Math Is All Around Us: Exploring the Teaching, Learning, and Professional Development of Three Urban Mathematics Teachers

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The MSUrbanSTEM fellowship program aims to support science, technology, engineering, and mathematics (STEM) educators teaching in an urban context. In this article, the authors used a multiple case studies methodology to examine the qualitatively different ways three urban mathematics educators implemented a yearlong project in their mathematics classrooms to support student learning. Through the use of innovative professional development offered by the MSUrbanSTEM instructors, these Chicago Public School (CPS) educators focused their projects around the idea of wonder, disciplinary focus, and strategic technology integration to transform their instruction and practice in their schools.

INTRODUCTION

The urban context of teaching is challenging and often receives negative press coverage around challenges teachers and students face in this environment, including large class sizes, lack of adequate resources, and teacher shortage (Stairs, Donnell & Dunn, 2012). The purpose of this article is to share the experiences of three urban school mathematics teacher MSUrbanSTEM fellows who despite the challenges they face, developed projects that provided meaningful learning opportunities for their students. We, the authors, aim to show that, through their participation in the MSU Wipro UrbanSTEM Leadership Teaching Fellowship program, these teachers demonstrated a commitment to their students, resourcefulness, and a desire to improve their teaching and student learning.

The MSUrbanSTEM program is a one-year fellowship program offered by Michigan State University in partnership and funded by Wipro Ltd. to selected Chicago Public Schools teachers. The goal of the MSUrbanSTEM program is to empower STEM teachers who teach in an urban context to create transformative, innovative, and multimodal instructional experiences for students. The program recognizes the challenges of teaching in urban settings. It offers a space for mathematics teachers, among others, to *explore* new ways to engage urban students in discipline-centered mathematics learning, *create* lessons and assessments using digital tools that foster authentic mathematics learning experiences for students, and *share* their work and practice publicly through the use of digital portfolios and social media.

MSUrbanSTEM Program - Teacher Professional Development in Urban Context

There are many reasons to account for student's poor performance, however in math, teachers have struggled to engage with the content and skills needed within that subject area (Goleman, 1995). The field of teacher professional development in mathematics is vast and much of what exists in the research centers around the development of pre-service teachers (Even & Ball, 2010). In 2014, the National Council for Teachers of Mathematics (NCTM) published *Principles to Actions* in response to the adoption of the Common Core State Standards for mathematics to provide teachers with the guidance necessary for successful implementation (Leinwand, Huinker, & Brahier, 2014). NCTM outlines six principles based on the latest research and evidence of excellent mathematics programs and calls for the support of

principals, coaches, specialists, and other school leaders in aiding teachers to realize these standards in the classroom (Leinwand, Huinker, & Brahier, 2014). The principles are as follows: teaching and learning, access and equity, curriculum, tools and technology, assessment, and professionalism (National Council for Teachers of Mathematics, 2014). Each of these six principles are meant to help shape and improve mathematics instruction and access to quality mathematics programs for all students. The MSUrbanSTEM program advances the professional development of mathematics teachers through principles closely related to those proposed by NCTM, though not developed in conjunction with NCTM. This program supports teachers in developing skills to apply these standards in their teaching via four focus areas of its program – urban teaching and learning (including performances of understanding), disciplinary focus, technology integration, and professional leadership. The program's commitment to access and equity is demonstrated through the explicit partnership with urban educators, many from under-resourced schools.

The MSUrbanSTEM program's approach to professional development centers a Deweyian experience (hands on) learning approach that utilizes technology in meaningful ways to support student learning. First, there is a focus on teaching and learning and on curriculum that is framed using Gardner's (1999) *The Disciplined Mind* conceptual framework, where Gardner promotes the importance of curriculum that encourages in depth fundamental questioning of existence. Work with the fellows primarily centered on the differences between mathematics as a subject matter and mathematics as a discipline encouraging the fellows to ground their work in disciplinary concepts by designing projects careful to consider both the prior knowledge and mathematical misconceptions of the students. Second, the MSUrbanSTEM approach to tools and technology utilizes the concept of TPACK (technological pedagogical content knowledge), a technology integration framework that engages fellows around ideas concentrated on the repurposing of technological tools, perhaps not originally intended for educational purposes, in creative ways to engage students in learning experiences. More Information about the MSUrbanSTEM program's approach to professional development can be read in the Seals, Mehta, Wolf, and Marcotte (2017) article of this issue.

Urban context is not just a backdrop for MSUrbanSTEM fellowship program; instead it is central to its professional development approach. Although there is no absolute consensus in the field among academics of what constitutes urban education or urban mathematics education (Milner, 2012; Martin & Larnell, 2013), Land and Stovall (2009) define urban as racialized

in reference to the majority of students of color who are in urban schools. Moreover, Irby (2015) shares that definitions of urban education must also consider "…the city and its intersection with cultural transformations, pedagogies, movements, and knowledge(s) that comprise educational processes" (p. 7).

Milner (2012) encourages researchers and practitioners to understand achievement and opportunity gaps that exist in urban education so that the needs of teachers and students in urban context can be supported. One framework Milner (2012) posits as an understanding of opportunity gaps include five elements which he describes as:

1. Colorblindness: When educators pretend to be color-blind, they are, in effect, constructing and enacting curriculum and instructional practices for students they see as incomplete rather than complete beings.
2. Cultural Conflicts: When educators operate primarily from their own cultural ways of knowing, the learning milieu can seem foreign to students whose cultural experiences are different from their teacher.
3. Myth of Meritocracy: many educators believe that their own success is merited because they have worked hard, followed the law, had the ability and skill, and made the right choices and decisions. They have little or no conception of how class and socioeconomic privilege and opportunity manifest.
4. Low Expectations and Deficit Mindsets: Low expectations and deficit mindsets can make it difficult for educators to develop learning opportunities that challenge students cognitively.
5. Context-neutral Mindsets and Practices do not allow educators to recognize deep-rooted and ingrained realities embedded in a particular place, such as a school in a particular community.

While MSUrbanSTEM programs's curricular and teaching approaches were not directly based on this framework, they do incorporate all the elements of it. The MSUrbanSTEM approach to professional development explicitly counters the deficit approach to teaching by providing teachers with support to address access and equity issues in their classroom context. One way in which support is provided for fellows teaching in this educational context is through social justice leadership training with an emphasis on action research.

As a person who teaches in an urban setting, Furman (2012) explains, "Leadership for social justice is conceived as a praxis, in the Freirean sense, involving both reflection and action" (p. 191). She states, "a common under-

standing among many leadership scholars is that social justice focuses on the experiences of marginalized groups and inequities in educational opportunities and outcomes" (p. 194). Through the course of the MSUrbanSTEM program, an emphasis is placed on allowing the fellows to explore projects that support minimizing the marginalization of students through the exploration of yearlong projects that address equity and or culturally appropriateness based on the context of the educational environment. Fellows are also encouraged to explore the idea of being change agents in their school. During the spring semester of the fellowship program, we read *Rocking the Boat* by Debra E. Meyerson. Here, Meyerson (2008) posited a framework described as "Tempered Radicalism", or "Everyday leaders". Such leaders are "quiet catalysts who push back against prevailing norms, create learning, and lay the groundwork for slow but ongoing organizational and social change." (Meyerson, 2008, p. 166). The program's extensive focus on leadership promotes these values in an effort to build sustainability of the MSUrbanSTEM tenets beyond the tenure of the fellowship program.

Discipline is another major tenet of the MSUrbanSTEM approach to professional development and the major way in which it combats approaches to teaching and learning with a deficit mindset. Howard Gardner (2006) speaks to this in his book, *Five minds for the future, where he* warns educators of that a subject matter approach produces ill effects noting how some secondary and collegiate level students cling to commonly held misconceptions that could easily be explained using concepts from their coursework. This approach is characterized by "committing to memory a large number of facts, formulas, and figures" (Gardner, 2006, p. 27). Gardner argues instead for the learning of disciplinary knowledge. He refers to disciplinary knowledge as "a distinctive way of thinking about the world" because, without it, the facts, formulas, and figures of subject matter knowledge just become "inert knowledge" (Gardner, 2006, p. 27-28; Whitehead, 1959, p. 197). MSUrbanSTEM recognized these teachers were already experts in their subject area and utilized that expertise in helping them develop yearlong project called the DreamIT wherein the fellows are encouraged to center the project around four major principles: 1) a big idea having enduring value beyond the classroom, 2) connected to a concept(s) central to the discipline (mathematics), 3) teaching focused on knowledge, concepts, and ideas that require "uncovering" instead of *covering* the curriculum, and 4) that will engage students. See Horton, Shack, and Mehta (2017) of this special issue to learn more about the DreamIT projects.

Another framework that is an integral part of the MSUrbanSTEM approach to professional development is the Technological Pedagogical Con-

tent Knowledge (TPACK) framework. TPACK stands for technological and pedagogical content knowledge (Mishra & Koehler, 2006) and is one way that educators can assess the effectiveness of technology integration. Teachers use TPACK to examine how teacher technology, pedagogy, and content knowledge intersect in the most meaningful way to support teaching and learning. TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques to teach content; knowledge of representations of understanding within a particular content area; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and strengthen pre-existing conceptual understanding (Graham, 2011).

In summary, the goal of the MSUrbanSTEM program is to empower STEM teachers in an urban context to create transformative, innovative, and multimodal instructional experiences for students. Regarding mathematics teaching, underlying themes that run throughout the MSUrbanSTEM approach to the teaching of learning of mathematics are purposeful technology integration, exposing and addressing students' mathematical misconceptions, and the creation of rich learning environments where many types of mathematical knowledge are valued and celebrated. As part of the fellowship program, students earn credit in a course offered at Michigan State University entitled CEP 805: Learning Mathematics with Technology. This course introduced the fellows to psychological and disciplinary perspectives on teaching and learning mathematics with a focus on understanding in urban contexts, as well as the role of technology in allowing for multiple representations of mathematical ideas, modeling, and authentic learning environments. MSUrbanSTEM fellows also spent a significant amount of time engaging in tasks specifically designed by the MSUrbanSTEM instructional team to challenge fellow thinking about what it means to teach, learn, and do mathematics. They explored various ways to transform curriculum, allowing students to engage in deep mathematical ideas beyond what most textbooks convey. This article explores the curriculum of three MSUrbanSTEM math teachers who used the concepts learned in their MSUrbanSTEM experience to develop year long learning projects for their students.

METHODS

This study uses a multiple case study method to explore the experiences of three mathematics teachers within the MSUrbanSTEM program.

This grounded theory approach (Strauss & Corbin, 1997) allows us not just to look at three individuals and share their experiences, but also to consider "how a phenomenon is influenced by the context within which it is situated." (Baxter & Jack, 2008). In other words, the multiple case study approach allows us to consider fellows' context (school, students, available resources, etc.) that had a direct impact on their teaching and learning. The research was guided by interest to answer the following research question: *In what observable ways have teachers demonstrated an exploration of mathematical, technological, pedagogical practices in planning and implementing their DreamIT projects?*

The selection of fellows was based on instructor recommendations. The selected fellows each brought unique perspectives and experiences that not only help to present different ways each experienced the MSUrbanSTEM program, but also illustrate some of the differences that exist among urban teachers and urban schools. The primary data sources for this study are the fellows' reflections of their learning that were incorporated in the curriculum. Teacher reflections are powerful tools in their learning and professional development process (Avalos, 2011). These reflections permit us to learn the degree of fellows' engagement in professional development activities and to highlight how teachers transferred several of the pedagogical approaches, introduced to them during their MSUrbanSTEM program, to their own classrooms. Additionally, the reflections allow us to understand how they examine their existing beliefs and attitudes and how they approach personal change and growth. In addition to reflections, we used artifacts from their online portfolios of their DreamIT projects (see Horton, Shack, & Mehta, (2017) of this special issue) and their social media postings. This is a qualitative case analysis that involved looking for themes in individual fellow's work. In addition, the authors met on a regular basis to discuss individual findings and to look for common themes.

Case Analysis Fellow 1: Keenan Franklin

Keenan teaches middle school mathematics on the west side of Chicago and has taught for Chicago Public Schools since 2002. He came into the MSUrbanSTEM fellowship program not only as an experienced teacher, but with over 10 years of experience as an information technology programmer prior to teaching. From the start, Keenan was very serious about his practice and laser-focused on student success. Keenan was selected as one of the cases for this study, because of his critical disposition to professional devel-

opment experiences and their claims. All members of the instructional team remarked that Keenan challenged them and often asked for justification for the tasks the he was being asked to engage in. This is one of the many qualities that Keenan started the program with and that legitimized transformations made because of this professional development experience.

At the conclusion of the first two-week MSUrbanSTEM summer session, Keenan was very thoughtful about his first impressions of the experience. He noted several aspects that resonated with him and that would potentially shape his practice by way of his DreamIT project for the remainder of the fellowship program. He spoke candidly about the impact of the experience in his summer reflection noting revelations from readings and discussions, group and individualized activities, and the stance that the program was taking on technology integration. In his summer reflection he remarked that the readings that touched on major themes in educational psychology such as misconceptions and various forms of understanding would continue to guide his classroom instruction. There was one reading, in particular, that aided in shaping some of the fundamental ideas of his DreamIT project. Here, in reference to an article on Culturally Responsive Differentiated Instructional Strategies provided by the Steinhardt School of Culture, Education, & Human Development (2008), Keenan articulates his thoughts:

> "...this article focuses on how educational research has shown that "children learn best when their culture and language are reflected in the school's curriculum". This fact, and the absence of these elements from the curriculum that students at my school have been taught with, is one of the major reasons I chose the year-long "DreamIT" project topic that I've elected to focus on as part of this MSUrbanSTEM fellowship program. My goal in the first year of this project is to design and implement a math curriculum that incorporates the cultural values and interests of our African American middle school students, in the low-income urban neighborhood that our school is located in. As the article highlights, 90% of all U.S. public K-12 school faculties are comprised of white females, with African American teachers making up only 7% of this group. Thus, it's not hard to argue that the majority of the purchased curricula providers are also predominantly comprised of non-African Americans. Thus, it is difficult to believe that students in urban public schools, like the ones that I've taught in, are learning at their best when curriculum language, activities, etc. have little to no relevance to their culture or life experiences."

With his DreamIT focus solidified, Keenan set off to create a STEM program at his school with a goal of promoting interest in STEM disciplines to help encourage more African-American students to pursue STEM careers. He was armed with the tools that he gained in the opening two weeks of the program as fueled by the news that his school would be bypassed and was not being selected by the district as one of the STEM focus schools. Keenan's DreamIT project was a three-year plan designed to first focus on mathematics and technology integration for the year with plans to extend the program to another STEM discipline with each successive year (science in year two and engineering in year three). Upon returning to his school, he assembled a team of mathematics teachers at each grade level and gained administrative support and buy-in for his plan. Keenan states "the most significant benefit to Spencer (name of school) students, in my opinion, is [the] focus on teaching content in depth versus breadth...a key ingredient for achieving academic success in mathematics for them this year….an approach that was highlighted by my MSU-Wipro team this summer as part of a jigsaw activity that instructors used to demonstrate the key ideas from the Mansilla & Gardner Disciplining the Mind (2009) article".

During the DreamIT implementation, Keenan's classroom practice was impacted in some major ways. Firstly, for the MSUrbanSTEM book review assignment, Keenan was supposed to read a book and contact/interview the author. Instead, he decided to get his students in on it and they all read *Math Doesn't Suck* by Danica McKellar together. He further engaged the students with technology integration by having them answer post-discussion questions about the reading via blog posts. Keenan had mixed feelings regarding the outcome of this assignment stating, "although it accomplished [my] goal of implementing a non-traditional method of creating interest and building comprehension in mathematics, I was disappointed   that the book provided more rote memorization methods for solving problems than concrete problem-solving strategies". Here, Keenan can be seen returning to the ideas of Mansilla and Gardner (2009) for engaging his students in discipline-rich mathematical experiences.

Additionally, Keenan remarked that the technology integration components of the MSUrbanSTEM program were "impressive" and he embraced several of these strategies for technology integration in his own practice. In his reflection, he wrote about being most impacted by Twitter, primarily for its ability to serve as an archive of classroom questions, discussions, comments, and other artifacts. He vowed to use it in his classroom for a variety of purposes. As part of his DreamIT project, students utilized online math skills practice systems like *Compass Learning* and *Think Through Math* to

help address gaps in their prior knowledge and to reinforce new math concepts. Eighth graders were "fully indoctrinated" in the use of Twitter and the CPS email system for assignment updates, notifications, and communications with their teacher. Keenan also created an app for his class that students could access for informational updates. While it was not originally a part of his plan, he jumped at the opportunity after the instructors presented the idea during one of the class sessions.

Throughout the course of the year, Keenan committed to a myriad of ways to involve his students mathematically and immerse them in meaningful mathematical exchanges, many of which were grounded in ideas from his MSUrbanSTEM experience. His students were introduced to and presented World of Wonder mini-projects and the gamification of mathematics. Keenan noted a variety of challenges faced throughout the year with regards to testing and test scores mandated by the district. These and other challenges are steeped in issues that often arise when teaching in urban contexts, but he faced them head on and with conviction. Whether it be the integration of social-emotional learning strategies or allocating class time for students to engage with the technology due to a lack of access to Wi-Fi in their homes, Keenan remained committed to educating the whole child and his vision of their success in mathematics and other STEM disciplines.

Case Analysis Fellow 2: Gabrielle Sullivan

Gabrielle is a middle school math teacher who has worked at Chicago Public Schools for over a decade. She is also a mentor to younger teachers and a lead teacher in her school. For her DreamIT project she chose to focus on improving number sense among her students. To achieve this, she incorporated several strategies and ideas learned during the MSUrbanSTEM summer session in classroom learning activities, such as World of Wonder, Movie Makers, selfies with math background, and interactive math journals. In addition, she created outside classroom learning opportunities for students such as math club, as well as "Math Madness" an afterschool six-week long boot camp. Moreover, Ms. Sullivan focused on family engagement. She connected with parents and students via Twitter, organized both a math night and a technology night to introduce families on how they can support their students via phone and internet at home.

Several areas of growth can be seen in Gabrielle's written reflections over time. One major area of growth is Gabrielle's recognition of the benefits of collaboration. Ms. Sullivan stated, "collaboration with other con-

tent teachers has definitely helped me work around time constraints." This allowed her to not only implement the six-week boot camp program, but also implement 15 minutes of computational practice in the science lab. Her DreamIT report, updates, and reflections, clearly showed that as her awareness of the need of collaboration grew, the more actively she pursued and led collaborative opportunities at the whole school level, such as math night for families that was attended by over 100 students and their family members. In her Final DreamIT reflection she stated, "The DreamIT process has made me appreciate working and collaborating with a team to create and execute additional programming for students and parents."

Recognition of the role of the technology was the second area of substantial growth. In her final reflection, Gabrielle acknowledged that "there is a noticeable difference in student engagement when students are able to use iPads in class…" and she also noted: "I'm starting to see how I can let go of some of the traditional paper-based activities and replace them with technology tools for homework, presentation of work, note keeping and journaling. One of the challenges that she faced was lack of access to technology and internet. Instead of seeing that as a roadblock, she constantly looked for ways to overcome it. She noted in her Fall semester reflection that she would actively look for grants to bring technology in the classroom, making possible events like technology night for parents. In her March 15 DreamIT update on her website portfolio she wrote:

> "The goal of the technology workshop for parents is to make them aware of and experience the online academic resources available to their children. We also hope to get parents to understand the necessity for technology access in their homes. Even during turbulent economic times, there are ways they can ensure their children have digital resources at home or in community venues (library, etc.)."

Resilience, positive outlook and resourcefulness characterized Gabrielle's work. For example, "Math Madness" boot camp that was originally planned for 6th grade students grew to include their younger siblings. In her Fall semester reflection, she described this turn of events writing "The program grew to include more than our targeted 6th graders, many of whom are responsible for walking younger siblings home from school. Other teachers pitched in to help provide activities for younger siblings from grades Pre-K to 5. On a typical day, we had 20-25 students participating in our after-school math boot camp program."

Gabrielle's DreamIT reflections showed that she used opportunities that the fellowship program provided to become a more reflective practitioner. She tried out new ideas, collected feedback from her students and col-

leagues, analyzed it, reflected on what worked or what did not, and continuously adjusted and improved her original plans. Her website and her Twitter presence became a part of her professional identity. Her sharing work with students, families and her colleagues became more intentional and show that she embraced the idea of teaching as a public practice that was one of the core ideas of MSUrbanSTEM .

Lastly, goal setting was one of the final tasks for the fellows. One of Gabrielle's short-term goals was:" I expect to increase my knowledge of the strategies and methods for teaching K-5 content and use technology tools to develop math center activities and projects to introduce, reinforce, and practice foundational skills." She also expressed her long-term goal: "… I hope to transition into a position that would allow me to support teachers in the implementation of technology to enhance daily classroom instruction in STEM content areas." These goals align closely with the set goals and purposes of the MSU Wipro STEM Program.

Case Analysis Fellow 3: Naomi Burke

Before being selected as a fellow with the MSUrbanSTEM program, Naomi's expectations for what she would learn through a professional development program were very low. She wrote in her first summer reflection,

> "I have completed several "STEM" programs through the Chicago Public Schools University, none of which taught me anything new or relevant. Nor did any of these programs keep my interest. I was always interested in combining technology and the teaching of mathematics in middle school. However, every professional development or college/university program stifled the use of current technology or moved at a snail's pace".

Mrs. Burke found the MSUrbanSTEM program a catalyst for change in her classroom in respect to how she could use technology to engage her students in exploring mathematics. After completing the summer component, she cited several ways in which she would use her DreamIT project to think through how to best integrate technology into her teaching practice, so that math content became more engaging to her students. Her reflections described how this change would occur:

> "Many of the mathematical units I teach have hands on experiences in them, such as putting recipes together, measuring and scaling school areas, acting out a mathematical problem, communicating math findings in any way possible and so on. However, I would

> like to use more technology-based tools, such as social media,
> stop motion movies, movable graphs, closed circuit equations, any
> physical tech tool that will help further understanding or at least
> have them question the things around us mathematically".

Naomi believed that by creating memes, video story problems, and Vine videos related to mathematics, she could help students become more engaged with mathematics materials. She could also use these tools to illustrate misconceptions and explain foundational principles in ways that may be more creative than are normally presented to students.

Another aspect in which Mrs. Burke showed in depth alignment with the tenants of the MSUrbanSTEM program was when she incorporated social media tools into her pedagogical and administrative practices. She outlined plans to use Twitter and Google Groups in her classroom to support out of school learning. The site contained information that parents could use to understand what occurred in class as well as help their children with homework and stay updated on upcoming events. She describes her plan by stating:

> "Homework, units, projects, math talks/tasks, and challenges will
> be posted on the website so parents and students have access to
> what is happening day to day. On my website will be a Twitter feed
> that students will have access to, but will also be closely moni-
> tored. Parents that do not want their students to be on social media
> just yet will be able to contact me directly via email, text, or in
> person".

After creating this public site, she created an internal site that students could access that was password protected. Naomi also expanded how use of technology in the classroom to connect students with content matter experts. She used Twitter to connect to the author of *Secrets, Lies, and Algebra*, by Wendy Lichtman, and arrange for her class to ask her questions about the book as well as perform a joint activity between the author and class.

In her DreamIT project, Naomi also decided to use Padlet.com to help demystify math for her students.

> "Every year I come across many students that 'hate' math or think
> it's such an impossibly complex thought process that only a few
> chosen students understand. I see students the first day walk in
> already given up with the lessons I haven't even taught. It is incred-
> ibly frustrating…"

Her DreamIT involved encouraging students to see math everywhere by photographing instances of math in their world. In her reflection, she noted that she decided to have "students upload pictures on "Selfie Saturday" and comment on pictures I have uploaded from my everyday life" to Padlet.com. In both instances students have to explain where the math is and relate it to what they are being taught that week in math class".

She shared that while the DreamIT project overall was successful, a challenge arrived in ensuring all her middle school students had access to technology outside of the classroom to take pictures. She worked with administration, parents, as well as started a GoFundMe page to garner the funds necessary to get technology in her classroom. Naomi was truly inspired by the results of her classroom transformation. She wrote in her final reflection:

> "I can tell students are just as hyped up as I am. Such love for math is exactly what I want to convey this school year. I truly believe if you love something you will see it and find it all around you. This DreamIT project is only the beginning. After I collaborate with my team of teachers and spread the word of educational technology INSIDE the classroom, only being used to further learning, no one will be able to stop the message from getting out." The DreamIT project provided Naomi with a foundation for establishing a norm related to integrating technology and social media in her classroom in a way that supported student learning and provided parents with agency in how their students interacted with these tools. It also helped her understand how to have deeper policy conversations with her administration around the use of technology for supporting pedagogical practices as well as student learning.

Cross-case Analysis

The focus of this article was the experiences of three mathematics teachers and how mathematical technology pedagogy was implemented in their DreamIT project as MSUrbanSTEM fellows. Major themes from the three fellows were that the urban contexts matter, math is all around, and engagement using technology.

1. Urban context matters: Although all three fellows taught in similar urban contexts in the Chicago Public Schools, their DreamIT projects showed that each fellow addressed specific concerns relevant

to their specific students and school contexts. Gabrielle pursued access to technology for her students to use both at school and at home. While Naomi had more physical access to technology, she worked to establish policy changes to help determine how technology could be used for teaching and learning. Keenan's primary focus was increasing student achievement through a rise in test scores. Gabrielle and Naomi both struggled due to working in schools that were underfunded.

2. Math is all around us: All three fellows focused on helping students to connect math with their everyday lives and to see how important being a successful math learn is for their lives. Keenan, Gabrielle, and Naomi all expressed an interest in having their students make deeper connections with mathematics. Naomi's DreamIT project encouraged students to analyze the people, places, and ideas in their world and make connections to the concepts they were exploring in class. She showed them glimpses into everyday activities in her home and connected those activities to fundamental mathematical concepts. Keenan expressed concern with curricular materials that he felt encouraged rote memorization over training in the critical thinking skills needed to examine mathematical problems. While he appreciated "tips and tricks" that can be used to help students solve questions faster, he recognized the need for materials to help students transcend the idea of simply answering a question to understanding the process of authentic problem solving. Gabrielle allowed students to engage in World of Wonder activities, which encouraged them to question their worlds and find answers to what they perceived as "big questions" in their lives. She found this activity was a helpful tool in increasing students' motivation and interest in mathematics, as mathematics also helps explain phenomenon in the real world.

3. Engagement through technology: There was also the common thread of the use of technology to increase student engagement. All fellows were excited about the ways technology, specifically social media, could be used to transform how they engaged students with mathematics. Naomi appreciated how visuals such as memes could be used to quickly capture a concept more creatively than traditional worksheets and textbooks. She also engaged in creating videos that integrated humor or irony to explain misconceptions and encouraged her students to do the same. Further, Naomi was able to use Google Groups to create forums where students could en-

gage in discussions around their assessments. She also encouraged students to share mathematical "selfies" through Padlet.com and Twitter. All teachers saw the advantage of sharing ideas about what worked in their classroom via Twitter and increased communications and collaborations with peers and parents. Gabrielle found Twitter to be a useful medium for promoting engagement amongst parents and students. Keenan used social media share some of his students' accomplishments, as well as the school email to teach students how to take ownership of their mathematical education and communicate with him around important class matters.

DISCUSSION

The three major themes developed from the cross analysis of each case were: 1) urban context matters, 2) math is all around us and 3) engagement through technology can be a tool for school engagement. These themes connect to the MSUrbanSTEM approach to professional development in many ways. One of the central themes of the MSUrbanSTEM approach revolves around action research in the urban context as means to combat tendencies towards focusing on achievement gaps and approaches to teaching with a deficit mindset. Each of the case studies demonstrated an action research component to the teaching of mathematics. For example, as part of the DreamIT project, fellows conducted focus groups with students and colleagues to assess their progress and make the necessary adjustments to increase engagement and effectiveness. During the focus group interviews, Keenan asked his students how he could better facilitate learning in the classroom. The students were silent for a moment, but then candidly responded that they would like more affirmation from him when they are providing responses to discussions in math class. It is experiences and feedback like this that are built into the MSUrbanSTEM professional development experience that allow fellows to adjust the project trajectory (major or minor) in response to their students' needs to facilitate richer learning experiences for students.

For the second theme, math is all around us, each fellow's disciplinary approach can be explicitly seen in their work and/or student artifacts. Whether it be Gabrielle's approach to increasing interest through her mathematical Worlds of Wonder project where students were able to pose questions that were important to them about the ways they seem mathematics in their worlds or Keenan's inquiry about the stagnant nature of using tips and

tricks to memorize mathematics algorithms while doing the book review with his students, these exercises showed a deep commitment to the nature of the discipline of mathematics; a central theme to the MSUrbanSTEM approach.

The engagement through technology theme is consistent with technology integration component of the MSUrbanSTEM approach to professional development. It is housed in the TPACK framework in some ways, but also connected to creative ways to engage parents and students when teaching in an urban context. All three fellows found ways to leverage technologies to engage students and parents in meaningful ways whether it be using Twitter and social media or apps that fellows created to disseminate content to students.

One goal shared by all three fellows was to minimize the inequities in educational opportunities and outcomes their students faced. One way in which this was accomplished was to integrate free and low cost technologies into their teaching practice. Introducing students to social media tools such as those integrated into Google Drive allowed teachers to integrate more efficient formative assessments into their teaching practices. It also encouraged students to be producers by allowing them to create images and videos that reflected their understandings of mathematics in their daily lives. While the teachers incorporated free technologies into their classroom, they still recognized not all students had access to the tools once they left school. This inspired the teachers to engage in grant writing and other funding activities to ensure students would be able to practice with tools outside of the confines of the course.

The ways in which teachers used technology disrupted environmental norms in their educative settings. Naomi renegotiated with her administrator the rules for how social media could be used for teaching and learning. This involved engaging parents in conversations about privacy concerns and explaining how social media could be repurposed for educational uses. These conversations led to amendments in school policy, and allowed students choice in how their work was shared inside and outside of school.

CONCLUSION

This article presented examples on how three urban school mathematics teachers, MSUrbanSTEM fellows, developed and implemented year-long projects to improve their student learning and allowed them to grow as teachers. This article highlights the complexity of teaching, specifically fo-

cusing on experiences of three mathematics teachers in urban schools. Their DreamIT projects and reflections show that the fellows did not specifically focus on different mathematics pedagogy ideas or teaching of specific content. Their work shows that teaching mathematics requires more than just content knowledge and mathematics pedagogy knowledge. Being a teacher is also about communicating with parents, collaborating with colleagues, it involves thinking about tests, after school programs. Through the fellows' work we discovered that technology plays an important role both in and outside the classroom. Many teacher professional development programs are too focused on content and pedagogy, as this article presented, there are other ways to improve student teaching, and hence it is important that there is more holistic and dynamic approach to teacher professional development.

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