich and complex framework for qualitative analysis of the blogs and tweets created by all participants. Selecting CHAT as the framework allowed for the elements of activity to be examined: the mediating artifacts, individuals, rules, community, division of labor, objects of learning and the outcome of the system. This broad look at the different elements of human activity encouraged the analysis to be
comprehensive enough to examine the relationships between different groups, while specific enough to determine individual patterns.

In the qualitative analysis, the complexity of the activity of conference attendance was uncovered. The remote and attending participants engaged in a complex community, which created and shared content from multiple types of sessions, while exhibiting behaviors of gratitude and active engagement. The activity of individuals and community was focused on objects of learning that fell into two main categories, learning for personal or professional growth, or learning to improve learning in the participants’ classrooms. The outcome of the activity was narrowly focused on the learning of the participants to improve skills of teaching.

In the mixed methods analysis, the quantitative analysis was used to inform the qualitative analysis, as well as the reverse. One of these analyses divided the qualitative data into the top 1%, next 9%, and the bottom 90% of activity based upon all participants betweenness centrality and compared these subcategories. In addition, the quantitative analysis was reexamined based upon self-identified first-time compared to experienced attending participants. In the mixing of the data, it was observed that the different groups were more similar than different. The networking behaviors of the first-time attendees were highly similar to the behaviors of the experienced attendees and the content of the tweets of remote compared to attending participants was also highly similar.

#Implications of the Study

#Implications: #Methodological Implications

The methodology employed in this study has important implications for the scholarship of conferences and understanding their networks and activity. Educational
conferences are incorporating Twitter into their standard practice by promoting a common conference hashtag and encouraging educators who use social media to use the hashtag when they tweet. Educators then use the common hashtag to search for content, and communicate with remote and attending participants. This usage of Twitter creates a Network of communication, where attending and remote participants can be categorized in different groups such as the 1-9-90% used in this study. Further, there may be clusters of all participants centered on different as a whole can be categorized into one of the six different communication patterns described by Smith et al. (2014). These networking patterns exist through the quantitative process used to analyze Twitter discussions. However, while every conference creates a network, not every conference or network forms a community.

Combining SNA with CHAT as a mixed methods analysis creates a way to understand the network of all the participants, while simultaneously delving deeply into the human activity of conference participation. Connecting the network to the individuals, rules, community, division of labor, objects of learning, and artifacts demonstrate how the attendees interact with remote participants, as well as how the community is created and propagated. A conference, which does not create a community, would be a conference without a core element of human activity. The mixed methods model employed in this study demonstrated how the quantitative method of SNA and the qualitative method of CHAT informed each other, focused on critical information, and highlighted the information each method alone may have missed. These methods could be modified to include other networks as well as different social networks.
Some also assume that in today’s socially networked world, educational conferences are learning communities composed of dynamic, complex networks. This assumption may be false. To substantiate the assumption of a learning community, the network should be analyzed to determine the nature and content of the connections to determine the expansive culture of the conference. This complex analysis can be done through the mixed methods of SNA and CHAT. While an SNA analysis may demonstrate the network which exists at an educational conference, it cannot show the interaction among remote and attending participants, first-time or experienced attendees, or any other group of participants. Likewise, a CHAT analysis on its own cannot show the way in which participants communicate and create a network. Through a mixing of the two methods, the complexity of the networks of educational or other conferences can be fully realized.

**#Implications: #Hashtag Creation for Conferences**

Hashtags are frequently ignored resources at conferences. At TMathC, hashtags played a crucial role in allowing remote participants the ability to find content, and they also spurred attending participants to engage at a greater rate. Attending participants tweeting with more regularity also gains the attention of remote participants, which creates a cycle of engagement. Having a conference hashtag was not sufficient to create this engagement. The keynotes that had a clear, identifiable hashtag had greater Twitter activity, as did the sessions. This analysis strongly suggests that every keynote and presentation have its own hashtag at a large conference.

This was true in July 2017 when the character count of a tweet was 140 and space for hashtags was limited. In November 2017, Twitter doubled the length of a tweet to 280
characters, providing more characters for content and hashtags alike (Rosen, 2017). With these additional characters, a conference should have multiple hashtags prearranged and a plan for communicating them. For example, national conferences should have an overarching conference hashtag as well as several others, to allow for effective searching.

Consider an hypothetical remote participant trying to find information from the 2019 NCTM Annual Meeting & Exposition with attendance on the conference strand of assessment (National Council of Teachers of Mathematics, n.d.). The only conference hashtag offered by NCTM was #NCTMSD2019, therefore the hypothetical remote participant’s only option is to search for ‘#NCTMSD2019 AND assess.’ A tweet using any other term such as ‘evaluate’ or ‘measure’ would be excluded. By having only a main conference hashtag, conference organizers set up a situation where content relevant to individuals is hidden in plain sight. An implication is therefore to have at least published hashtags for the conference, the strands, and the invited speakers. In addition, the conference organizers should ask attending participants to include both hashtags in their tweets and encourage speakers in those strands to remind participants of the hashtags. One purpose of hashtags is to allow for the searching and organization of information, and one hashtag is not enough to sort thousands of tweets, on multiple strands, over hundreds of sessions, spread out over multiple days (Zappavigna, 2015, 2018).

Conference organizers must also consider hashtag ‘creep’ when planning hashtags. People typing on phones shorten words and hashtags to make typing easier, and shortening a hashtags creates confusion when searching. To overcome this, individuals often include multiple hashtags because of the confusion hashtag creep creates, “Loved presenting @Flipgrid during #NCTMSD2019 Thank you to everyone who attended the
session!!! #NCTMSD19 #NCTM2019 #NCTM19” (Bennett, 2019). This tweet from a recent conference demonstrates the outcome of hashtag creep. The author used four different hashtags to refer to the same event. The published hashtag was the longest and most complex, and therefore participants created simpler, shorter tags to minimize typing. Conference organizers should start with a simple, more accessible hashtag, and encourage users to add additional, planned hashtags that contribute to searching and finding of content.

#Implications: #1TMCThings Analogues

A characteristic objective of conference attendance is learning, however, conferences have not typically asked attending or remote participants to share their learning goals. TMathC had a hashtag used to identify the one ‘thing’ the participant was planning on doing or practicing after the conference. The hashtag appeared in blog posts to identify larger goals, with many participants having two or three ‘1 things.’ By focusing all participants on identifying one thing they learned and wanted to implement, the conference was able to encourage actions after the conference was over. All educational conferences should have all participants identify at least one actionable item to implement in their classroom practice. This would not need to be a hashtag, nor would it need to be shared on social media, but there should be an active discussion on the topic of the thing or things participants are planning on implementing.

Conference organizers should encourage participants to share their ‘things,’ however. The goal of creating a public space, inside the conference, on social media, or both, would be to shift the conference away from a passive place where educators go to ‘sit and get’ information, towards the ideal of an active event where educators go to find
ideas they can implement in their practice. A benefit to having the discussion on social media is that conference organizers could download the activity of their selected hashtag, and ask educators a month or two later how their implementation was going. Whether the space for the ‘one thing’ discussion occurs on social media or in a physical space, follow-up and further discussion of the goals is important. This practice would extend the conference activity by several months, increasing its value to the participants. Conference organizers should create this learning goal early, and ask participants to engage with the idea before, during, and after the conference.

**#Implications: Virtual Filing Cabinet (#VFC)**

Conferences should also create a virtual space where sharing files and content is streamlined, encouraged, and open to all participants, not only presenters. Many conferences create space on their official website for presenters to post the slide deck of their presentation. TMathC went beyond this practice and had a wiki site where all participants could post links and files for others to view or download. Many tweets each day were statements like, ‘the wiki has been updated for our session.’ Since the wiki site was accessible to all participants, it became the one place to go to for all session information and was updated regularly. In addition, all participants could request posting access and upload files or links, adding further value to the site and, by connection, the conference. Having space where all participants can access and upload materials further shifts participants from passive consumers of information to active creators and sharers of information.

An implication of having a virtual filing cabinet for a conference is that all participants, remote and attending, as well as presenters can share files, images, and links
to resources equally. The boundary between the presenter and audience weakens, and all participants can be encouraged to share what they know or have created. Further, by adding in the message that all teachers have ideas, content, and expertise to share, participants can be encouraged to add to the collective body of knowledge on a topic.

That this virtual filing cabinet could be organized along similar lines as the hashtags and conference strands further reinforces the searchability and the ease of finding information. The strength of this implication is the shifting of conference attendance from the passive activity of simply attending sessions, to the active process of collaboration, building of knowledge, and sharing those constructions so the cycle can continue.

Without a shared space in which to work, each participant might end up learning alone.

#Implications: Building #Community

Some major educational conferences like the National Council of Supervisors of Mathematics (NCSM) annual conference boast of having 2000 attendees, while others like the NCTM annual conference claims an attendance of over 8000, yet both have very little remote participation. Harnessing the power of social networking as TMathC has done could have a deep impact on thousands of mathematics educators who could share in the wealth of great ideas explored by attending participants. Further, large numbers of remote participants could be transferred into future attending participants, greatly benefiting the mathematics community at large.

As was pointed out in the methodological implication, every conference creates a network, but not every network results in a community. A community is a complex human activity that has rules, divisions of labor, individuals, tools, and goals. If conference organizers wanted to make the outcome of conference activity the creation of
a community, they must consider all of the elements. The conference organizers should think about implementing rules such as:

1. ‘Show gratitude.’ This rule could be put in place through having thank you cards available from day one so that any participant could pick up a card and write a note of appreciation to any other participant. The physical act of thanking others could be mirrored on the network by encouraging participants to thank others on social media for sessions, ideas, or support.

2. ‘Email home.’ All participants are encouraged to send two ideas each day to their colleagues in their home locations. While not every participant utilizes social media, almost everyone in the 21st century has email access. Participants would be asked to take two ideas each day and email them to colleagues. If a group were attending together, they would be asked to collaborate and send one collective email to their colleagues. The goal of this rule would be to extend the learning outside and away from the conference, and invite and encourage remote attendance through invitation. This rule would push the conference into the attendees’ existing community.

3. ‘Help others.’ Each participant would be asked to find one other participant who will commit to helping and holding them accountable for their OneThing. Each participant would identify an idea, task, lesson, or other learning goal, commit to implementing the goal, and find another participant to follow up and make sure they are implementing the goal. This rule encourages participants to talk and share their goals, creating personal connections and fostering relationships.

The conference organizers would also have to plan the tools and artifacts for the conference aligned with the goal of community building. Besides having a virtual filing
cabinet and hashtags for the conference, the organizers should think about dedicated space at the conference for discussion of topic strands. For each strand of the conference, have consistent space dedicated to the topic, and have whiteboards or chart paper with challenges for participants to accomplish for each of the strands. Physical space for working together fosters relationship building, which contributes to community building. Additionally, the items created at the physical spaces must be shared to the conference community regularly. Social networking provides one way of sharing, but the conference context may provide other methods.

The conference organizers must also consider how the division of labor occurs. If attending participants are only passive consumers of information, the community might struggle to form. The organizers must create ways to engage the attendees in active roles in the conference. Whether active roles occur through short, small sharing opportunities such as TMathC’s My Favorites, or some other process, the importance of not dividing the labor along the lines of presenters and attendees cannot be stressed enough. Participants should feel like they have a role in the labor and production of the conference, not only the consuming of information. This may be accomplished more easily at small conferences; it must also be accomplished at large conferences to build a productive community.

**Future #Questions**

The research and implications in this study generate other questions, as is common in worthwhile research. While every interaction between individuals forms networks, identifying the types of networks, which educators form at educational conferences, creates questions about the dynamics and activity of participation. An
important series of questions is whether other TMathC conferences have similar
relationships among the patterns of communication and activity as TMathC in 2017.
Collecting data and doing a similar analysis on TMathC 2018 or other TMathC
conferences would provide confirmation or disconfirmation of this study. While the
sample data for the 2017 conference was ample in quantity, it was still only one-year’s
worth of data. Repeating this mixed methods analysis on subsequent years could confirm
this analysis. In addition, collecting data on NCSM, NCTM, or Association of
Mathematics Teacher Educators (AMTE) conferences and investigating this data using
similar methods could create comparisons between conferences of different sizes and
populations. Further, are the behaviors and outcomes found in mathematics teachers’
conference similar to conferences of other types of educators, or even non-educators?
While there is nothing obviously unique about the interactions found in this study in
relation to mathematics teachers, studying other non-mathematics teacher conference
participation could show differences. The method described in this study of quantitative
SNA and qualitative CHAT analysis provides a rich methodology for uncovering the
activity at conferences beyond mathematics teachers or educator conferences.

Another type of question, which arises from this study, is whether the application
of the implications of this study contributes to the creation of community among
conference participants. Answering this question would require studying a conference
both pre and post implementation, and while time consuming, would add to the literature
on how educators create learning communities at conferences.
#Conclusion: The Outcome of Teachers Learning from Each Other

As education and technology advance, social media use by educators will also advance, and conferences are actively incorporating the technology into their platforms. The practices found through this study of sharing, gratitude, effective hashtag use, and personal and professional growth can inform future conferences and their development. Taking what worked from TMathC and incorporating those features into other conferences through their social media strategies will help future conferences create communities of their own for their participants’ growth and development. Helping conferences develop their participants matters, because those individuals are also teachers of children, who deserve the best teachers we can develop.
References


Bennett, A. [sweetteacherabc]. (2019, April 7). Loved presenting @Flipgrid during #NCTMSD2019 Thank you to everyone who attended the session!!! #NCTMSD19 #NCTM2019 #NCTM19 [Tweet]. Retrieved April 7, 2019, from @sweetteacherabc website: https://twitter.com/sweetteacherabc/status/1114918204202053632


*Every student succeeds act. , § 8002(42)(A) - (B) (2015).*


Levin, B., ben. levin@utoronto.ca. (2012). Why don’t we learn at education conferences? Phi Delta Kappan, 94(3), 74–75.


Appendix A: § 8002(42)(A) - (B) (2015) of the ESSA

(42) PROFESSIONAL DEVELOPMENT.—The term ‘professional development’ means activities that—

(A) are an integral part of school and local educational agency strategies for providing educators (including teachers, principals, other school leaders, specialized instructional support personnel, paraprofessionals, and, as applicable, early childhood educators) with the knowledge and skills necessary to enable students to succeed in a well-rounded education and to meet the challenging State academic standards; and

(B) are sustained (not stand-alone, 1-day, or short term workshops), intensive, collaborative, job-embedded, data-driven, and classroom-focused, and may include activities that—

(i) improve and increase teachers’—

(I) knowledge of the academic subjects the teachers teach;

(II) understanding of how students learn; and

(III) ability to analyze student work and achievement from multiple sources, including how to adjust instructional strategies, assessments, and materials based on such analysis;

(ii) are an integral part of broad schoolwide and districtwide educational improvement plans;

(iii) allow personalized plans for each educator to address the educator’s specific needs identified in observation or other feedback;

(iv) improve classroom management skills;
(v) support the recruitment, hiring, and training of effective teachers, including teachers who became certified through State and local alternative routes to certification;

(vi) advance teacher understanding of—

(I) effective instructional strategies that are evidence-based; and

(II) strategies for improving student academic achievement or substantially increasing the knowledge and teaching skills of teachers;

(vii) are aligned with, and directly related to, academic goals of the school or local educational agency;

(viii) are developed with extensive participation of teachers, principals, other school leaders, parents, representatives of Indian tribes (as applicable), and administrators of schools to be served under this Act;

(ix) are designed to give teachers of English learners, and other teachers and instructional staff, the knowledge and skills to provide instruction and appropriate language and academic support services to those children, including the appropriate use of curricula and assessments;

(x) to the extent appropriate, provide training for teachers, principals, and other school leaders in the use of technology (including education about the harms of copyright piracy), so that technology and technology applications are effectively used in the classroom to improve teaching and learning in the curricula and academic subjects in which the teachers teach;

(xi) as a whole, are regularly evaluated for their impact on increased teacher effectiveness and improved student academic achievement, with the findings of the evaluations used to improve the quality of professional development;
(xii) are designed to give teachers of children with disabilities or children with developmental delays, and other teachers and instructional staff, the knowledge and skills to provide instruction and academic support services, to those children, including positive behavioral interventions and supports, multi-tier system of supports, and use of accommodations;

(xiii) include instruction in the use of data and assessments to inform and instruct classroom practice;

(xiv) include instruction in ways that teachers, principals, other school leaders, specialized instructional support personnel, and school administrators may work more effectively with parents and families;

(xv) involve the forming of partnerships with institutions of higher education, including, as applicable, Tribal Colleges and Universities as defined in section 316(b) of the Higher Education Act of 1965 (20 U.S.C. 1059c(b)), to establish school-based teacher, principal, and other school leader training programs that provide prospective teachers, novice teachers, principals, and other school leaders with an opportunity to work under the guidance of experienced teachers, principals, other school leaders, and faculty of such institutions;

(xvi) create programs to enable paraprofessionals (assisting teachers employed by a local educational agency receiving assistance under part A of title I) to obtain the education necessary for those paraprofessionals to become certified and licensed teachers;
(xvii) provide follow-up training to teachers who have participated in activities described in this paragraph that are designed to ensure that the knowledge and skills learned by the teachers are implemented in the classroom; and

(xviii) where practicable, provide jointly for school staff and other early childhood education program providers, to address the transition to elementary school, including issues related to school readiness.
Appendix B: TMathC 2017 Program

Thursday, July 27th
8:00 – 9:00 am  Registration, Dining Hall
8:15 – 8:45 am  Intro to TMC, Julie Reulbach and Glenn Waddell, Jr., Room 700
9:00 – 9:25 am  Opening Session, Dining Hall

9:30 – 11:30 am Morning Sessions
Room 717  Talk Less, Smile More: Discussion in Math Class – Matt Baker and Chris Luzniak
Room 614  Mathematical Yarns - David Butler and Megan Schmidt
Room 618  Rich Tasks Demand Rich Implementation to Maximize Student Learning - Peg Cagle, Cal Armstrong, and Bill Thill
Room 716  What is the relationship between the Standards for Mathematical Practice & equity? - Grace Chen, Brette Garner, and Sammie Marshall
Room 714  Socratic Seminars in the Math Classroom - Of Course!!! – Tara Daas
Room 712  Hinge Questions - Nik Doran
Room 710  The Co-teaching Tango - Andrew Gael, Melynee Naegele, and Tina Cardone
Room 708  Using Cooperative Learning Strategies to Incorporate Group Work in the Math Classroom - Sarah Martin
Room 711  Playing with Exeter Math - Wendy Menard, Danielle Reyicer, and Jasmine Walker
Room 611  Math Coaches Huddle - Chris Shore and Pierre Tranchemontagne
Room 706  Unpacking and Creating Connecting Representations Tasks - Megha Singh, Margarite Yuelys, and Kaitlin Ruggiero
Room 700  Differentiating CCSS Algebra 1 — from drab to fab using Exeter Math 1 & Exploratory Talk - Elizabeth Statmore
Room 624  Become a Classroom Chef - John Stevens and Matt Vaudrey, Mullet Extraordinaire

11:30 am – 1:00 pm  Lunch (on your own)

1:00 – 1:30 pm  Afternoon My Favorites, Dining Hall

1:30 – 2:30 pm  Keynote, Dining Hall
The Politics(?) of Mathematics Teaching - Grace Chen
Thursday, July 27th

2:45 – 3:45 pm Afternoon Sessions

Room 611  Algebra Tiles and Area Models - Mary Bourassa and Sheri Walker
Room 614  A Teacher's Guide to Action - Andrew Browning-Couch
Room 712  Developing Concepts in Middle School; an Illustrative Mathematics Curriculum Delve. - Nik Doran and Kate Nowak
Room 618  Differentiation and Student Choice - Megan Dubee
Room 617  The Pigeonhole Effect: Undoing the Manipulative Trap through Flexible Representations - Graham Fletcher and Joe Schwartz
Room 708  SmudgedMath: Blurring tasks sparks mathematical curiosity, conversation and critique - Norma Gordon
Room 624  What is university math? A lightning answer with pictures. – Edmund Harriss
Room 710  From Calculus Zero to Calculus Hero in 60 Minutes - Chase Orton
Room 711  Mathematicians are Not Just White Dudes - Annie Perkins and Jonathan Osters
Room 706  Reaching the Full Range - Henri Picciotto
Room 714  "An Object to Think With": The whole body as a tool for mathematical sense making - Malke Rosenfeld and Max Ray-Riek
Room 714  Exploring a Researched Informed Framework for Teaching Fractions - Pierre Tranchemontagne
Room 716  Teach Me How to Factor: AKA My Favorite Unit - Anna Vance
Room 717  Bridging elementary skills & concepts to high school & beyond

4:00 – 4:30 pm Afternoon Sessions

Room 614  Expos: Student Presentations in Math Class - Matt Baker and Kat Glass
Room 618  A Half Hour of COOL! - Sadie Estrella
Room 620  Did My Students Actually Learn Anything Today? - Dylan Kane
Room 706  One Task + 4 Beanbags = So Many Entry Points! - Bob Lochel
Room 700  Micro-decisions in Questioning - David Petersen
Room 708  Radio Free Mathematics - David Petro and Amy Zimmer
Room 711  Spiraling Algebraic Art - Megan Schmidt and Stephen Weimar
Room 710  Fraction Operations: From Arithmetic to Problem Solving – Lisa Soltani
Room 712  Pimp My Worksheet - Sara Vaughn and Lydia Kirkman
Room 714  Discovery Learning in Calculus - Jasmine Walker
Room 717  Informative Formative Assessment - Mary Williams

4:30 – 5:00 pm Speed Dating, Dining Hall
Friday, July 28th
9:00 – 9:30 am Morning My Favorites and Announcements, Dining Hall
9:30 – 11:30 am Morning Sessions (same as Thursday)

11:30 am – 1:00 pm Lunch (on your own)

1:00 – 1:30 pm Afternoon My Favorites, Dining Hall
1:30 – 2:30 pm Keynote, Dining Hall
All I Really Need To Know I Learned From The MTBoS...Not Really, But Close - Graham Fletcher

2:45 – 3:45 pm Afternoon Sessions
Room 618  Documenting Student Progress - Cal Armstrong
Room 611  Standards Based Grading in a Traditional Setting - Jennifer Brackney and Tony Riehl
Room 614  Textbook Exercise Renovation: From Rote to Rich - Gary Brown
Room 706  One Hundred Factorial: Playful and joyful maths - David Butler
Room 624  SMPs: leading learners to level up - Jill Gough
Room 711  Significant Statistics - Kerry Gruizenga
Room 700  Learning from Children's Mathematical Play at Math On-A-Stick - Ilana Horn, Christopher Danielson, and Lara Heiberger
Room 710  A Trig Exploration: Exact Values and the Golden Triangle – Rachel Kernodle, Jamie Collie, and Molly Tanner
Room 712  The Big Ideas Of Algebra Are Just Fancy Counting - Brian Miller
Room 708  So Much and yet So Little Time- Making the Most of the Elementary Math Block - Nicole Paris
Room 716  Teachers as Advocates: A How To - Max Ray-Riek and Peg Cagle
Room 617  Using Google Apps for more engagement in math - Venetia Ricchio
Room 714  Am I Asking the Right Questions? - Pam Wilson

Friday, July 28th
4:00 – 5:00 pm Afternoon Sessions
Room 624  Finding a "Place" for Place Value – Devin Anderson CANCELLED
Room 710  Finding the Words: Learning the Universal Language of Mathematics - Tina Cardone
Room 617  Rational Function Graphs for Dummies - Meg Craig and Sheri Walker
Room 611  Making Practice and Review Activities Fun! - Jennifer Fairbanks
Room 700  Statistics and Probability for the Terrified MS Teacher – Shauna Hedgepeth and Joel Bezaire
Room 716  Coaching Partnerships - Megan Holmstrom and Ryan Grady
Room 714  A Step To The Left – Navigating and Understanding Sequences - Doug McKenzie
Room 706  Engaging the Reluctant Colleague - Scott Miller and Bob Lochel
Room 712  Engagement + Enjoyment = Learningment - Anya Ostapczuk, Lydia Kirkman, and Sara Vaughn
Room 614  CO + DE = MATH - Stephanie Reilly and Tamar McPherson
Room 708  Context for Learning - Jenise Sexton
Room 717  The Clothesline: The Master Number Sense Maker for Secondary - Chris Shore
Room 711  Expanding Professional Learning - Steve Weimar, Dylan Kane, and Megan Schmidt

Saturday, July 29th
9:00 – 9:30 am Morning My Favorites and Announcements, Dining Hall
9:30 – 11:30 am Morning Sessions (same as Thursday and Friday)

11:30 am – 1:00 pm Lunch (on your own)

1:00 – 1:30 pm Afternoon My Favorites, Dining Hall
1:30 – 2:30 pm Keynote, Dining Hall
Hitting The Darn 'Send' Button - Carl Oliver

2:45 – 3:45 pm Afternoon Sessions
Room 708  Assessing and grading workgroup - Anna Blinstein
Room 624  Calculus for the Algebra Teacher – Jonathan Claydon
Room 710  Going Vertical - How I started using #VNPS - Jennifer Fairbanks and Kathy Campbell
Room 717  Sense-Making: Is It at the Core of Your Classroom? - Annie Fetter
Room 618  Exploring the Progression of Order Through Game Play – John Golden and Joe Schwartz
Room 712  Exploring Base Eight - Kent Haines
Room 614  Breakout EDU Challenge: Can you open the box in time?! – Alison Hansel and Jacqueline Richardson
Room 711  Math Teachers: Raid the Physics Lab! - Megan Hayes-Golding
Room 700  Practical Ideas on the Kind of Coaching We Need to Provide and Demand - Steve Leinwand
Room 706  An Hour of Codebreaking - Bob Lochel
Room 617  Debates in Math Class - Ethan Weker
Room 611  Pulling it all Together: How Implementing Ideas from Make it Stick Unified My Teaching Philosophy - Anna Vance

4:00 – 5:00 pm Flex Sessions, TBD

Sunday, July 30th
9:00 – 11:00 am My Favorites and Closing, Dining Hall
Appendix C: TMathC Wiki Page Index

This index can be found online at http://twittermathcamp.pbworks.com. All links are clickable.

Welcome to the TMC Wiki!

TMC 2017

TMC 2017 took place July 27-30, 2017 at Holy Innocents' Episcopal School in Atlanta, Georgia. This wiki houses what our morning session groups created and shared, information from our afternoon presentations and "My Favorites," as well as subsequent ideas and refinements.

TMC17 Morning Session Pages
TMC17 Presentations (Afternoon Sessions and "My Favorites")
TMC17 Participant Blogs
TMC17 Participant Twitter List
TMC17 Recap and Reflection Blogposts
TMC17 Shutterfly Site

Here are the 2017 Morning Session Pages:

Rich Tasks, Rich Teaching Morning Session
Talk Less, Smile More: Debate & Discussion in Math Class – Matt Baker and Chris Luzniak
Mathematical Yarns - David Butler and Megan Schmidt
Rich Tasks Demand Rich Implementation to Maximize Student Learning - Peg Cagle, Cal Armstrong, and Bill Thill
Socratic Seminars in the Math Classroom - Of Course!!! – Tara Daas
Hinge Questions - Nik Doran
The Co-teaching Tango - Andrew Gael, Melynee Naegele, and Tina Cardone
Using Cooperative Learning Strategies to Incorporate Group Work in the Math Classroom - Sarah Martin
Playing with Exeter Math - Wendy Menard, Danielle Reycker, and Jasmine Walker
Math Coaches Huddle - Chris Shore and Pierre Tranchemontagne

Unpacking and Creating Connecting Representations Tasks - Megha Singh, Margarite Yuelys, and Kaitlin Ruggiero

Differentiating CCSS Algebra 1 — from drab to fab using Exeter Math 1 & Exploratory Talk - Elizabeth Statmore

Become a Classroom Chef - John Stevens and Matt Vaudrey

From Calculus Zero to Calculus Hero in 60 Minutes - Chase Orton

Please feel free to create your own page for your TMC17 presentation.

*This is a public wiki so you do not need permission to join.*

The easiest way to create a page (linked to this page) is:

1. Hit the edit button at the top of this page. (next to VIEW)
2. Find your session under the appropriate day.
3. Hi-light the name of your session and hit ADD LINK above.
4. When you do this, the name of your page will show up in a pop-up box, hit ENTER on your keyboard.
5. Hit SAVE at the bottom on the page.
6. Click on your new link. It will make the new page for you, all you have to do is click on Create Page. You do not have to put it in a folder.
7. Hit SAVE and CONTINUE once you create your new page so that it will be saved on the wiki.

Thursday, July 27th

1:00 - 1:30 My Favorites

**Thursday Lunch** and **Thursday Lunch Update** - Lisa Henry

**Two Teacher Hacks: You Gotta Ring Them Bells & Never Forget Exit Slips Again** - Sam Shah

1:30 – 2:30 pm Keynote

The Politics(?) of Mathematics Teaching - Grace Chen

2:45 – 3:45 pm Afternoon Sessions

**Algebra Tiles and Area Models** - Mary Bourassa and Sheri Walker
A Teacher's Guide to Action - Andrew Browning-Couch
Developing Concepts in Middle School; an Illustrative Mathematics Curriculum Delve. - Nik Doran and Kate Nowak
Differentiation and Student Choice - Megan Dubee
The Pigeonhole Effect: Undoing the Manipulative Trap through Flexible Representations - Graham Fletcher and Joe Schwartz
SmudgedMath: Blurring tasks sparks mathematical curiosity, conversation and critique - Norma Gordon
What is university math? A lightning answer with pictures. – Edmund Harriss
From Calculus Zero to Calculus Hero in 60 Minutes - Chase Orton
Mathematicians are Not Just White Dudes - Annie Perkins and Jonathan Osters
Reaching the Full Range - Henri Picciotto
"An Object to Think With": The whole body as a tool for mathematical sense making - Malke Rosenfeld and Max Ray-Riek
Exploring a Researched Informed Framework for Teaching Fractions - Pierre Tranchemontagne
Teach Me How to Factor: AKA My Favorite Unit - Anna Vance
Bridging elementary skills & concepts to high school & beyond - Glenn Waddell, Jr.

4:00 – 4:30 pm Afternoon Sessions
Expos: Student Presentations in Math Class - Matt Baker and Kat Glass
A Half Hour of COOL! - Sadie Estrella
Did My Students Actually Learn Anything Today? - Dylan Kane
One Task + 4 Beanbags = So Many Entry Points! - Bob Lochel
Micro-decisions in Questioning - David Petersen
Radio Free Mathematics - David Petro and Amy Zimmer (longer list of podcasts here)
Spiraling Algebraic Art - Megan Schmidt and Stephen Weimar
Fraction Operations: From Arithmetic to Problem Solving – Lisa Soltani
Pimp My Worksheet - Sara Vaughn and Lydia Kirkman
Discovery Learning in Calculus - Jasmine Walker
Informative Formative Assessment - Mary Williams

Friday, July 28th
9:00 – 9:30 am Morning My Favorites
What Else Can Google Slides Do? Jennifer Fairbanks

SQWIGLES: Guiding One-on-One Teaching - David Butler
  • Prezi presentation online
  • Blog post about SQWIGLES

1:00 – 1:30 pm Afternoon My Favorites
Dynamic Web Sketches - David Petro
Make a Difference Monday & 5 Things - Pam Wilson

1:30 – 2:30 pm Keynote
All I Really Need To Know I Learned From The MTBoS...Not Really, But Close - Graham Fletcher

2:45 – 3:45 pm Afternoon Sessions
Documenting Student Progress - Cal Armstrong
Standards Based Grading in a Traditional Setting - Jennifer Brackney and Tony Riehl
Textbook Exercise Renovation: From Rote to Rich - Gary Brown
One Hundred Factorial: Playful and joyful maths - David Butler
SMPs: leading learners to level up - Jill Gough
Significant Statistics - Kerry Gruizenga
Learning from Children's Mathematical Play at Math On-A-Stick - Ilana Horn, Christopher Danielson, and Lara Heiberger
A Trig Exploration: Exact Values and the Golden Triangle – Rachel Kernodle, Jamie Collie, and Molly Tanner
The Big Ideas Of Algebra Are Just Fancy Counting - Brian Miller
So Much and yet So Little Time- Making the Most of the Elementary Math Block - Nicole Paris
Teachers as Advocates: A How To - Max Ray-Riek and Peg Cagle
Using Google Apps for more engagement in math - Venetia Ricchio
Am I Asking the Right Questions? - Pam Wilson and BONUS Teacher Hacks

4:00 – 5:00 pm Afternoon Sessions
Finding a "Place" for Place Value - Devin Anderson
Finding the Words: Learning the Universal Language of Mathematics - Tina Cardone
Rational Function Graphs for Dummies - Meg Craig and Sheri Walker
Making Practice and Review Activities Fun! - Jennifer Fairbanks
Google Slide with more info on my session - Jennifer Fairbanks
Statistics and Probability for the Terrified MS Teacher – Shauna Hedgepeth and Joel Bezaire
Coaching Partnerships - Megan Holmstrom and Ryan Grady
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Engaging the Reluctant Colleague - Scott Miller and Bob Lochel
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CO + DE = MATH - Stephanie Reilly and Tamar McPherson
Context for Learning - Jenise Sexton
The Clothesline: The Master Number Sense Maker for Secondary - Chris Shore
Expanding Professional Learning - Steve Weimar, Dylan Kane, and Megan Schmidt

Saturday, July 29th
9:00 – 9:30 am Morning My Favorites

1:00 – 1:30 pm Afternoon My Favorites
Having Students Practice with a Continuum - David Petro

1:30 – 2:30 pm Keynote
Hitting The Darn 'Send' Button - Carl Oliver

2:45 – 3:45 pm Afternoon Sessions
Assessing and grading workgroup - Anna Blinstein
Calculus for the Algebra Teacher - Jonathan Claydon
Going Vertical - How I started using #VNPS - Jennifer Fairbanks and Kathy Campbell
Sense-Making: Is It at the Core of Your Classroom? - Annie Fetter
Exploring the Progression of Order Through Game Play – John Golden and Joe Schwartz
[Math game adapted for K-12+]
Exploring Base Eight - Kent Haines
BreakoutEDU Challenge – Alison Hansel and Jacqueline Richardson
Math Teachers: Raid the Physics Lab! - Megan Hayes-Golding
Practical Ideas on the Kind of Coaching We Need to Provide and Demand - Steve Leinwand

An Hour of Codebreaking - Bob Lochel

Debates in Math Class - Ethan Weker

Pulling it all Together: How Implementing Ideas from Make it Stick Unified My Teaching Philosophy - Anna Vance

4:00 – 5:00 pm Flex Sessions

Sunday, July 30th

9:00 – 11:00 am My Favorites

Mixed, Spaced Practice Homework Sheets - Debbie Boden