

The Absence and Presence of Mathematics in Teacher-Led, Interdisciplinary Unit Design

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Despite the role that teachers play as vehicles between curriculum and student learning, only a few studies include teachers as integral participants in curriculum design (Skilbeck, 1984). The purpose of this pilot study was to explore the experiences of middle grade mathematics teachers as they designed interdisciplinary curriculum units using a backward design model. Using Actor Network Theory (Fenwick & Edwards, 2010) as our theoretical lens together with qualitative methods, we considered the networks associated with teachers' perceptions of and choices about curriculum design. Findings indicate that teachers' initial perceptions of mathematics and its fit within an interdisciplinary unit changed during the curriculum design, implementation and reflection cycle. Teachers also reported positive experiences in designing curriculum noting the investment of their time and collaborative synergy manifested in student engagement and ownership of their learning.

Key Words: Curriculum design, middle grades, interdisciplinary.

Standardized academic curriculum has been around for over a century. Beatty (2011) notes, "The curriculum for the Chicago public schools in 1862, for instance, prescribed what elementary school teachers should do every second of the day, in five- to twenty-minute intervals," (p. 23). Other early scripted curriculum programs were found in Froebelian kindergartens and Montessori schools. More recently, standardization has taken the form of student performance standards and teacher accountability (US Department of Education, 2004). As a result of the standards movement, curriculum in various content areas has been designed by hired curriculum writers instead of the teachers who are being held accountable for its implementation (Burch, 2006). Often, mathematics teachers are expected to implement this pre-fabricated curriculum (McGee, Wang, & Polly, 2013).

Although the goal of math curriculum is to educate and prepare all students for future success, teachers using prescribed curriculum, such as math textbooks (Thompson & Huntley, 2014), often feel it does not sufficiently meet the needs of their students (Kliebard, 1995). School districts adopt different pacing calendars, which can affect the usefulness of the prescribed curriculum. While the same content standards are covered in each school

district, the different pacing decisions might result in students having insufficient background knowledge required to successfully meet the curriculum expectations. Some teachers follow the prescribed curriculum even if it does not meet the needs of their students because of assessments and job evaluations that are connected to the curriculum (Taylor, 2013). Others make modifications to the curriculum for a variety of reasons, but not all modifications are beneficial to students (Taylor, 2013). Teachers have the professional knowledge about their content, the personal understanding of their unique students, and they are the conduits for curriculum implementation. As such, it seems that teachers should be integral players in curriculum design.

Purpose of the Study

The purpose of this pilot study was to explore the experiences of middle grade mathematics teachers as they designed interdisciplinary curriculum units using a backward design model. Using Actor Network Theory (ANT) (Fenwick & Edwards, 2010) as our theoretical lens, we considered the multitude of networks associated with teachers' perceptions of, and choices about, curriculum and how these networks influence the design of the curriculum units. This exploratory study included six participants from one school. We collected several forms of data including interviews, observations, and artifacts. The study sought to answer the following two research questions:

1. *In what ways is mathematics absent and present in teachers' curriculum design work?*
2. *What are teachers' experiences and conceptions of designing mathematics curriculum?*

Relevant Literature

Engaging students in authentic learning experiences is widely heralded among mathematics education communities (NCTM, 2014). This form of learning aligns with King, Newmann & Carmichael's (2009) definition of authentic intellectual work which "involves original application of knowledge and skills, rather than just routine use of facts and procedures while carefully studying the details of a particular topic or problem resulting in a product or presentation that has meaning beyond success in school" (p. 44). Studies conducted in the 1990s indicated that authentic learning and assessments improve student academic achievement, particularly for those students who have been considered to be low performing (McTighe & Seif, 2003). Some researchers also believe that curriculum designers should focus on student learning experiences (Wraga, 2011) to increase student achievement. Often,

though, outside sourced curriculum used by schools does not include authentic learning and assessments, or appear to give much consideration to student learning experiences. Teachers involved in curriculum design could ensure that their students' needs are being met while developing a deeper understanding of and connection with the curriculum they teach.

One type of curriculum design program is the teacher design team, which is organized to allow teachers to work in professional groups redesigning educational material (Binkhorst, Handelzalts, Poortman, & van Joolingen, 2015). These teams are comprised of teachers “who collaboratively analyze, design, develop, implement, and evaluate their shared curriculum,” (Huizinga, Handelzalts, Nieveen, & Voogt, 2015). Because curriculum design is new to most teachers, they require varying levels of support. Research has shown that some teachers easily adapt to their new role as curriculum designer, while others need extra assistance and feedback from facilitators of the teacher design team (Huizinga, Handelzalts, Nieveen, & Voogt, 2014). Teachers engaging in the curriculum design process report being satisfied with the changes they made to the curriculum and also experienced changes in their teaching practice (Voogt et al., 2011).

We argue that in order to provide the best mathematics instruction to students, teachers must feel confident in their understanding and delivery of the curriculum. Providing teachers with the means to take control of mathematics curriculum through design teams could increase their confidence and strengthen the delivery of instruction. This study seeks to expand the limited body of work exploring the role of teachers as curriculum designers.

Theoretical Framework

A multitude of entities contribute to teacher-designed curriculum including both human and non-human constituents such as the teachers' and administrators' influences, student learning, available material resources (textbooks, manipulatives, paper, writing tools, technology etc...), learning spaces and more. The network of all of these entities, in addition to the many more that would be infeasible to list here, plays a critical role in the curriculum design team's experiences as well as in the final curriculum product. For this reason, we drew from ANT (Fenwick & Edwards, 2010) in the design and analysis of this project.

ANT examines the assemblage of these human and non-human components as they exist and interact and assume equal importance (Fenwick & Edwards, 2010). All objects or entities have the ability to exert force, connect and disconnect to create a web that has the potential to create energy, assumptions, and meanings. As Fenwick & Edwards (2011) describe, “ANT shows how the entities that we commonly work with in educational research— classrooms, teaching, students, knowledge generation, curriculum, policy, standardized testing, inequities, school reform—are in fact assemblages

of myriad things that order and govern educational practices” (p. 3). ANT is used to examine these linkages at a fine grain level, allowing us to make sense of often-overlooked influences on curriculum development and practice.

There is the possibility that alternative networks, forces, or other outside entities may challenge any given network, changing its form or reducing its strength. In this study, a textbook focused network such as this one is challenged by curriculum designed by the teacher. The teacher-designed curriculum draws from and acknowledges the textbook material but is also influenced by administrator expectations, students’ prior knowledge, learning spaces, and material resources. One critical difference is that because the teacher authored the curriculum, his or her intentions are in sync with curriculum interpretation, which, arguably, may affect curriculum enactment. The focused interest was in exploring teacher experiences and curriculum development through this lens.

Method

The researchers used Design Based Implementation Research methodology (DBIR) (Fishman, Panuel, Allen, Cheng & Sabelli, 2013) in crafting the study. This methodology emphasizes the importance of multiple stakeholders working as equal partners in solving a common problem of practice. In this study, educational researchers (higher education faculty) and practitioners (teachers, administrators, central office personnel) met multiple times, several months before the start of data collection, to discuss their interests and opinions with regard to the teacher designed curriculum. These conversations helped shape the study design by bridging the needs and viewpoints of each of the stakeholders. In this exploratory, qualitative study, the researchers worked with six middle grade teachers in a southeastern state on designing authentic, intellectual, interdisciplinary curriculum using a backward design framework. Data was collected over the course of one calendar year and includes audio-recorded pre- and post-interviews, video-recorded bi-weekly planning meetings, teacher and student artifacts, and video-recorded classroom observations and teacher workshop days.

Setting and Participants

The study took place in a middle school where 74.3% of students are economically disadvantaged. The teachers in this study typically work in two person teams, with each pair responsible for teaching the four core content areas to one group of students. One teacher in this pair instructs students in social studies and mathematics while the other teacher instructs ELA and science. Table 1 provides information about the participants and their team groupings. For the purposes of this paper, we will describe each team using the names “Clean Water Team” (CWT) and “Service Learning Team” (SLT).

These names describe the curricular units that were designed by each group of teachers.

Table 1
Teacher Design Teams

Teacher*	Subject Area	Team
Paul	Mathematics/Social Studies	Clean Water Team, CWT (7th grade)
Aria	Science/ELA	
Eli	Special Education	
Natalie	Science	Service Learning Team, SLT (8th grade)
Tyler	Science/ELA	
Vonn	Mathematics/Social Studies	

*All names are pseudonyms.

Data Collection and Sources

Data was collected between August 2015 and August 2016. Data sources included (1) pre- and post-interviews with teachers, (2) video recordings of teacher workshop days, teacher planning days and unit implementation, and (3) teachers' written artifacts. In August 2015, researchers conducted semi-structured, audio-recorded interviews with teachers. These interviews were transcribed and provided information pertaining to teachers' beliefs about curriculum, teachers' roles in designing curriculum, and factors influencing curriculum development and implementation in their school.

In October 2015, teachers engaged in a 2.5-day (20 hours) curriculum development workshop (titled "Curriculum Design Collaborative") with the two researchers. In line with DBIR, it was important to the researchers that this Collaborative was a collegial space in which university faculty and the teachers learned from one another. In this way, during this Collaborative, researchers guided teachers in developing curriculum using a backward design framework while the teachers provided critical views about the realities of designing curriculum given the inevitable affordances and constraints inherent in schools for designing and implementing standards based curriculum such as time constraints, space issues and peer expectations. Teachers spent time during the 2.5 days working together on designing one curriculum unit that would be implemented in their classrooms the following February or March. Each day of the Collaborative was video recorded and written artifacts developed by the teachers were collected. Additionally, teachers completed evaluations about their experiences each day.

Following the Collaborative, teacher teams met bi-weekly to develop their curriculum unit with both researchers in attendance. These one-hour

meetings were video recorded totaling about 5 hours of video footage for each team. During this time, the teachers used Google docs to document their curriculum development work, which allowed the researchers to access these documents between meetings while also serving as additional data sources.

Each team spent approximately four weeks implementing their curriculum between February and March. One day of CWT's unit implementation was video recorded and two days of SLT's unit implementation was video recorded. Following unit implementation, each teacher team was interviewed for about fifty minutes about their experiences in designing and implementing these units. Finally, the two teachers who taught mathematics, Paul and Vonn, were each interviewed individually to share their thoughts about designing mathematics curriculum. These interviews lasted approximately 40 minutes each.

Data Analysis

To answer the first research question, *In what ways is mathematics absent and present in teachers' curriculum design work?* we examined the final unit plans looking for places where there was potential to include mathematics. We then examined the pre-interview transcriptions, workshop videos, planning videos, and post interview transcriptions seeking evidence of teachers' inclusion of mathematics throughout the design experience. Using comparative analysis, we examined the absence and presence of mathematics in teachers' work which included the final curriculum product, discussions, and other materials included throughout the process.

In answering the second research question, *What are teachers' experiences and conceptions of designing mathematics curriculum?* we again analyzed the pre- and post-interviews with each teacher, this time focusing on the teachers' beliefs and experiences in the design process. We then used the quotes from the individual teachers as the basis for seeking confirming or disconfirming evidence in the video recordings of teachers' unit planning throughout the project.

Because ANT takes into account animate and inanimate objects and their linkages within the network, we carefully considered these details when examining data sources by paying particular attention to all entities involved in the curriculum design process. This micro-lens allowed us to develop a deeper perspective for the many factors that influence curriculum design.

Findings

Because teachers' experiences and conceptions about designing mathematics curriculum are so closely related to the absence and presence of mathematics within the curriculum units that teachers created, we chose to provide a chronological account of the findings. Furthermore, ANT

recognizes the many connections that impact factors associated with curriculum development. For this reason, we felt it important to share all participants' (e.g., all subject areas) experiences and engagement in this design process as these play roles in the outcome of the mathematics curriculum products and process. The teacher-participants in this study chose to design interdisciplinary curriculum units; this is another reason for the inclusion of teacher perspectives from each content area.

Preconceptions about designing mathematics curriculum

The teachers in our study brought with them a range of curriculum design experience. One teacher worked over the summer with a district level curriculum design team on creating the 7th grade science curriculum. Two teachers worked within their grade level teams to create the social studies curriculum using the state standards as a guide. Several of the teachers adapted the pre-designed curriculum provided to them. The final teacher described his hesitation with making any significant changes to the existing mathematics curriculum, but he attempted small connections between disciplines within the framework of the curriculum. Figure 1 depicts a continuum of the range of experiences with curriculum design the participants held prior to embarking on this project.

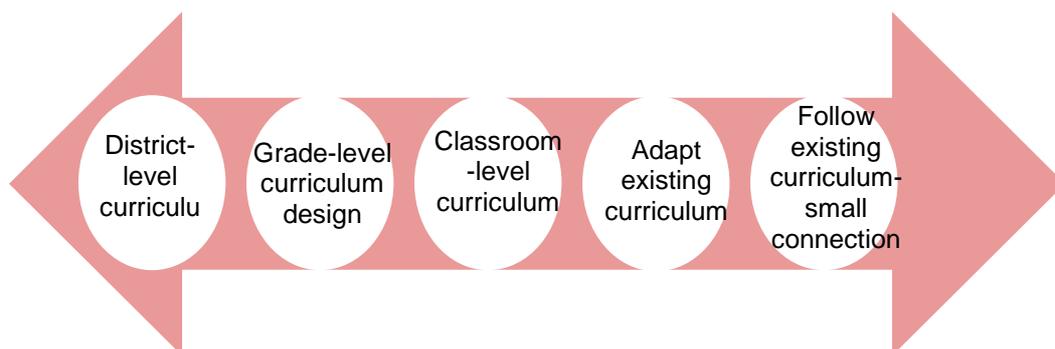


Figure 1: *Teachers experiences with curriculum design.*

Despite their different experiences, all six teachers held the same belief about the value of teacher involvement in curriculum design. They cited the importance of meeting students' diverse interests and learning needs from both an academic engagement perspective, *"We are the only ones standing in front of these children. We know their needs, and more importantly we know what their interests are. And we can use those two components to create more adaptable and responsive classes"* (Eli) and a socio-emotional perspective, *"But, yes, you do need teachers who are right here on the front lines designing curriculum. Because they are right here attached to these kids"* (Vonn). Teachers also reported feeling more passionate about their teaching practice when given the autonomy to use professional judgement in the classroom.

I don't feel I teach with the same level of passion or fidelity, a piece of literature that I don't like or that I can find no personal relationship to. So, I can teach that story and we can go through the steps in the old-fashioned, what's the theme, who are the characters blah, blah, blah, but I'm going to find a harder time of making it something that I extended upon, that the children want to be involved with. 'Cause I don't want to be involved with it. (Aria)

Tyler's experience working with the district level curriculum design team gave her a unique perspective on the differences between teaching curriculum that was self-designed (science) versus teaching curriculum designed by someone else (language arts). In particular, she noted the increased level of confidence that she felt in teaching her science curriculum because she understood the intent and purpose of the activities, learning goals, and assessments. She expressed that engaging in curriculum development increased her content knowledge which in turn, gave her more freedom to modify her instruction as needed and allowed her to be more relaxed and "herself" with her students. Despite being passionate about language arts content, she feels that because she did not design the ELA curriculum, she is "pushing through" and she has to "go by the rules with language arts" feeling as though she needs to keep moving because she follows a pacing guide and does not have the flexibility or background knowledge to modify this curriculum.

While all six teachers recognized the benefits of teacher engagement in curriculum design, Paul expressed some apprehension in his ability to develop interdisciplinary mathematics curriculum. He attributed this to disposition, "I am much more rigid and I say, Alright this is math. We are doing math, and let's connect it to those things but if we step too far out we may lose sight of where we were. So, personally that's something that I struggle with, in making those interdisciplinary connections." Notably, the mathematics curriculum, unlike the social studies curriculum which he also teaches, is a pre-fabricated textbook based curriculum that comes complete with a pacing guide and instructions for daily activities. Paul indicates his hesitation to deviate from this plan in fear of not being able to get back on track.

Overall, the teachers' preconceptions about designing interdisciplinary curriculum reflected an excitement for (1) the possibility of helping students make connections between content areas, (2) the potential for increased teacher content knowledge and hence, renewed ownership of their instructional practice, and (3) developing meaningful learning experiences for their students. Past experiences, curriculum resources, administrative expectation, student impact, and peer collaboration were cited as factors associated with teachers' perceptions about engaging in curriculum design.

Curriculum Units: Absence and Presence of Mathematics

The CWT developed a unit focused on the impact that clean water, or the lack of it, has in several African countries. The curriculum addressed ELA, social studies and science standards. Curriculum documents coupled with the team's discussions during the Curriculum Design Collaborative evidenced participants' interest in including mathematics standards in this unit, but in the end, the team did not include mathematics in the final product. Instead, the unit took students on an exploration through Africa where they learned about life in various countries and were exposed to interdisciplinary content that included biomes, religion, politics, adaptation, economy, and disease. The unit began with the students as passengers in a fictional plane crash, which left them each stranded in an unknown region of Africa. The students were told to "travel" toward the Nile River and along the way, they explored the savanna, the Sahel, the rainforest and the desert. Students were faced with various challenges during this journey. Their only means of survival, on this fictional plight, was use of their content knowledge to deal with these challenges; this, in turn, provided the teacher with formative assessment data.

The SLT also created an interdisciplinary unit that incorporated ELA, social studies and science standards. Much like the CWT, Tyler and Vonn started out with plans of including mathematics in this unit but did not include it in their final product. In this unit, students were challenged to consider identity and the disparities between adults' perceptions of teenagers and teenagers' perceptions of themselves. The teachers guided students learning in about the identities of several historic figures and situations that impacted the perception of different groups of people within society. Students were charged with designing a service learning project as their culminating activity. Criteria for this project included a means for bridging the perceptions of teenagers between younger and older generations.

The "absence of mathematics" is resoundingly apparent in both of these units with each unit drawing from each of the other three core content areas (ELA, science and social studies). The presence of mathematics is not as obvious. Yet, our analysis revealed mathematics in both the final curriculum units along with the verbal and written work teachers engaged in when designing the units, both during the workshop and in their planning meetings. A common belief is that mathematics is present in situations both inside and outside of the classroom (NCTM, 2000). As such, we identify several areas where mathematics is present regardless of teachers' capitalization on engaging students in formalizing the mathematics. We are defining "presence" as both the concrete and the abstract. Using ANT as our lens, we believe that mathematics in the abstract is present in curriculum regardless of whether or

not students realized they were engaging in mathematical topics or analysis; it is part of the network that comprises this interdisciplinary curriculum.

Clean Water Team Unit: Presence of Mathematics. The school district in this study subscribes to the Common Core State Standards as a guide for developing curriculum. One math standard is *Developing an understanding of and applying proportional relationships*. Integrating science, social studies and ELA topics, students analyzed and described the relationship between (1) germ theory and interdependence in living organisms and (2) the ways in which the lack of clean water causes problems for a population, including the spread of waterborne diseases. In doing this, the students were shown a map (Figure 2) depicting the probability of malaria death in African children.

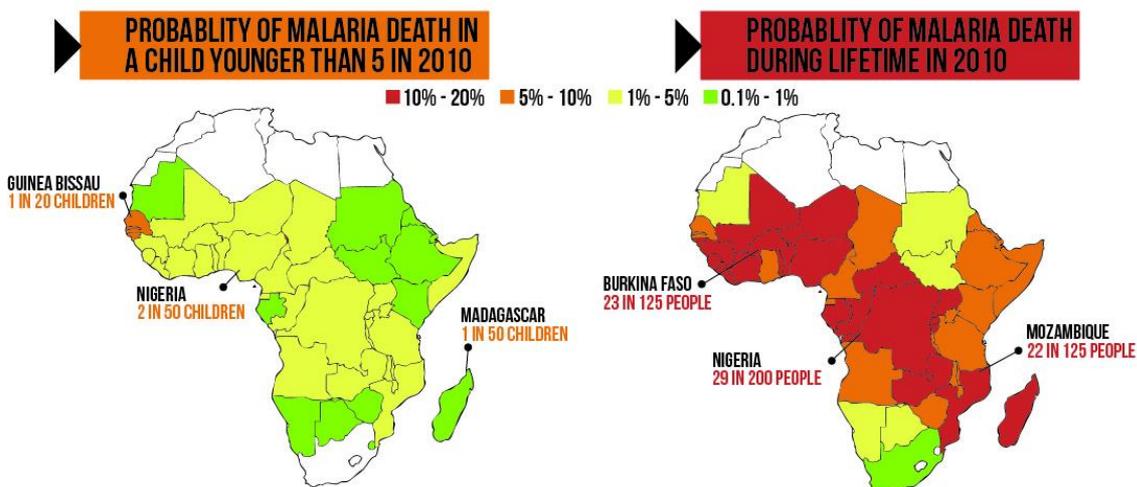


Figure 2. Heat map depicting the probability of malaria death in African children.

Using this map, students were asked the questions, *If our school were in Nigeria, how many students would likely die from malaria? Madagascar?* The context, representation and overall information presented in this map and in these questions inherently present mathematical relationships. Particularly striking is the question asking students to consider relationships between the probability of malaria death in children in Nigeria and translating this probability to children in their school. Answering this question involves equivalent ratios using data from the map and relating that to the school population. The authentic context in this situation presents an opportunity for students to include a layer of quantitative analysis that supports the work they are doing in social studies, science and ELA. Exploring the magnitude of the child death rate within African countries and relating this to their own community has the potential to make a powerful and memorable impact on their learning experience.

Another math standard is *Drawing inferences about populations based on samples*. One of the understandings that students explored in this unit was the idea that *ecological systems are made up of interdependent parts and their stability can be affected by environmental changes*. In analyzing the teachers' curriculum documents together with their workshop discussions, we identified population sampling as an area of mathematics that was present in the unit. One of the science teachers, Natalie, regularly conducts sampling experiments with water in a fish tank that is housed in her lab. There was some conversation surrounding the natural fit of probability and statistics (Figure 2) within an authentic context such as the one in this unit.

The unit design included opportunity for students to compare samples of water from their local environments, draw inferences about the quality of the water and how this may affect a community. This understanding could transfer to a global scale by comparing water systems and quality in Africa with those in the U.S. and thus, engaging students in their local communities and asking them to transfer this knowledge to another context.

Service Learning Team: Presence of Mathematics. Like the CWT's curriculum, the SLT's unit did not include mathematics, despite the extensive effort that the teachers invested in planning for the inclusion of mathematics. Planning documents included several standards that were not included in the final product. During a planning session in November, Tyler cited the lack of time as a reason for eliminating many of these standards. Mathematics was present in the teachers' curriculum design work during the 2.5 day workshop but it was not until the conclusion of the unit implementation, when the teachers had time to reflect on their work, that they recognized some of the mathematics inherent in their unit.

Teachers' Reflections on Designing the Curriculum Units

Teachers reflected upon their experiences in designing and implementing the curriculum units citing an appreciation for the positive synergy that they generated when exchanging ideas, the time that was dedicated to unit design and the powerful effect their work had on their students. Teachers also noted challenges they faced in designing units. One challenge they noted was how daunting this project seemed at first. Many teachers had little experience creating interdisciplinary curriculum and using backward design prior to this, and found it to be a large task. One teacher remarked, *"I just think we were a little overwhelmed too with what to do."* She and her teammate also explained that they found it difficult to determine what the end result of their unit would be. They shared, *"it took a while to set that out there for us, as opposed to knowing there is a test with this information on it."* Another challenge discussed was the school-level policies, such as pacing charts and testing schedules. The CWT explained that they could see cross-content connections, but because of the testing schedule, they had to adhere to the pacing chart. One member of the team said, *"the content*

that we had that we wanted, the common topics, didn't all line up across our content areas at the same time of the year."

The challenges teachers faced in designing the curriculum units also influenced their incorporation of math. One of the mathematics teachers, Paul, explained that he did not intend to include math in the unit, as he believes the pacing chart and current textbook-based curriculum need to be followed to ensure that students receive mathematical instruction in the appropriate order. He describes his textbook curriculum as "building blocks" with connected context. He explained that *"It makes it stronger when you use the whole curriculum, but it makes it less flexible and free in other resources."* He also stated that the school administration places a different amount of emphasis on mathematics than on social studies, which plays a role in his colleagues' willingness to make changes and try something new. Hence, it is easier for him to modify his social studies curriculum as these teachers have less pressure. As per ANT, there are several factors influencing his resistance to designing mathematics curriculum including, but not limited to, the contents of his textbook, administrator and societal expectations, collaboration with colleagues, and his own self-efficacy.

Although his initial feelings were that mathematics did not need to be included in the interdisciplinary unit, Paul began to think differently after the unit was implemented. While self-reflecting during the post-interview, Paul commented that incorporating mathematics into the unit could have been possible on a smaller scale than he initially imagined.

When I think about mathematics problems and projects, I think about something big. I have a hard time reminding myself that those interdisciplinary connections can be small. It can be one to two problems or one or two ideas. It doesn't have to be some big elaborate thing.

This experience led him to the belief that including mathematics in the integrated content benefits the students. While he appreciates his current textbook curriculum for its cohesiveness, investigative nature and comprehension, he stated that he feels more effective when instructing curriculum that he designed.

...one of the things that we discount in teaching is how effective teachers are when they design their own curriculum because they are so invested in it. ...the more passionate I am about it, the more they see that passion. ...I just remember the nuances of that curriculum a lot more intricately. When I teach math (textbook), I've taught all my lessons multiple times and I remember them. But a lot of times, I don't remember some of those little things until I go back and look at it

again. Whereas, I could look at most of my social studies curriculum, probably 90% of it, and I could teach it without any materials and do it almost verbatim from how I've done it in in the past. Because there is something intellectual that is required to create it and then make it your own and then to implement it and the math curriculum doesn't involve that because I didn't make it.

Vonn held similar beliefs about the effectiveness of a teacher-designed curriculum and, despite the fact that the SLT did not include mathematics in their unit, his belief in teacher designed curriculum never changed. He explained that his team was overwhelmed with trying to make progress on their unit design and because they were excited about the ideas developing in their brainstorm, it was easier to stay focused only on social studies and language arts then to figure out a way of including mathematics.

And we were really like firing away at each other and really loved what we were developing, so we just ran with it and didn't really want to mess with that or you know, it stressed me out trying to figure out how to put math in there too. I shied away from trying to incorporate math because of how big a project it seemed. And I just wanted to be able to accomplish something. So I kind of put math on the back burner there.

Upon reflection, teachers did describe ways they could have included math in the curriculum units. In his post interview, one member of the SLT explained how he could have expanded the unit to have students create business plans. Based on historical events that affected African American businesses, the students would have conducted math calculations to determine their profit losses and revamp their plans to stay afloat. He explained how utilizing math in the interdisciplinary unit would have helped students identify more deeply with the social studies content being covered.

Teacher reflections after implementation of the curriculum units also revealed how students responded to the teacher created curriculum. Teachers reflected that students responded favorably to the interdisciplinary curriculum units. One teacher from the CWT explained how the unit met the needs of all students, regardless of modifications they typically needed. She stated, *“Every single one of our students’ needs were built into it from the beginning. So everyone could create the product without it needing further modification.”* The SLT also reflected on the unit product as helping maintain student engagement. They explained, *“It was their ability to create and own that product that really made a huge difference.”* As a result of successful implementation of the interdisciplinary units, teachers report their intentions to continue developing interdisciplinary units throughout the new school year. One member of the SLT shared with the researcher, in his post-interview, that

he was inspired by the curriculum design work and he has designed an interdisciplinary assessment, containing all four content areas, for his new grade level this year.

Discussion and Implications

This project demonstrated that curriculum development and implementation is complex and teachers' choices to exclude mathematics from the final unit designs were not based on one factor but instead, these choices were influenced by a network of entities. Even when given support in the form of time, curriculum autonomy, and collegial collaboration, the teachers in our study chose not to include mathematics in their interdisciplinary units despite the inherent presence of this content in the contexts of the units.

One of the challenges noted by the teachers was their inability to see a natural fit for the mathematics in the unit during the design phase; these same teachers recognized the underlying mathematics in their work following implementation. One reason for this change of perspective may be attributed to the beliefs teachers hold about mathematics and the way they understand the content. The teachers in our study struggled to incorporate mathematics into the design of their units. After implementing and reflecting on the process and products, these teachers recognized the potential for mathematics in the interdisciplinary curriculum. While the unit design or implementation did not increase their content knowledge, it did provide a space for changing teachers' perspectives about mathematics content and how mathematics may be situated within curriculum.

The interdisciplinary nature of the unit development also seemed to play a role in teachers' design choices. In our study, teachers were not only challenged with designing curriculum units within one content area but were creating authentic, situation-based learning experiences that incorporated a range of subject areas. This model provided an opportunity for teachers to focus on subject areas that were an "easy fit" and avoid the challenge of situation based mathematics. Engaging in teacher-led, interdisciplinary curriculum design provides opportunities for professional growth while challenging teachers to alter their current perspectives of curriculum and subject matter.

Assessment and teacher accountability have been cited as influential factors in the decisions of collaborative design teams (Baildon & Damico, 2008; George & Lubben, 2002) and these systemic influences were also present in our study. Mathematics teachers may feel an elevated level of pressure to use a mandated curriculum (textbook or other) because of schools' foci on mathematics test scores. We argue that pre-fabricated curriculum is less meaningful to both teachers and students and this, in turn, plays a role in

teaching and learning. Teachers should benefit from curriculum resources, including textbooks and similar documents, but the power of these resources coupled with the influence of other school-based factors should be carefully considered so as not to limit teachers from creating meaningful mathematics curriculum.

Furthermore, we recognized teacher professional growth (Clarke & Hollingsworth, 2002) in that teachers' continued working in teacher design teams following the conclusion of this project. Clarke and Hollingsworth describe this enduring practice as different from "teacher-change" which has a short term effect. From an ANT perspective, teachers were empowered by the positive synergy during unit planning which tapped into each of their individual strengths and allowed them to use material resources creatively. This long lasting change positioned one teacher as a curriculum leader in follow-up work which is much like the findings of Deketelaere and Kelchtermans (1996) who reported participants who worked in teacher design teams continued on to design curriculum at the school level.

Further research unpacking the complex network of factors associated with teacher-led curriculum design is needed to uncover the benefits and drawbacks in this form of professional practice and could have implications for teachers' professional development, sense of agency, and student learning. Our theoretical lens, ANT, accounts for the abstract presence of mathematics in the teachers' final unit products together with the concrete inclusion of mathematics in their curriculum design process. It also allows us to consider the wide network of influences on the process, product and teacher experiences. We conclude that the overall experiences of teachers in designing curriculum were positive, they felt that the units were effective and the time spent was valuable. They unanimously agreed that their students were more engaged in learning during these units than during typical instruction. The teachers believed that the passion they felt for these units was unparalleled by the lessons they teach using pre-fabricated curriculum and the curriculum design experience led to professional growth in both perspectives of mathematics and the concrete inclusion of mathematics in follow up curriculum.

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Appendix A

Interview Protocol for Teachers Prior to Curriculum Design Work

1. How do you define and/or describe curriculum?
2. As a teacher, what role do you think curriculum plays in education?
 - 2a. What role do you think the common core plays in education?
 - 2b. What role does common core play in your curriculum and instruction planning?
3. What are your allotted planning periods and how do you use those periods?
4. Do you believe that teachers should design their own curriculum? Why or why not?
5. Have you ever designed your own curriculum unit? If so, please describe your processes when designing the unit. Describe the experiences you had teaching your unit. How did you perceive your students’ engagement and interest during that unit? If not, can you explain why?
6. How would you define interdisciplinary curriculum?
7. How do you use technology for teaching and learning?
8. What does it mean (to you) to use a backward design approach when designing your lesson plans and/or unit plans?
9. What seems most exciting about designing your own curriculum?

10. What are some of your concerns about designing your own curriculum?
11. How do you feel supported by building and district administration with regard to curriculum and instruction?
12. What kinds of school wide initiatives are being implemented this year that you are required to participate in?
13. Is there anything else you'd like to say regarding this project/process?

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