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Investigating the Relationship Between Mathematics Education and Global Citizenship Education Through K-12 Mathematics Teacher Perspectives

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In an increasingly connected world, a higher demand exists for global (citizenship) education in all disciplines, including mathematics. Although researchers in *Teaching Mathematics for Social Justice* (TMfSJ) have not ignored the need for a critical use of mathematics in society and culture, a primary goal of this work is to promote mathematics as a tool that can be used to analyze and act upon issues of social justice.

Similarly, researchers in Global Education have developed frameworks over several decades identifying characteristics of individuals who can communicate effectively with others across cultural and language differences and act as responsible citizens of the world. While the goals of these fields align, additional research is needed to understand explicit theoretical connections between mathematics education and global education and provide examples of classroom tasks that effectively integrate mathematics content and issues of global (or national or local) significance.

As a result, the primary goals of this study are to (1) identify instances of, and opportunities and challenges for addressing objectives of global education in the context of K-12 mathematics classrooms, (2) identify factors that influence the ways in which K-12 mathematics teachers design and implement mathematics tasks which integrate global issues, and (3) analyze selected mathematics tasks for the ways global education objectives are addressed and what factors influenced the design and implementation of a specific task. The
participants of this study are all K-12 mathematics teachers and qualitative methods of data collection and data analysis are used in this study.
Investigating the Relationship Between Mathematics Education and Global Citizenship
Education Through K-12 Mathematics Teacher Perspectives

Kyle Evans

B.S., Sacred Heart University, 2011
M.S., University of Connecticut, 2013

A Dissertation
Submitted in Partial Fulfillment of the
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APPROVAL PAGE

Doctor of Philosophy Dissertation

Investigating the Relationship Between Mathematics Education and Global Citizenship
Education Through K-12 Mathematics Teacher Perspectives

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University of Connecticut
2018
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It’s over. Seven years ago I couldn’t even imagine what this would be or look like or if this would even be possible, but I made it. I started the Ph.D. program at UConn in the fall of 2011 as a naïve and sheltered 20-year-old and I’m graduating the program in the spring of 2018 as an aware and informed emerging academic and scholar. This journey has meant so much more to me than the writing of this dissertation because these seven years have been by far the most transformative of my life. I’ve grown up at UConn and I suppose this dissertation is a product and an outgrowth of how far I’ve come, but this evolution and product could not have been achieved alone and I want to acknowledge and give thanks to all of the amazing people that have had an impact on my life and this journey.

I first want to thank my advisor, Fabiana Cardetti, for her unwavering support over the four years that we worked together. This experience was an evolution for each of us in navigating Mathematics Education research, and once again I very much appreciate your role in my transformation from a skeptic to a scholar. Most importantly, you whole-heartedly supported me at my lowest points and when I needed it most and I am and will be forever grateful for that.

The remaining members of my advisory committee, Manuela Wagner and Luke Rogers, also deserve recognition. Manuela – your ability to bring laughter and smiles to higher education is a gift I’ve always appreciated and admired, and I’m grateful for your perspectives from another discipline which had a real impact in shaping my own perspectives. Luke – your insight into academics has been incredibly valuable as all of your feedback has expanded my thinking and awareness of details that I could never have thought of on my own.

There are so many other academics and professionals that have made a difference in my time at UConn. All of the graduate students in the department owe so much to Amit Savkar and Monique Roy. Amit – we are all so appreciative of the ways in which you support graduate
students and your perspectives on Mathematics Education helped to shape my own. Monique – you have done more for graduate students than anyone could imagine and your relentless energy, love, and attention to detail have made a significant impact on this experience.

I need to thank each of the 13 teachers that graciously volunteered their time to participate in my study. While I gained incredible insight into my research questions, I also developed a deep appreciation for the work that they do in such a demanding position. As our school education system continues to evolve and adapt, it is important to remember that above all, teaching is a human profession and I am grateful for the kindness of every teacher that I worked with.

I also want to thank Tutita Casa and the Neag School of Education for my development as a Mathematics Education researcher. Tutita – I am beyond grateful for being a part of a research project with you and our team of graduate students, and for the entire experience of conducting research and crafting publications.

I don’t want to go any further without thanking my family. Mom, Dad, Andrew, Anna – you all have been an incredible escape from the stress associated with academics. I have always been grateful for your love and support no matter what, and the last seven years has been no different. Big things are on the horizon for all of us, and I’m so proud to be a part of the success of this family.

In this journey, my family also includes my academic family and my academic siblings deserve their own recognition. Melissa – I hope you know how much our friendship means to me and how much your character has pushed me to become a better person. Steve – our conversations through the years challenged my perspectives and I have to say that I’ve missed all of your one-liners in the past year.

To all of the graduate students I have interacted with over the years, in particular the ones that I’ve been close with (you know who you are) – thank you for being a part of my growth
and my evolution as an academic. These seven years have flown by, yet the group I entered here with feels like a lifetime ago, and I’m so lucky to have had that group to begin with and to have made a handful of lifelong friends along the way.

It’s important to have friends outside of academics to keep you grounded and to not get lost in the world of academics. Bobby and CJ – even though I don’t see you as much as I would like, maintaining contact on a nearly daily basis has meant so much to me and I’m so glad to be even remotely associated with your successes as well as sharing our struggles.

Anyone that knows me knows how important teaching is to me and how passionate I am about my students and my classroom each and every semester. I recently went through all of my grade spreadsheets and counted that I have had 728 unique students plus the absolute best four REU students anyone could have in my seven years at UConn. Whether individually or collectively, each and every one of those 732 people has made a difference in my life. The classroom has always been my escape and the place where I feel the most empowered and have a voice and ability to make a difference in the lives of others. Upon entering grad school, I had no idea where math would take me, but all of the amazing people, interactions, and experiences surrounding my teaching has led me to claim with complete certainty that teaching is my calling and my dream that I never knew I had. And as I’ve recently begun to open up about life with my classes, I want to give a special thanks to my most recent semester of students in Math 1030Q. You’ve showered me with more love than any group ever has and it really means the world to me. I will miss you and everyone else I’ve gotten to know at this amazing place.

Speaking of this place, deciding to come to UConn is easily the best decision I’ve made in my life. Everything about this university is special to me, from the countless amazing people to the physical spaces and experiences outside of academics. In particular, I want to thank the UConn women’s basketball program for setting a standard for excellence that we should all strive towards and for providing so many days that I looked forward to, and so many nights in
Gampel that I will never forget. Outside of the classroom, you were my largest escape and the heartbreak of the past two seasons makes me that much more appreciative to have been here during the historic four-year championship run. You know I'll be back for as many games as possible, and I look forward to even more banners and accolades.

Lastly, it is quite fitting that this dissertation and journey concludes in May, which also serves as Mental Health Awareness Month. Personally, I am proud for what I have accomplished especially given my battles with anxiety, particularly in the last 2-3 years. The culture of academics is one that breeds anxiety and depression (among other mental health concerns) and it is so important to know that you are not alone. Taking action against my struggles including opening up and allowing myself to be vulnerable to others has had a positive impact on my life, and while it is much easier said than done, I encourage others to do the same. The results will be more encouraging and fulfilling than you expect, and can help you identify the people who are important in your life and who make you feel like you matter. And it works both ways – even if you may not have any mental health concerns of your own, you never know what others may be hiding and it is important to be understanding, loving, and empathetic. I firmly believe that being an advocate for mental health and doing my part to #EndTheStigma is also a part of my calling in higher education. In this spirit of advocacy, I will end with something that I have ended many of my class periods with:

    Spread. Love. Always.
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CHAPTER 1
INTRODUCTION

Sharing the planet with over six billion other people creates shared responsibility on issues such as climate change or global warming to everyday events. On any given day, logging onto Facebook allows us to see what someone else is doing locally and across the world. We can make international banking transactions instantly on our phones. Business deals and collaborations occur between people of different cultures all around the world. The ramifications from political decisions in another country impact us in new ways than ever before. All of these examples show that the world has grown increasingly interconnected through social media, economics, politics, and the environment and as a result of this globalization, the notion of citizenship has expanded to include a global interpretation beyond the traditional national connotation.

Global organizations such as the United Nations (UN) and the Organization for Economic Co-Operation and Development (OECD), among others, have recognized the need for and importance of developing future generations of citizens into individuals that are best equipped for an increasingly interconnected world. Known as global competence, the OECD provides the following definition:

Global competence is the capacity to analyse global and intercultural issues critically and from multiple perspectives, to understand how differences affect perceptions, judgments, and ideas of self and others, and to engage in open, appropriate and effective interactions with others from different backgrounds on the basis of a shared respect for human dignity. (2016, p. 4)

In other words, global competence is multi-faceted and demands many qualities in today’s citizens, including qualities associated with strands of knowledge, attitudes and beliefs, skills
and abilities, values, and taking action to improve conditions of a community, nation, or the world (Byram, 1997; COE, 2016).

Addressing and developing these traits in new generations of learners and citizens requires attention in education, with these global organizations building on the work of researchers in the field of intercultural competence (Spitzberg & Changnon, 2009) to identify the necessary traits and promote a need for change in curricula and policy. The organizations share a main goal and priority of providing an education containing global dimensions which “aims to be transformative, building the knowledge, skills, values and attitudes that learners need to be able to contribute to a more inclusive, just and peaceful world” (UNESCO, 2015, p. 15).

The demand for global education exists both on its own and within disciplines, as sets of knowledge and skills that are unique to each discipline provide beneficial lenses through which one can analyze global issues. Specifically, mathematics is a discipline which is often overlooked in the context of integrating global issues, but the mathematics standards outlined in the Common Core State Standards (NGA, 2010) which have been adopted by over 40 states in the United States (as of March 2018) “offer ample flexibility for teachers to create learning experiences in which students examine topics of global significance to meet the demands of an increasingly interconnected world” (Boix Mansilla & Jackson, 2011, p. 8).

As a result, there exists a need to critically examine the relationship between mathematics education and the growing field of global education to understand the opportunities and challenges that may exist in meaningfully integrating the two disciplines and developing learners that are able to use mathematics skills to analyze and improve the world.

**Meaningful Mathematics**

The field of mathematics education has certainly not ignored the demand for a mathematics education which is responsive to global issues. Between twenty and thirty years ago, prominent researchers in the field (Frankenstein, 1989, 1994; Skovsmose, 1994) developed...
frameworks for “critical” mathematics education designed to shift the traditional mathematics curriculum to one that is meaningful in society and is applicable to a wide range of issues, such as political, economic, and social issues. In addition, pioneering work by Gloria Ladson-Billings (1995a, 1995b) introduced “culturally relevant pedagogy” that when applied to mathematics, calls for a curriculum with a multicultural view which is meaningful, empowering, and equitable for students of all backgrounds, not just those with various forms of privilege.

These significant frameworks and curricula led to the development of Teaching Mathematics for Social Justice (TMfSJ) which includes components of critical mathematics education and equity in the discipline (Gutstein, 2006; Gonzalez, 2009). According to Rochelle Gutiérrez (a renowned scholar in the field), TMfSJ consists of:

...learners being able to make sense of data in ways that help them see the humanity behind the numbers and to use mathematics as a tool for exposing and analyzing injustices in society and as a means for convincing others of a particular (often nondominant) point of view. (Gutiérrez, 2013, p. 41)

This definition and additional work in TMfSJ acknowledge the action component, or the use of mathematics to take action and create a change in the world. Elements of the TMfSJ pedagogy include positioning students as active learners and effective communicators to utilize mathematics skills for positive action. As a result, this use of mathematics leads to a wider set of skills that comprise the notion of citizenship (Gutiérrez, 2013).

The work done in TMfSJ has grown over the last decade and mathematics organizations have increased the demand to address social justice issues and equity in mathematics curricula. For example, a position statement published jointly by the National Council of Supervisors of Mathematics (NCSM) and TODOS: Mathematics for ALL (TODOS) advocated for systemic changes to mathematics education to counter the existing inequities, privilege, and oppression in the discipline. In alignment with the research done in critical mathematics and
TMfSJ, the organizations state that: “Mathematics can be used to problem-solve and model real-world phenomena, sociopolitical situations, community issues, and power relationships” (2016, p. 3). To support these purposes, curricula should include “students’ mathematical, cultural, linguistic, and community-based funds of knowledge” and “tasks that demand quantitative analysis of fairness and civic engagement issues” (p. 5).

Opportunities to engage students with issues of social justice can be found in the national (United States) standards in mathematics. The Common Core State Standards for Mathematics (NGA, 2010) identify that “Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace” (p. 7) as one of their eight Standards for Mathematical Practice, or set of “processes and proficiencies” that teachers should aim to develop in their students. These eight standards were derived from the process standards for mathematics as defined by the National Council of Teachers of Mathematics (NCTM) (2000b). The process standards also include opportunities for the use of social justice issues as mathematics education should enable students to recognize and apply mathematics in “contexts that relate mathematics to other subjects” and use mathematical representations “that significantly expand their capacity to model and interpret physical, social, and mathematical phenomena” (p. 4). Although the use of social justice in mathematics is not explicit in the national standards, TMfSJ can be viewed as an extension of processes already identified as crucial to all students’ mathematics education (Wager & Stinson, 2012).

**Global Education**

The desire to educate students for the purpose of developing effective citizens in a democratic society is not new. Two hundred years ago, Thomas Jefferson wrote that a primary goal of education was “to instruct the mass of our citizens in these, their rights, interests and duties, as men and citizens” (Peterson, 1984, p. 459). Although the tenets of democracy and the
power vested in each individual to make informed decisions remains unchanged today, schools have “increasingly focused on standardized test scores in math and literacy to the near exclusion of all other educational goals” (Westheimer, 2017, p. 15). In order to emphasize citizenship in education, schools may need to shift their goals to forming students who ask challenging questions of the status quo, are exposed to multiple cultural and ideological perspectives, and have local service-learning opportunities to counter standardized tests that do not capture varied local contexts and cultures. By doing so, students will have increased opportunities to acquire “knowledge, capacities, and dispositions associated with a robust democratic life” (Westheimer, 2017, p. 18).

These forms of knowledge, skills, and attitudes associated with effective democratic citizens can be traced back as early as the 1970’s through many theoretical frameworks of intercultural competence (Spitzberg & Changnon, 2009). These frameworks identify characteristics required for effective interactions with people of other cultures, such as an understanding of one’s own perspectives, knowledge of other cultures (Byram, 1997), and the ability to critically evaluate beliefs, cultures, and identities to “deconstruct stereotypes and prejudice in the classroom” (Nugent & Catalano, 2015, p. 18). Many of these characteristics can be seen today in policy documents and frameworks of global education in the United States (Boix Mansilla & Jackson, 2011), Europe (COE, 2016), and globally (UNESCO, 2015), each with shared goals of encouraging education systems and educators to develop students who are “knowledgeable and curious about world regions and global issues, attuned to diverse perspectives, able to communicate across cultures and in other languages, and disposed to acting toward the common good” (Boix Mansilla & Jackson, 2013, p. 2), and are “active participants in democratic processes, in intercultural dialogue and in society more generally” (Council of Europe, 2016, p. 16).
Although many global education frameworks exist, implementation of explicit objectives has been far from widespread in United States schools – likely a product of the newness of global education documents and the political process and implications of systemic change in the field of education. However, the demand for an education that is responsive to today’s increasingly globalized world is higher than ever. This is especially true following the vitriol associated with the 2016 election cycle in the United States, which “should spur renewed emphasis on the need for schools to instill in children an appreciation for civic values and not just a skill set for private employment” (Kahlenberg & Janey, 2016). In fact, the atmosphere surrounding the election inspired a collection of articles aimed at practitioners to motivate the need for civic (as well as democratic and global) education, to detail skills of this education that teachers can seek to develop in students, and to provide examples of projects that target these skills (Rebora, 2017).

**Statement of the Problem**

In the last ten years, many frameworks of global education have been published and endorsed by national and global organizations. Each of these frameworks was designed with a shared goal of identifying and developing the “knowledge, skills, values and attitudes that learners need to be able to contribute to a more inclusive, just and peaceful world” (UNESCO, 2015, p. 15).

The past decade has also witnessed an increased focus on issues of social justice and equity in mathematics education (Aguirre & Civil, 2016). Mathematics education researchers and educators have identified the importance of transitioning from a traditional mathematics curriculum to one in which “mathematics becomes a tool used to examine social environments, increase awareness of social injustice, and serves as a valued language that can be used to further an agenda of social change towards a more just society” (Gonzalez, 2009, p. 25).
Although global education and mathematics education have largely operated as separate fields, they share a common goal of building a more just world and society through education. In addition, global education has begun to strive for change in each discipline to create “globally infused” curricula. In mathematics, a global context implies that students “should be able to use mathematical tools and procedures to explore problems and opportunities in the world, and use mathematical models to make and defend conclusions and actions” (Asia Society, n.d.). This definition and understanding of global mathematics also recognizes that challenges exist in “finding genuine, relevant and significant examples of global or cultural contexts that enhance, deepen and illustrate an understanding of the math” (Asia Society, n.d.).

As a result, research is needed to understand and identify connections that exist between global education and mathematics education. It appears that global education and mathematics for social justice share many similar goals and desired qualities in learners, and systematic research can reveal explicit connections between the two fields of education. The view of mathematics through a lens of global education (as opposed to social justice) is limited (Cotton, 2016) and invokes the question: What do global education frameworks offer or contribute to the goals of Teaching Mathematics for Social Justice and the demands for global education in the discipline of mathematics? Many of the global education objectives are not explicit in TMfSJ and research can illuminate objectives (the desired traits such as knowledge, skills, attitudes, and action) that may already be addressed in mathematics education, opportunities for an increased focus on particular objectives in the classroom, and challenges that exist in addressing particular objectives (specific to mathematics education). Each of these relationships has the potential to inform mathematics tasks, curricula, and policy seeking to attain a mathematics education that is meaningful in the context of globalization.
**Purpose of the Study**

Teachers experience a significant number of interactions among students in their classrooms, and will be responsible for the implementation (and possibly the design) of mathematics tasks that address objectives of global education. As a result, their perspectives are valuable in initiating research which seeks to understand the connections between global education and mathematics education with respect to existing educational practices, the potential for future tasks and curricula, and current challenges in achieving goals of global education in mathematics. In addition, because many of the global education objectives are observable, classroom observations of students’ interactions (among themselves and with the teacher) complement the perspectives of teachers.

Thus, the purpose of this study is to apply a framework of objectives from global education to mathematics education to examine which global education objectives are already addressed in classrooms, which objectives have to the opportunity to be addressed, and which objectives face challenges in being addressed. These objectives are interpreted through the perspectives of K-12 mathematics teachers and observations of interactions that occur in their classrooms. This fills a gap in the literature by explicitly linking global education and mathematics education from a theoretical perspective. In addition, this study informs practitioners interested in integrating global issues into their mathematics classrooms by identifying the factors that influence the design and implementation of these integrated tasks. The application of the previous purposes to specific tasks in order to bridge the theoretical frameworks and previous results of the study to practice may also be of interest to researchers and practitioners. Lastly, this study seeks to merge ideas and goals from mathematics education with those from global education in hopes of motivating future collaborative work with scholars and practitioners from each field.
Research Questions

The purposes are tied to the three research questions of this study, which investigate impacts on theory and practice of the connections between global education and mathematics education:

1. Which global education objectives can be incorporated in K-12 mathematics classes and in what ways are the objectives meaningfully addressed by students?
2. What factors influence the ways in which K-12 mathematics teachers integrate global education objectives into their mathematics classes?
3. When analyzing specific mathematics tasks, which global education objectives do students address and what factors influence how teachers design and implement the task?

Definitions of Key Terminology in This Study

Global Citizenship – A sense of belonging to a shared humanity. This is not a literal form of citizenship of a nation, but rather a reflection of today’s world which has become increasingly interconnected through politics, economics, languages, and cultures across communities, nations, and the world (UNESCO, 2015).

Global Competence – Sets of knowledge, skills, attitudes, and values that contribute to effective communication and productive action in a globalized world. Examples include knowledge of other cultures, critical thinking skills, an attitude of openness, and values associated with human rights (Boix Mansilla & Jackson, 2011; COE, 2016).

Global Education – An education that seeks to develop learners’ global competence in order for learners to become effective global citizens. Frameworks of global education include objectives addressing the sets of knowledge, skills, attitudes, and values that comprise global competence. Global education is often not viewed as a separate school subject, but as one that
is integrated within existing disciplines by re-contextualizing the learning in each discipline.

Global education is synonymous with global citizenship education (GCE).

**Global Issue** – Issues of global significance such as climate change, gender inequality, crime, disease, poverty, peace and conflict, pollution, migration, unemployment, sustainable development, refugees, and natural disasters. Issues of global significance are often localized, so "global" issues also include issues of local and national significance as global education seeks to uncover the implications of local and national issues on a global society (UNESCO, 2015).

**Intercultural Competence (IC)** – Sets of knowledge, skills, attitudes, and values that contribute to effective interactions with individuals or groups from another cultural context. These characteristics are similar to those of global competence (global competence was derived from IC). An expanded version of IC known as intercultural communicative competence (ICC) is the combination of IC and linguistic skills of foreign languages required for effective communication between people from different cultural contexts (Byram, 1997).

**Mathematics Task** – A problem or set of problems which focus on a mathematical idea and also provide an opportunity to develop mathematical habits of mind. Specifically, a mathematics task may be a worksheet, lesson plan, activity, project, assessment, or a combination of these materials (NCTM, 2000a).

**Teaching Mathematics for Social Justice (TMfSJ)** – A pedagogy and branch of research in Mathematics Education that uses mathematics content as a tool for understanding, analyzing, and acting on issues of social justice. Social justice issues consist of issues related to inequalities of humanity including discrimination such as racism, sexism, and ageism, as well as inequalities resulting from government policies such as poverty, unemployment, and access to healthcare or education (Gonzalez, 2009).
CHAPTER 2
LITERATURE REVIEW

The purpose of this study is to understand connections between global education and mathematics education by applying frameworks found in global education to classroom instances of mathematics teaching and learning. These connections are explored in this chapter not only in the theory found in the two fields, but also in practice to inform practitioners and researchers seeking to address the demands of global education across the disciplines.

The review of the literature begins with a brief background of intercultural competence frameworks before describing current global education frameworks which were used as the theoretical foundation for this study. Next, the work done in mathematics education and its application to social justice issues is presented. This includes the theoretical foundation of “critical” mathematics education, selected studies conducted with in-service and pre-service teachers, and resources that contain sample mathematics tasks that integrate real-world problems. Lastly, the limited resources focusing on explicit connections between global education and mathematics education are offered.

Intercultural Competence

Global education frameworks have begun to gain traction in educational policy and were developed from previous work done in the field of *intercultural competence*. This term has many different definitions each with their own nuances that many times depend on the context in which it is used. In addition, various models and frameworks for intercultural competence exist that were designed for different purposes or fields such as business, education, or healthcare. Deardorff (2006) met with over twenty experts behind many of the models and frameworks and synthesized their work and knowledge to define intercultural competence as “behaving and communicating effectively and appropriately (based on one’s intercultural knowledge, skills, and attitudes) to achieve one’s goals to some degree” (p.254).
Deardorff’s definition encompasses the many purposes of intercultural competence frameworks, and in this study the focus is education, thus the definition used here follows the work of language researcher and educator Michael Byram, which defines intercultural (communicative) competence as “a person’s ability to relate to and communicate with people who speak a different language and live in a different cultural context” (1997, p. 1).

Byram developed a model which identifies components that comprise an individual’s intercultural competence and contains the following five dimensions: (1) knowledge of your own and other cultures, (2) attitudes such as curiosity and willingness to change existing beliefs, (3) interpreting and relating aspects of other cultures to your own, (4) skills of discovery and interaction in real-time communication, and (5) the ability to critically evaluate cultural elements from multiple perspectives. This model is also one of the few to emphasize linguistic competences required to effectively communicate with others in a foreign language and the combination of intercultural competence and the linguistic competences is known as intercultural communicative competence (ICC). It is worth noting that Byram later expanded this model to create a framework for Intercultural Citizenship, which identifies conceptual relationships between ICC and political education, which includes sets of attitudes, knowledge, and skills to develop learners’ ability to take responsible political action (Byram, 2008).

Byram’s model for intercultural competence is one of a few which were intended for use in the field of education. Another model can be found in the work of Milton Bennett, whose Developmental Model of Intercultural Sensitivity (1993) describes the acquisition of intercultural competence as a process through a linear set of stages. These stages begin with the denial of cultural differences and progress to defense and then minimization of cultural differences before moving to acceptance, adaptation, and ultimately integration of cultural differences. This linear progression of acquiring intercultural competence is in contrast to Byram’s model, whose
five dimensions are described as interwoven such that the development of one dimension positively impacts the development of the other dimensions.

Numerous additional models and frameworks for intercultural competence exist as shown in the review and categorization by Spitzberg and Changnon (2009). Their review illustrates that while nuances between models are present depending on the purpose and field of the model, there are many common factors that describe the components of intercultural communicative competence. These factors provide a foundation for the current global education frameworks created and endorsed by various national and global organizations. Although some of these organizations use names such as global competence or global citizenship to describe their goals of global education, many of the objectives contained in these frameworks have clear connections to those found in the theoretical models of ICC.

Global Education Frameworks

Due to the demands of today’s global society and the “central role that global interdependence will play in the lives of our youth” (Boix Mansilla & Jackson, 2011, p. 7), many non-profit global organizations have recently developed frameworks and curriculum recommendations for global education. These frameworks were designed through task force meetings and consultations with experts in education and intercultural competence. Due to the status of these large organizations, their sponsorship of these frameworks and policy documents has increased the focus on global issues within the field of education. This study will feature four of the most prominent frameworks and organizations promoting global education, and also acknowledges the work of additional organizations.

Asia Society

In the United States today, the Department of Education (2012) endorses a framework for global competence produced in 2011 through a collaboration by the Asia Society, a global organization whose emphasis is the development of relationships and dialogue between the
United States and Asia, and the Council of Chief State School Officers, a national organization of state leaders in education who also sponsored the Common Core State Standards (NGA, 2010). This framework was motivated by the desire to educate students to address the growing interconnectedness of the world through economic, cultural, technological, and environmental issues. This collection of categories are known as “issues of global significance” and the organization defines *global competence* as “the capacity and disposition to understand and act on issues of global significance” (Boix Mansilla & Jackson, 2011, p. xiii).

In this framework, the objectives are divided into four categories that collectively constitute global competence in students. First, students *investigate the world* by identifying important global questions and issues and researching their questions in order to draw conclusions. Second, students *recognize perspectives* to understand what shapes their own and others’ points of view. Third, students *communicate ideas* to collaborate with and understand people from diverse backgrounds. Lastly, students *take action* to improve conditions in their community, country, or the world. As applied to education, the framework has a foundation of disciplinary and interdisciplinary understanding which emphasizes the importance of discipline-specific skills and the integration of skills from multiple disciplines in the development of a student’s global competence.

**Council of Europe**

The Council of Europe (COE), an international organization supporting and advocating human rights, democracy, and European culture, also recently released a policy document and model outlining competences for democratic culture (2016). This model was motivated by the desire to develop learners into effective citizens in a peaceful, democratic society. Their working definition of *democratic and intercultural competence* is “the ability to mobilise and deploy relevant values, attitudes, skills, knowledge and/or understanding in order to respond appropriately and effectively to the demands, challenges and opportunities that are presented
by democratic and intercultural situations” (COE, 2016, p. 10). The emphasis on democracy is built on the argument that as societies become increasingly culturally diverse, effective intercultural dialogue and exchanges are necessary to make political decisions affecting all citizens.

The model was created through an audit of over 100 existing frameworks and through an analysis conducted by a team of established scholars in the field, the final model includes four categories and a total of twenty competencies. The first category of Values speaks to valuing both similarities (human rights) and differences (cultural diversity) among humans and valuing the tenets of a democratic culture. Second, the categories of Attitudes includes openness towards other cultures, respect towards people from different cultures, civic-mindedness and civic duty, responsibility and accountability, self-efficacy in accomplishing tasks, and tolerance towards new and unfamiliar situations. The third category contains many sets of Skills to be employed in intercultural interactions, including critical thinking, listening, empathy, cooperation, and conflict resolution skills. The fourth and final category of Knowledge contains understanding and knowledge related to oneself, language, and many characteristics of the world, such as politics, the environment, cultures, economies, and history. The council is currently developing performable actions and identifying levels of proficiency for each competence to further aid widespread implementation of the competencies into educational policy.

UNESCO

On a global level, the Educational, Scientific, and Cultural Organization of the United Nations (UNESCO) released a pair of policy documents in 2014 which identified global education as one of the organization’s major initiatives and strategies for the next seven years (2014a) and outlined the basic tenets and importance of global citizenship education (2014b). Their push for global education led to the research-based document outlining a framework and
objectives associated with global citizenship education (2015). Their definition of global citizenship is “a sense of belonging to a broader community and common humanity, emphasizing political, economic, social and cultural interdependency and interconnectedness between the local, the national and the global” (p. 14). While the emphasis in this definition is on the citizenship component, many of the objectives identified in the framework (as can be seen below) align with the objectives from each global education framework in this section.

In the UNESCO framework, the objectives are divided into three categories based on the three domains of learning (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956): cognitive, socio-emotional, and behavioral. In the cognitive domain, learners acquire knowledge of global issues, including the interconnectedness of issues, and also develop research, critical thinking, and communication skills associated with investigating global issues. In the socio-emotional domain, learners acquire an understanding of human rights issues to recognize characteristics shared by all human beings. Furthermore, learners acquire an understanding of cultural diversity to recognize and appreciate differences that exist across human beings and their cultures. In addition, learners develop attitudes such as empathy, fairness, and respect to improve communication and understanding in intercultural interactions or with individuals or groups from another culture who may have different perspectives. Lastly, in the behavioral domain, learners act on global and social justice issues and understand their responsibility to participate in actions that are informed and ethical. Within each domain of this framework, specific objectives are presented along a developmental spectrum and are divided into four different age groups which span from 5-18+ years old.

OECD

Another global organization, the Organisation for Economic Co-Operation and Development (OECD), facilitates world trade and released a policy document (2016) outlining global competence as a response to the demands of increased cross-cultural communication.
Similar to the Council of Europe, the OECD’s definition for *global competence* is focused on the communicative nature of global encounters:

> Global competence is the capacity to analyse global and intercultural issues critically and from multiple perspectives, to understand how differences affect perceptions, judgments, and ideas of self and others, and to engage in open, appropriate and effective interactions with others from different backgrounds on the basis of a shared respect for human dignity. (OECD, 2016, p. 4)

The associated framework contains three dimensions that collectively form an individual’s global competence. First, *knowledge and understanding* are the information held by an individual about global issues and the ability to fully comprehend that information. Second, *skills* are sets of abilities that can improve intercultural interactions such as communication, empathy, flexibility in perspectives, and critical thinking. Third, *attitudes* are dispositions and values held by individuals that, when combined with knowledge and skills, can produce “globally competent behavior” (p. 5).

Unlike the other organizations and models, OECD is directly involved in assessment through the administration of the PISA (Programme for International Student Assessment) exam, which is given every 3 years to 15-year-olds around the world and tests their abilities in mathematics, science, reading, and financial literacy (over 500,000 students from over 70 countries completed the 2015 exam). As a part of their global competence document, the organization is also planning to field test survey items on the upcoming 2018 PISA exam which measure a student’s global competence. This data would have the potential to inform schools and curricula on what gaps exist in their global education, and provide a baseline comparison of globally-minded characteristics in students and future leaders around the world.
Additional Frameworks

Other organizations have released frameworks and definitions of global competence to be used within education. Oxfam’s education branch (based in the UK) released a document (2015a) detailing their definition and framework for global citizenship and benchmarks for learners by age level as well as suggestions for the inclusion of global citizenship objectives in all school subject areas. Partnership for 21st Century Learning, a United States education organization with about half of the states represented, released both a document outlining “grade level indicators” of global competence objectives (2014b) and a document promoting change in educational policy to support the integration of global education into curricula (2014a). World Savvy, a United States-based education non-profit, has a global competence framework (2014) that guides their work, as does the National Education Association (2010) which supports their efforts in promoting political and policy changes in education in the United States. The categories and objectives in each of these additional frameworks align with the objectives in the global education frameworks described above and share an overall goal of preparing students to be effective citizens in today’s globalized world.

Mathematics and Social Justice

In the past few decades, the field of mathematics education has also responded to the demand for an education which places students in a more active role to understand mathematics through a critical lens and ultimately improve the world.

Before its later application to mathematics education, critical pedagogy originated with the work of Paulo Freire (1970) who argued for a significant philosophical shift in education. This shift would be from the “banking concept” of education in which teachers are the owners of knowledge and transition the knowledge to students who listen and accept the knowledge, to the “problem-posing education” in which students “develop their power to perceive critically the way they exist in the world with which and in which they find themselves” (p. 83). In this
“pedagogy of the oppressed,” the world is seen not as static, but as dynamic, and students are given agency to actively reflect and shape their community and the world.

A few key researchers helped shape the application of the “Freirean” approach of critical education to mathematics education. Marilyn Frankenstein (1989) argued for a “criticalmathematics” curriculum with a focus on “demystifying the structure of mathematics to using numerical data for demystifying the structure of society” (1994, p. 175). The goals of her curriculum included both improving the understanding of mathematics and the understanding of social issues including those related to politics, economics, ethnicity, gender, and class. Her work (1989, 1994) includes many examples of school-level (K-12) mathematics problems which rely on authentic data and are situated in the context of a particular social issue.

Ole Skovsmose (1994) also applied the work of Freire to mathematics education and suggested the concept of “mathemacy” as a parallel to literacy. This critical understanding of mathematics was described as an important competence in society and as an empowering set of skills that can be used to analyze and reform our world. Through the lens of Danish education, Skovsmose also provided examples of projects done in school education to illustrate the power and potential of critical mathematics education which expands the traditional curriculum to meaningful applications in society.

The work of Gutstein (2003, 2006) has arguably had the widest impact on the field of Teaching Mathematics for Social Justice (TMfSJ) today. His work is also seen as an application of Freire (1970). Gutstein identified the two major goals of learning social justice in mathematics as the ability of students to read the world and to write the world with mathematics. Reading the world with mathematics refers to the use of mathematics to understand social and global issues such as racism, power relations, unequal resource allocation, and discriminations based on characteristics including race, gender, and class (Gutstein, 2003). This critical view of the world through mathematics also emphasizes students
making connections between multiple social issues as well as making connections to their own lives to understand the world through their own cultural background. Writing the world with mathematics refers to the use of mathematics to actively and tangibly change the world. Gutstein (2006) described a project in which his students needed mathematics to analyze the issue of gentrification in their local neighborhood and used mathematics to communicate (through written discourse with letters and oral discourse with presentations) with community leaders to take action and change their community (their “world”).

Beyond the explicit connections to social justice topics, Gutstein’s approach includes goals associated with students’ mathematics ability and disposition towards mathematics. These goals include increasing students’ flexibility and creativity in the use of mathematics skills, achieving in mathematics through college-level courses, and changing the disposition of students so that mathematics is not seen as a set of rules to memorize, but as a powerful set of skills that can be utilized in analyzing and understanding complex social issues.

It is worth adding that the definition of *Teaching Mathematics for Social Justice* and the work contributed to that field contains not only goals associated with mathematics content, but also goals associated with mathematics as a discipline. Building on the work of Moses and Cobb (2001) and Gutiérrez (2007), Gonzalez (2009) added that TMfSJ encompasses ensuring that all students have equal access to high-quality mathematics instruction and creating opportunities for mathematics to be relevant and meaningful to students from marginalized backgrounds and communities. These components of equity align with the goals of the National Council of Teachers in Mathematics (NCTM), who recognize Access and Equity as one of the six Guiding Principles for School Mathematics (2000a). Although issues of equity are significant in TMfSJ, they are not the focus of this study which seeks to identify connections between mathematics content, tasks, and projects found in TMfSJ and the frameworks of global education.
TMfSJ with In-service and Pre-service Teachers

As theories and pedagogies of Teaching Mathematics for Social Justice (TMfSJ) have developed and emerged, studies have been done with in-service and pre-service teachers to create tasks and projects to answer various questions about the teaching and learning of social justice issues in mathematics.

Key studies utilized in-service teachers in different settings with a common goal of using the tenets of TMfSJ to create learning materials and experiences for students. One important example of these studies is the work by Gonzalez (2009) with high school mathematics teachers in urban areas of New York City working in a weekly professional development group. The researcher (Gonzalez) provided the teachers with key readings related to TMfSJ and led guided discussions for the first five weeks of the group’s meetings before the teachers began to develop their own projects targeting social justice issues. In developing and implementing projects that utilized data from their own school to engage students, teachers were influenced by their shared backgrounds with their students and were challenged at selecting the appropriate rigor of the mathematics. Gonzalez also found that the teachers’ beliefs towards TMfSJ changed over the course of the meetings, that awareness of school issues was not enough and students need opportunities to take action, and that teachers were concerned with discussing issues that were potentially controversial and worried about negative responses from school administrators or parents.

Another example at the graduate level is the work by Stinson (Stinson, Bidwell, & Powell, 2012) who taught TMfSJ to in-service teachers along with PhD students in Education. The course began with reflective writing assignments before having his students create and implement mathematics tasks incorporating social justice issues. His study featured two of these tasks, one of which focused on racial profiling and the analysis of traffic data, while the other investigated minimum wage data through mathematical modeling. In each case, it was
found that conversations occurred in class which connected to the students on a personal level, and to current topics in politics. In addition, students felt empowered and the tasks led to the co-development of new knowledge by the students along with each teacher.

Bartell (2013) also taught a graduate course to in-service secondary teachers which began with written reflections on sample tasks before teachers worked together to create their own social justice mathematics tasks. The topics of their tasks included investigations of population by race vs. GPA by race, minimum wage vs. living wage, and the cost of prison vs. the cost of school. Through the course, Bartell found that when designing tasks teachers focused on the social justice elements, but when implementing tasks the focus shifted to the mathematics content. They also treated the two components as separate and struggled with the sequencing of the components and selecting the appropriate difficulty level of the mathematics when coupled with a social justice issue. Some teachers expressed a lack of comfort with discussing racial issues during class time and also noted the importance of selecting data that is appropriate for students. Lastly, the researcher identified the overall need for professional development to aid teachers in creating mathematics tasks which integrate social justice issues.

A case study by Gregson (2013) explored the practices of Ms. Myles, an eighth-grade teacher who was also a community activist and taught at a school with a majority of students from marginalized backgrounds, including low-income families and students of color. The teacher engaged students in tasks and discussions about authentic current issues and wanted students to view mathematics as a tool for addressing social justice issues. One such project prompted students to analyze data on the low wages of migrant farm workers. In this project, students answered mathematics questions, connected their learning to topics they had studied in other subject areas, attended a rally, and wrote letters to community leaders using mathematics to support their argument for higher wages. Ms. Myles also discussed many
general logistical factors and challenges associated with TMfSJ, such as the amount of prep
time required for these tasks and projects. In addition, Ms. Myles recognized the need to
negotiate the balance of mathematics content which is either “mathy enough” and provides rich
mathematics that also supports preparation for standardized tests or is “too mathy” and
includes mathematics outside the scope of their standardized tests or mathematics that may
negatively impact students’ disposition towards the discipline.

Studies done with pre-service teachers have yielded similar results. Leonard & Moore
(2014) taught a course in which their students designed and taught mini-lessons in groups to
their peers with the goal of incorporating principles of social justice pedagogy into
mathematics. The researchers found that the students were able to do this successfully in this
environment and found that their beliefs towards social justice pedagogy were positively
changed as a result of taking the course.

A group of researchers (Simic-Muller, Fernandes, & Felton-Koestler, 2015) conducted a
survey and interviews about the beliefs of pre-service (elementary and middle level) teachers
towards social justice in mathematics teaching and found that students (pre-service teachers)
identified a limited range of real-world scenarios that they identified as issues to be explored in
a mathematics class. Many also expressed caution when discussing the inclusion of
controversial issues, leading to recommendations from the researchers to include an expanded
use of controversial issues in the classroom, more authentic real-world connections, and to
increase exposure to social justice issues both in and out of the classroom.

On the elementary level, Felton-Koestler, Sutherland, and Tracy (2016) showcased two
tasks designed by pre-service teachers whose topics included salaries of teachers around the
world and the price of school lunches (the tasks were not implemented). The researcher took a
critical view of both tasks and felt that each benefit students by making meaningful connections
with mathematics, and that these benefits could be increased with a further critical approach taken the address the issues.

Additional studies have explored the use of social justice topics in mathematics classes in different contexts. Brantlinger (2013) developed tasks for remedial mathematics students attending a night school program (for academic or disciplinary reasons) and found that these students were engaged in the content but displayed resistance to a task exploring recess times by school and race. A self-study by Harrison (2015) documented the researcher’s experience guest-teaching (replacing an official teacher) a weeklong unit at a middle school on racial profiling and unemployment. This experience challenged Harrison’s own views of social justice and confidence in leading discussions, and she stressed the importance of knowing and having personal relationships with your students to successfully engage in social justice content. Chao and Jones (2016) described an activity done with pre-Kindergarten students which simulated the bus boycott of Rosa Parks to instill the idea of fairness in students while also developing counting skills (the number of empty seats on the bus).

**Resources for Social Justice and Global Mathematics**

In addition to existing research, there are various resources for teachers seeking to learn more about or spark ideas for the inclusion of social justice and global issues into K-12 mathematics classroom. With the frameworks of global education and pedagogies of TMfSJ in mind, an overview of existing resources can reveal how current tasks demonstrate connections between mathematics and global education. In addition, the various resources provide a landscape of what is currently available to teachers and may indicate the lack of particular types of tasks, such as grade level, mathematics topic, global topic, or those in alignment with problem-based learning (Gasser, 2011).
**TMfSJ Resources**

Along with the examples of tasks and projects found in the research studies identified above, additional resources exist for practitioners and researchers that align with the theoretical framework of TMfSJ. The resources present collections of sample tasks and projects that incorporate social justice issues in mathematics. A current major resource of this type is *Rethinking Mathematics* (Gutstein & Peterson, 2013), a collection of over twenty tasks or projects produced by various teachers and researchers across many grade levels. Each author describes their product, their associated thought process of its design, and shares reflections about the design and implementation of their product. Examples of social justice topics addressed include the financial implications and ethics of sweatshops, foreclosures and neighborhood displacement, deforestation, the density of movie theaters and liquor stores in urban and suburban communities, the distribution of wealth, and climate change.

The task designed and implemented by Staples (2005) which appears in *Rethinking Mathematics* was selected for further analysis by Leonard, Brooks, Barnes-Johnson, and Berry III (2010) due to its unique context of students exploring the distribution of wealth through mathematics with privileged high school students at a prestigious private school. Many of these students were unaware of their privilege, in contrast to the middle school students from working-class backgrounds that investigated the distribution of wealth to illuminate power relations (Gutstein, 2003).

Leonard et al. (2010) described and analyzed three additional tasks to provide a resource and analysis to benefit teachers, teacher educators, and mathematics education researchers. First, two fourth-grade teachers integrated the mathematics concepts of perimeter and area with the civil rights movement of the Underground Railroad by having students create patches for a quilt. As a result, students were able to bring their own cultures, identities, and stories into the classroom while learning about a social justice issue (Leonard, 2008). Next,
Brantlinger’s (2005) task asked students to use maps and mathematics to compare resources of communities with varying levels of economic status. Students found that a particular working-class community contained no movie theaters and a significant number of liquor stores but were unable to make a connection to social justice unlike the students in Tate’s (1995) study who explored the same issue. Finally, the work by Moses & Cobb (2001) on the use of displacement (quantity and direction) to support students’ understanding of arithmetic and algebra evolved into The Algebra Project, a non-profit organization supporting equitable practices in mathematics education by providing teachers with resources and professional development.

Another collection of tasks informed by research in TMfSJ can be found in the NCTM book Teaching Mathematics for Social Justice: Conversations with Educators (Wager & Stinson, 2012). Chapters include descriptions of an experience integrating elementary mathematics to students’ lives, issues of equality, and history (Peterson, 2012), a project using mathematical modeling to analyze minimum wage in a remedial mathematics class at a community college (Powell, 2012), a project on the statistics of gender-based violence completed with middle school students (Stocker, 2012), and five sample tasks and associated considerations for the use of TMfSJ with high school students (Wamsted, 2012).

The textbooks by Stocker are another important contribution to the available resources. His first textbook (2006) was developed to provide accessible examples of lessons that integrate mathematics standards with a meaningful context of social justice issues. The subsequent book (2017) adds a new set of sample lessons that focus on moving from awareness to action and address current issues in social justice, such as the importance of intersectionality (recognizing the impact of a person’s multiple identities on a social issue). Additional examples of topics from the most recent edition include the use of oil resources, equity issues associated with Indigenous communities, loan systems, public transportation
costs, diseases obtained from chemicals released in the air, pesticides and GMOs, and homophobia in schools. Each of the fifty lessons contained in each book is further categorized by at least one of five different strands of mathematics contained in the lesson (Number Sense & Numeration, Measurement, Geometry & Spatial Sense, Algebra, and Data Management & Probability) as well as at least one of eleven different social justice categories contained in the lesson (such as Gender, Race, Class, Sexuality, or Environment). Each lesson was designed to align with mathematics standards in grades 6-9 and because the textbooks were published through a Canadian organization, many of the lessons focus on issues that take place in Canada while other lessons feature issues that occur on a global level.

Finally, the website RadicalMath was created in 2006 by an educational consultant and former teacher Jonathan Osler. The website contains links to many of the resources mentioned above, benefits to including social justice topics in mathematics, practical “how-to” considerations for teachers, and suggested connections between particular mathematics topics and particular social justice topics with links to sources of authentic data (Osler, 2007).

**Global Education applied to Mathematics**

While many tasks, projects, and resources have been developed to align with TMfSJ, the recent global education frameworks have led to publications of mathematics-specific guidelines, suggestions, or examples to advocate for connections to global education in mathematics. Examples of these initiatives can be found in the works published by the Asia Society, Oxfam Education, and Partnership for 21st Century Learning (P21).

The Asia Society’s Graduation Performance System (Asia Society, 2015) is a list of objectives by subject area for students to achieve to be prepared for college and the world. It includes a rationale for linking mathematics and global competence, objectives aligned with the Common Core State Standards, and rubrics for measuring global competence in the context of mathematics. The overall goal and rationale for forming these links is stated as:
The goal of a mathematics program at a globally focused school is to develop an individual’s capacity to understand the role of mathematics in the world; to study issues, situations or events of global significance that call for a mathematical approach or solution; and to use mathematics to support conclusions, arguments, and decisions that lead them to act as reflective, constructive and concerned citizens of the world. (p. 38)

These goals are further supported by objectives that align with the Asia Society’s framework for global competence (Boix Mansilla & Jackson, 2011), and each objective has an associated rubric which measures a student’s proficiency towards a given objective on a scale with four levels of benchmarks.

As previously mentioned, Oxfam Education’s document framework on global citizenship education (2015a) also relates to specific disciplines. The organization released supplementary documents describing the motivation for linking their global citizenship framework to each discipline and provide the following motivation for mathematics:

Global Citizenship provides real-life contexts which engage learners’ curiosity and make them want to use maths to explore patterns and formulate ideas about the world...Through a Global Citizenship approach to maths, learners critically analyse the statistics they are exposed to in daily life; make connections between the local and the global and then share their understanding with others. (Oxfam, 2015b, p. 1)

The document also includes suggestions for specific connections that can be made from global issues to specific strands of mathematics, benefits for including global citizenship goals in mathematics, and a list of resources to support teachers.

Lastly, Partnership for 21st Century Learning (P21) released a guide (2014c) for connecting their global competence framework to the Common Core State Standards for Mathematics. This guide includes mathematics “lesson starters,” or examples for fourth, eighth, and twelfth-grade topics containing the idea for the lesson and the targeted Mathematics
Content Standards and Mathematical Practices from the Common Core State Standards along with the global competence objectives.

At this time, publications including research studies and resources that make explicit connections between global education and mathematics are limited. Two examples of mathematics tasks whose design were guided by global education can be found in Cotton’s (2016) article, which details two different tasks focusing on current global issues – the Brexit vote and the Syrian refugee crisis. The mathematics content used in each task is described along with the ways in which the tasks connects to characteristics of global citizens as established by the learner profile of the International Baccalaureate (2013), which includes traits such as curiosity, open-mindedness, knowledgeable, caring, and reflective thinking.

An additional resource was developed by Facing the Future, a group of researchers based out of Western Washington University. A textbook published by the group (2011) is not explicitly linked to a global education framework, but contains tasks based around global issues such as poverty, population growth, carbon emissions, energy, and sustainability. The mathematics content is at a middle school level and each task contains a background reading on the global issue and associated mathematics questions.

Chapter Summary

The literature related to this study was presented by first offering descriptions of the frameworks of intercultural communicative competence and global education which served as the theoretical foundation for the study. Next, the work done in mathematics education to relate mathematics content to its “critical” use in understanding and improving the world can be seen in the field of Teaching Mathematics for Social Justice (TMfSJ). This field contains many studies and resources that relate mathematics to social justice issues and given that early work in TMfSJ predates the current global education frameworks, minimal connections exist between the two fields. As a result, the organizations associated with the global education frameworks
have begun to publish guidelines and demands for increased connections from the frameworks’ objectives to mathematics education but at this time, sample tasks and resources are limited.

Each component of the literature helped to inform the methods, findings, and analysis and interpretation of this dissertation study. The global education frameworks were analyzed, integrated, and modified to create a framework specifically for this study. Research studies done in TMfSJ provide many useful examples of ways in which mathematics teachers interact with issues of social justice. Existing examples of tasks that apply mathematics to real-world problems show what has been done, what is possible, and also provide an opportunity to view tasks through the lens of global education.
CHAPTER 3

PILOT STUDY

In this chapter, the methods and findings of a pilot study are presented. The pilot study was conducted for the purposes of testing research instruments, evaluating the effectiveness of recruitment processes, assessing data analysis techniques, and fully developing research questions and research plans (van Tiejlingen and Hundley, 2001). It is important to note that the pilot study was conducted and the data was analyzed one semester prior to conducting the dissertation study to allow time for appropriate modifications. The results of this pilot study and its role in shaping the procedures and the analysis of the dissertation study are presented below.

Pilot Study Design

After conducting an initial literature review, the research questions were designed based on the primary goal of exploring the connections between mathematics education and frameworks of global education. Given the nature of a pilot study, the research questions were subject to change based on the data collection and analysis procedures.

The first research question was considered to be the primary research question for this study and represents a major goal of the research:

1. In what ways do K-12 teachers understand and implement global citizenship education in the mathematics classroom?

The remaining three research questions were considered to be secondary research questions for this study seeking to support the primary research question:

2. In what ways do mathematics tasks support both mathematics (in terms of CCSS-M) and global citizenship learning goals?

3. How are teachers’ thoughts towards the creation of mathematics lessons and tasks influenced by exposure to global citizenship education?
4. How do skills and aspects of global citizenship education present themselves in mathematics classrooms and how do they interact with mathematics skills?

Qualitative methods were selected to address each of the four research questions because the questions are open-ended and require responses and actions with nuances that cannot be captured by purely quantitative variables. Forms of qualitative data include individual interviews, focus groups, observations, and artifacts, each of which allow researchers to obtain rich data to understand a particular phenomenon (Creswell, 2013). In this particular study, interviews and classroom observations were selected to gain insight into the perspectives of K-12 mathematics teachers and to support the first, third, and fourth research questions. In addition, mathematics tasks were collected to further support what could be gained with interviews and observations, and to address the second research question.

Participants

Three high school mathematics teachers participated in the pilot study. A convenience sample was used with participants who had prior ties to our research team and were available for the study. IRB procedures were followed, including a letter obtained from the principal of the school to conduct classroom observations and signed consent forms from each of the participants. Table 3.1 (on the next page) summarizes the demographics of the teachers in the pilot study by providing their number of years of teaching experience and the high school mathematics courses that they taught while participating in the study.
Table 3.1

Pilot Study Participant Demographics

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Years of Teaching Experience</th>
<th>Classes Taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucy</td>
<td>8 years</td>
<td>Algebra 2, Precalculus, Geometry</td>
</tr>
<tr>
<td>Jeff</td>
<td>18 years</td>
<td>Statistics, AP Calculus, Geometry</td>
</tr>
<tr>
<td>Paula</td>
<td>12 years</td>
<td>Financial Algebra, Money Management, Geometry</td>
</tr>
</tbody>
</table>

Note. All names of participants are pseudonyms to protect their identities.

The three teachers in the pilot study taught mathematics at the same high school that serves students in grades 9-12. There are approximately 100 students per grade level with an average class size of approximately twenty students. The school is located in a rural area in the northeast region of the United States with 25% of the student population receiving free or reduced lunch. The vast majority of the students at the school are White and come from varying socioeconomic backgrounds.

Data Collection

For this pilot study many different forms of qualitative data were conducted and collected, including semi-structured interviews, classroom observations and mathematics tasks to help answer the research questions. Table 3.2 on the following page displays the sequence of study procedures and data collected for each participant in the study with each procedure further explained below.
Table 3.2

Sequence of Pilot Study Procedures

<table>
<thead>
<tr>
<th>Study Procedure</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview 1</td>
<td>Interview responses, tasks</td>
</tr>
<tr>
<td>Classroom Observation</td>
<td>Observation protocols, tasks</td>
</tr>
<tr>
<td>Collect Mathematics Tasks</td>
<td>Mathematics Task Protocols</td>
</tr>
<tr>
<td>Interview 2</td>
<td>Interview responses, tasks</td>
</tr>
</tbody>
</table>

Interview 1

Each interview was conducted using a semi-structured format, in which an interviewer has a predetermined set of questions but maintains the flexibility to ask related or further probing questions depending on a participant’s responses (Leech, 2002). A researcher may elect to seek further elaboration about particular enlightening responses in lieu of asking additional questions from the existing interview protocol.

Initial interviews were designed to first elicit teachers’ thoughts on “real-world problems” in mathematics, serving as an entry point for the researcher to understand the familiarity of each teacher with frameworks of global education. Teachers were then presented with an excerpt from the UN’s document on Global Citizenship Education (GCE) (UNESCO, 2015; see Appendix C for the excerpt) and were asked about their broad understanding of the framework’s possible connections to mathematics education. This framework separates GCE into three categories of objectives and teachers were asked about each category individually as well as what the framework offers holistically. The duration of these interviews was between forty minutes and one hour and depending on the time remaining, participants were also asked about related topics such as district and/or school efforts related to GCE, the teacher’s own personal comfort level and beliefs on the inclusion of global issues in education, and their desired
resources for the integration of global issues in mathematics (see Appendix B for the full first interview protocol).

Classroom Observation

At the end of the first interview, a time was set up with each teacher to observe an implementation of a mathematics task identified by the teachers as one which incorporates global education into the task. During each classroom observation, an observation protocol was used and field notes were taken. The observation protocol used was the Reformed Teaching Observation Protocol (RTOP) created by the Evaluation Facilitation Group of the Arizona Collaborative for Excellence in the Preparation of Teachers (2000) with parallel items created by the researcher for this study. The RTOP instrument contains 25 items on a 5-point Likert scale and was developed to “synthesize three instructional aspects [as they relate to mathematics]: standards-based teaching, an inquiry orientation in lesson design and implementation, and student-centered teaching practices” (Boston, Bostic, Lesseig, & Sherman, 2015, p. 155). In alignment with Boston et al., these three aspects comprise “reform-oriented mathematics teaching.”

The parallel items were created to measure the same instructional aspects in the context of global citizenship education in the classroom. Each of the 25 items on the RTOP was extended to include a part (a) and a part (b) on the protocol that will be used for this study (see Appendix F for the full protocol). Part (a) is the exact item from the RTOP designed to measure reform-oriented teaching for mathematics and part (b) was created by the researcher to correspond with part (a), but modified to measure reform-oriented teaching for global education. For example, the RTOP item “Students were reflective about their learning” includes “(a) in mathematics” and “(b) of local, national, and/or global issues.”
The researcher completed the online training for the tool to ensure that administration of the RTOP produced reliable and valid results. The online training consisted of scoring three videos within a given margin of a master scoresheet.

**Collection of Mathematics Tasks**

A mathematics task is a problem or set of problems which focus on a mathematical idea and also provide an opportunity to develop mathematical habits of mind (NCTM, 2000a). Specifically, a mathematics task may be a worksheet, lesson plan, activity, project, assessment, or a combination of these resources. In this particular study, participants were asked (at various times) to send a copy of a mathematics task they have used in class identified by them as a task which incorporates or demonstrates the potential for incorporating global education and its associated objectives.

The mathematics problems within the tasks were first coded for their mathematical cognitive demand level according to the model developed by Stein, Smith, Henningsen, and Silver (2000). In addition, they were coded for the presence of global education objectives using a scheme created by the researcher for this study. This coding scheme was created by extracting the primary objectives and categories outlined in the 2015 UNESCO framework (pp. 22-40) (see Appendix G for the full task protocol). These tasks and the classroom observations supported at least one of the four research questions and served as the basis for many specific questions asked in each participant’s second interview.

**Interview 2**

As in the initial interviews with teachers, each second interview was also conducted with a semi-structured format to give the researcher flexibility to ask related or further probing questions depending on a participant’s responses (Leech, 2002). One noteworthy difference between the two interviews was that many questions in the second interview were prepared
based on specific first interview responses, classroom observation, and mathematics tasks collected from a given teacher.

The second interview with each teacher was designed to focus on the class observed and the mathematics tasks collected. A discussion of the classroom observation was the initial focus with questions designed to elicit the perspectives of the teacher related to the mathematics content, student engagement in the task, and the development of global education objectives. Teachers were also asked about the different tasks they submitted whose implementation was not observed by the researcher. Each teacher was asked to reflect on both the mathematics and global education goals of the task and on ways that particular elements of the task may or may not be altered to reach each set of goals. Questions related to specific tasks then transitioned into questions about each teacher’s process of designing or implementing mathematics tasks that incorporate global education objectives, including the balance of time spent on various goals for the task, desired resources, and assessment. The duration of the second interviews was also between forty minutes and one hour and depending on the time remaining, teachers were also asked to provide insight into any of their evolving thoughts since the first interview as well as their future plans for using mathematics tasks which incorporate global education objectives in their classroom (see Appendix D for the full second interview protocol).

Data Analysis Procedures

Data Preparation

After conducting each interview, the audio was transcribed using oTranscribe, an online transcription program, and printed out for the researcher to have a tangible document to code. The protocol for each classroom observation was completed immediately following the observation and was stapled to the field notes (handwritten) of the corresponding observation.
Similarly, the protocol used for each mathematics task collected was completed shortly after receiving the task from a teacher.

All data collected in this study was confidential and only maintained and accessed by the researchers. Pseudonyms were created for each participant and all data was labeled only with pseudonyms with a separate password protected document linking participants to their pseudonyms. All names of people and places in the transcriptions were redacted or changed so that no collected data contained any identifiable information.

Coding

Shortly after the interviews were transcribed, the researcher initiated open coding procedures. Open coding consists of attaching a short word and/or phrase to a segment of the text to assign it meaning as it relates to the research questions (Merriam, 2009). In particular text segments, In-Vivo coding (Saldaña, 2013) was utilized by identifying meaningful quotes as codes that could themselves directly help to answer the research questions. An example of a segment of Jeff’s interview is provided below. The underlined segments of text are followed by their corresponding code (in parentheses and bolded).

Time is always the #1 concern with everything (time pressure) and making sure that I am addressing the mathematical needs first and foremost, (math content priority) that the rest of the issue is wonderful if they take something away from that, (learning from context a bonus) but that’s not really my focus, (focus on content not context) my focus is on getting them to learn the math that’s in the curriculum (pressure of curriculum goals/standards).

Source: Jeff, Interview 1, page 12
Open coding continued as other data collection in the study was still ongoing. In addition, as new interviews were coded, the codes were constantly compared to the codes from previous interviews (Saldaña, 2013).

**Protocols**

The RTOP protocol with the added parallel items addressing global education objectives was completed immediately following the classroom observation. With the additional items, each protocol had a total of fifty completed items scored on a 5-point Likert scale. The item responses were used to triangulate a teacher’s responses in either of their two interviews, guide the questioning for their second interview, and inform the dissertation study.

The mathematics task protocol consisted of classifying the mathematical cognitive demand level and scoring items identifying global education objectives extracted by the researcher from the UNESCO framework (2015). A final protocol contained the task’s cognitive demand level and fifteen items scored on a 4-point Likert scale related to the global education objectives. This protocol was also used to triangulate a teacher’s responses in either interview, guide the questioning for the second interview, and inform the dissertation study.

**From Codes to Categories**

During and after the compilation of codes for the full set of data collected for the pilot study, categories were formed by listing the codes generated by the researcher and organizing the codes based on similarities or patterns among the codes. This process is known as “themeing the data” (Saldaña, 2013) and was repeated for each of the four research questions of the pilot study. These categories, and in some instances sub-categories, provided the findings for the pilot study and informed the data collection and data analysis methods of the dissertation study.
Pilot Study Findings

The analysis of the interviews, classroom observations, and mathematics tasks through basic interpretative qualitative methods led to the findings for this pilot study. The findings are presented for each of the four research questions, followed by the implications of these findings on the research plans of the dissertation study.

Research Question 1

The first, and primary, research question for this study was: In what ways do K-12 teachers understand and implement global citizenship education in the mathematics classroom? The question and the analysis dictated that the findings related to this question be split into two sections: one for the ways in which teachers understand global education in the mathematics classroom and one for the ways in which teachers implement global education in the mathematics classroom.

Understand. The first insights into the ways teachers understand the connections between global education and mathematics education is through their own definition and use of real world mathematics problems. Each of the three teachers felt that different types of these problems existed, but each categorized them differently. One teacher stated that generally real world problems were opportunities to model phenomena with mathematics but that specific problems “would really depend on the course that you’re talking about” (Paula, Interview 1, p. 1). Another teacher felt that real world problems were any opportunities for students to personally connect with the mathematics, but that the connections were dependent on the individual student, and the third teacher felt the primary difference was in the scale of the problem and felt that real world connections could be made in short word problems or in larger scale project-based problems.

Although teachers had different views of real world problems, they each shared the belief that global citizenship education (GCE) was separate from mathematics in the classroom.
The additional objectives associated with GCE were viewed as extra objectives to prepare for and also seen as a distraction from mathematics content in the classroom if class discussions were to occur about the global context of a problem. Paula’s educational background even includes foreign language education and while she expressed the importance of including connections to GCE through cultures and languages, she also admitted that many GCE objectives “are probably harder [to address] for a math environment” (Paula, Interview 1, p. 7) and that she has not explicitly made these connections in her mathematics classes.

The separation of GCE from math for the teachers was further revealed through discussions about the school’s overall learning goals which are visible on a poster in the front of every classroom. The poster contains an overall mission statement as well as eight expectations, or goals, for every student and one of the expectations reads: “value and demonstrate an understanding of global citizenship.” Despite this being listed as one of the main learning goals in the school, one of the teachers had never heard the phrase “global citizenship” before, another felt that there was no clear definition provided for the teachers nor has there been any guidance on how to measure that goal in students, and the third teacher was a part of the committee that created the goals and yet admitted that the goals play no role in the day-to-day procedures and interactions that occur in their mathematics classrooms.

Lastly, teachers also identified potential benefits of the inclusion of GCE into mathematics by providing students an opportunity to truly engage in the mathematics content. Furthermore, Jeff suggested the prospect of a mutually beneficially relationship between the two:

And the reward is that they will learn the mathematics if they’re bought into it there [through global issues], but also they may become more...well their view on the subject may be a little bit more robust having some mathematics to go with their opinions.

(Interview 1, p. 10)
Implement. In addition to gaining insights into the teachers’ understanding of GCE into math, teachers revealed ways that they have implemented or would implement tasks incorporating GCE in their mathematics classrooms, which was supported by the tasks collected and observed. Teachers were asked to provide a mathematics task that they identified as making connections to the global citizenship objectives from the UNESCO framework (2015). Each teacher was exposed to these objectives in their first interview and their choices in selection of tasks provide another glimpse into the teachers’ evolving understanding of GCE.

Jeff decided to create a task specifically for this study for his Statistics class in which he researched and found an article online with authentic data comparing the SAT math scores of males and females. He then turned the data into statistical distributions and asked students mathematics skill-based questions about the distributions and a concluding reflection question about the context of the data. He asked students to write what they thought about the data and reported back the responses with one student stating that the higher SAT math scores for males meant that “teachers should encourage females to want to do better in math.” Jeff was intrigued by this particular response but admitted to simply not having additional class time available to further discuss the context of the data with his students.

The other two teachers also expressed concerns related to available class time and that their priorities should be placed on the mathematics content. Each felt that they would be doing a disservice to the material that they needed to cover if the priority wasn’t placed on the content, particularly due to the pressure they experience from the Common Core State Standards for Mathematics (CCSS-M) and the demand to cover a significant amount of content in each academic year. For example, Lucy noted that the inclusion or discussion of any global issues could not “take up a lot of class time because we have much more to cover in math” (Interview 1, p. 11). Furthermore, even though Jeff’s Statistics courses were not associated with the CCSS-M, he still expressed feeling the pressure of available class time and noted that if he had the
option, he would prefer having his class run over a double period to allow time for discussions surrounding the context of particular data sets.

In reflecting on the implementation of GCE topics and objectives into their mathematics classrooms, the teachers also believed that a particular classroom environment would be necessary in order to successfully implement GCE concepts. This classroom culture would not necessarily be explicit in tasks, but teachers identified the importance of having a welcoming classroom environment in which students would be open and comfortable in expressing their views and opinions while also being respectful and accepting of one another. These are characteristics that the teachers already strive to achieve in their classrooms, but they believed carry additional weight and importance given the divisive nature of particular GCE topics. Each of the teachers identified the possibility that these topics, especially ones that are largely controversial, could lead to students expressing opinions that are highly political and negatively affect the classroom environment. Jeff expressed this concern, saying: “I just worry about having a controversial topic take away from the spirit of the math and end up having us focus on something that they should be doing in their sociology class” (Interview 1, p. 6).

Lastly, Lucy viewed her implementation of real world problems as an opportunity for her to display an application of mathematics to the real world, but felt strongly that she should stifle any discussion associated with the context of the real world connection. She believed that any discussion would take classroom time away from the mathematics content goals and objectives that she needed to cover. In addition to the time constraints, she expressed that any inclusion of global issues would not include class discussions due to her own personal discomfort: “this [math class] is not the place for them to voice their opinion, in social studies maybe yes but I’m not a social studies teacher and I’m not ready to deal with some of the social issues” (Interview 1, p. 11).
Research Question 2

The remaining three research questions each acted as supporting research questions for the study, with the first of these asking: *In what ways do mathematics tasks support both mathematics (in terms of CCSS-M) and global citizenship learning goals?* The mathematics tasks protocol along with the teachers’ responses to their submitted tasks were the sources of data analyzed to answer this research question.

First, Paula noted that mathematics tasks that focus on procedural understanding will naturally lack goals associated with global citizenship education and the items from the mathematics task protocols support this claim. The analysis of the tasks also revealed that when the cognitive demand level of the task increased, additional opportunities for GCE objectives were present. Additionally, Paula believed that larger project-based problems could provide an entry point for the systematic inclusion of GCE goals through student investigations into global issues while using relevant mathematics. These responses also align with the teacher belief that students with strong mathematical abilities would be better suited to engage with global issues, including ones that may be controversial.

When discussing the mathematics tasks, teachers often addressed the challenges and barriers that might be associated with the design or implementation of tasks that integrate GCE goals. Even if these tasks were to already exist, teachers maintained that their own lack of comfort with particular global issues would be an impediment to achieving the GCE objectives. Each teacher also identified the importance of having a positive rapport with students in order to fully engage in the task, and believed that this would be more likely at their school compared to other schools due to its size (about 100 students per grade level). Similarly, teachers felt that a lack of rapport between students and the teacher would also represent an obstacle towards addressing GCE objectives in the classroom. Paula stated that without rapport:
I don’t think you’re gonna get to any of these [GC goals] and maybe you wouldn’t even recognize it if you did because I think the students wouldn’t be as willing to share it and wouldn’t really necessarily show you that they’re acquiring any of these skills. (Interview 1, p. 10)

This illuminates the notion that teachers believed other factors beyond mathematics tasks were significant towards addressing global issues and GCE objectives in their classrooms.

**Research Question 3**

This supporting research question was: *How are teachers’ thoughts towards the creation of mathematics lessons and tasks influenced by exposure to global citizenship education?* This question seeks to identify teachers’ perspectives towards the design and implementation of mathematics tasks that include GCE goals, particularly following their exposure to the framework provided by UNESCO (2015).

To be able to meaningfully incorporate GCE into their math classrooms, each teacher agreed that they would need extra time to prepare tasks, including time for the teachers themselves to fully understand various global issues. For example, Jeff stated “with my own comfort level I think it’s more about having enough information to feel like I can make a case for anything that comes at me with that particular subject” (Interview 1, p. 12). This belief was consistent as each of the other two teachers did not want to integrate global issues into their tasks without feeling comfortable and prepared to lead any potential discussions about the issue(s).

When considering what resources would facilitate the design of tasks that incorporate GCE topics into math, teachers shared different ideas and preferences. Lucy preferred an online open-sharing resource in which teachers from the United States or even around the world could upload their mathematics and global issues tasks to a portal that would be easily accessible for any teacher. Jeff expressed a desire for a template or program that would provide instructions
on a process to systematically link global issues and mathematics content and he would then create his own tasks with that guidance. Yet another idea was offered by Paula who suggested increasing interactions with other schools to provide students with experiences of talking or writing with students of the same age that live in a setting which is different than their own. This was relevant at their school as Paula noted that the school and town populations lack cultural diversity and as a result, suggested that the school should partner with one that is in the same state but located in an urban setting to widen the perspectives of her students. It was unclear exactly how this school partnership would play a role in her mathematics classes, but Paula believed that the widening of her students’ perspectives was crucial and could address GCE objectives.

**Research Question 4**

The final supporting research question was: *How do skills and aspects of global citizenship education present themselves in mathematics classrooms and how do they interact with mathematics skills?* The interview responses and classroom observation data were analyzed to address this question.

With respect to diversity, each teacher discussed the concept in different ways and separated the idea of mathematical diversity, or differences in mathematical abilities, from cultural diversity and the backgrounds of their students. In the classroom, the teachers all mentioned being constantly attentive to the mathematical diversity of their students, both as students enter the class and throughout the school year. The teachers all stated that they were less attentive to cultural diversity but that this was representative of the relatively homogeneous student and town populations.

In discussing group work and classroom interactions, teachers indicated that many of the communicative objectives of GCE already occur in their classrooms, even if the objectives and goals are not made explicit to the students or the teacher. To illustrate this, Jeff provided an
anecdote about a past experience with an immigrant student from Kosovo and described the academic year with the student as an “eye-opening experience” due to the student’s lack of English language communication skills. Although this might have affected the student differently in other courses, Jeff acknowledged that he was still able to effectively communicate with the student through the shared symbolic language of mathematics. In addition to the anecdote, when Jeff reflected on characteristics of an ideal student in his classes, he included “being willing to listen to other people’s [mathematical] approaches” (Interview 1, p. 13) which identifies an intersection between GCE objectives and desired characteristics in a mathematics classroom.

In considering the GCE objectives that may already be present in a mathematics class, Paula stated that she has recognized curiosity and openness from her students towards exchange students that the school has hosted through the years. She also acknowledged the way her class was more open toward gender diversity and attributed that to an increased exposure through social media. Although these objectives were observed in a mathematics class, Paula noted that they were not associated with mathematics or her classroom practices.

Whether the goals of GCE occur in a mathematics classroom or not, Paula shared her worldview on the responsibility that educators such as herself hold in cultivating global perspectives: “I think we’re very much in danger of growing a generation that really doesn’t have much of a concept of what goes on outside of their own little world” (Interview 1, p. 8). This statement was made while acknowledging the increased presence of social media and modes of communication and the statement aligns with an existing goal for the inclusion of GCE in modern education.

**Informing the Dissertation Study**

As previously mentioned, goals of conducting this pilot study included further developing the research questions and informing adjustments in the research plan of the dissertation study
(van Tiejlingen and Hundley, 2001). The study procedures, including the methods of data collection and data analysis, and the findings of the pilot study prompted a few important changes that are discussed below.

**Research Questions**

A major modification informed by the pilot study was the need to consolidate and reformulate the research questions. Additional comparison of existing codes resulted in two main categories addressed by the data: (i) the identification of global citizenship objectives achieved by students in the context of learning mathematics, and (ii) the factors that influence the ways teachers can connect global citizenship objectives to mathematics teaching and learning. Thus, the research questions from the pilot study were consolidated by combining the second and fourth research questions into one research question to target (i) above, and the first and third questions were combined into one research question to target (ii) above. This led to the formulation of the first two research questions for the dissertation study as:

1. Which global education objectives can be incorporated in K-12 mathematics classes and in what ways are the objectives meaningfully addressed by students?

2. What factors influence the ways in which K-12 mathematics teachers integrate global education objectives into their mathematics classes?

   In order to provide examples to potentially benefit both practitioners and researchers, a third research question was formed to help us understand how (i) and (ii) above unfold in explicit examples developed by teachers:

3. When analyzing specific mathematics tasks, which global education objectives do students address and what factors influence how teachers design and implement the task?
Data Collection

In the pilot study and the dissertation study, the sequence of study procedures remained the same. That is, each participant completed an initial interview, a classroom observation, a second interview, and was asked at multiple times in the study to submit mathematics tasks that they identified as making connections to global education objectives. Participants were asked to reflect on their submitted tasks during the second interview, and their responses provided insight into the relationship between their tasks and the global citizenship objectives that helped address the three research questions.

In addition, the nature of the samples in each study allowed for increased researcher flexibility in various interview questions for teachers in the dissertation study. In the pilot study, all three teachers taught at the same school and although many questions were tailored to each individual's classroom observation and unique tasks, many questions were similar due to their shared school setting and student population. The dissertation study plan was modified to include an expanded sample from multiple grade levels (elementary, middle, and secondary), types of schools (public, private, and magnet), and locations (urban, suburban, and rural). As a result, the interview questions that were dependent on the context of a teacher's environment were adjusted accordingly.

Data Analysis

Significant changes to the data analysis procedures were required to best address the modified research questions for the dissertation study. The basic inductive qualitative approach employed in the analysis of the pilot study was retained for the second research question of the dissertation study, but with additional rounds of coding. All methods of data analysis for the dissertation study are detailed in Chapter 4, including justification for the selected analysis approach of each research question.
The forms of data collected and analyzed in the pilot study remained the same with two exceptions. First, the mathematics task protocol containing the classification of the task’s mathematical cognitive demand level and scored items addressing global citizenship objectives extracted from the UNESCO (2015) framework (see Appendix G for the full protocol), was not used in the dissertation study. This protocol was removed due to the difficulty in identifying the global citizenship objectives based on a mathematics task on paper without an observation of its associated classroom implementation and interactions. Second, the modified RTOP protocol used for the classroom observations (see Appendix F for the full protocol) was completed in each study, but was not used in the analysis of the dissertation study. The instrument items became increasingly disconnected from the evolving research questions of the dissertation study and did not meaningfully support the analysis, but the protocol items were completed following each classroom observation in hopes of informing the second interview with each teacher.

Chapter Summary

This chapter presented the study design, research questions, participants, methods, and findings obtained from the analysis of data obtained from three high school mathematics teachers participating in a pilot study. Each of the findings informed the modification of the research questions from the pilot study to create new research questions for the dissertation study. In addition, the effectiveness and purposes of the methods of data collection and analysis were reviewed, evaluated, and modified to improve the processes and findings that best address the research questions of the dissertation study.
CHAPTER 4

METHODS

This chapter presents the study’s design, participant recruitment and demographics, methods of data collection and analysis, and issues of trustworthiness. Finally, the details for the methods provided in this chapter are supported by strategies of triangulation and peer review, and a statement of my own background and perspectives to address the trustworthiness of this study. Each component of the study was selected with a purpose to answer the three research questions:

1. Which global education objectives can be incorporated in K-12 mathematics classes and in what ways are the objectives meaningfully addressed by students?
2. What factors influence the ways in which K-12 mathematics teachers integrate global education objectives into their mathematics classes?
3. When analyzing specific mathematics tasks, which global education objectives do students address and what factors influence how teachers design and implement the task?

Study Design

A qualitative research approach was chosen for this study because the overall goal in answering the set of research questions is to deeply understand the process of linking mathematics to global education and the perspectives of the teachers involved. Specifically, in a basic interpretative qualitative study, researchers are interested in “understanding how participants make meaning of a situation or phenomenon” (Merriam, 2002, p. 6) through rich and descriptive data such as interviews, observations, and document analysis, all of which are incorporated in this study to best support the research questions.

Employing a basic qualitative approach also means that no hypotheses or predictions are made about potential findings; rather the findings emerge from the data through the
analysis (Patton, 2002). Despite having conducted a pilot study in which preliminary findings were discovered (see Chapter 3), these findings were not being tested against the new data as new categories and findings emerged for the research questions for this study which evolved from the pilot study.

Informed by the review of the literature and guided by methods of qualitative inquiry and data collection from the pilot study, a research plan was developed to best address the research questions of this study. This includes the recruitment of teachers, the selection of interviews, classroom observations, and collection of mathematics tasks as the primary forms of data collection, and both deductive and inductive methods of qualitative data analysis.

Participants

In qualitative studies, sample sizes are often much smaller than in quantitative studies because the goal is obtain rich information through in-depth analysis of select cases (Patton, 2002). In addition, the samples are not random samples, but rather purposeful to maximize the information obtained and analyzed to best address the research questions. In this study, K-12 mathematics teachers were the unit of analysis since their perspectives, experiences, and mathematics tasks directly contribute to the research questions.

Recruitment

The study design included the recruitment of between ten and twelve K-12 mathematics teachers that represent a range of grade levels and types of schools (public, private, urban, suburban, etc.). A combination of strategies was employed to obtain the final sample size of ten teachers.

A school with prior collaborations with the research team expressed interest in participating due to the alignment of the study with a school initiative. Teachers at the school were invited to participate and ultimately one teacher became a participant in the study. Many regional school principals, mathematics coaches, and mathematics interventionists were
invited via email to participate in the study. Through this method, one mathematics interventionist from an elementary school expressed interest and was then able to recruit two interested teachers at the same school and an additional two teachers from another school in the same school district. The remaining four participants came from a pool of teachers that had previously participated in workshops implemented by a colleague.

These recruitment strategies and leads occurred simultaneously and continued until the final number of ten participants was reached. At any point, if a teacher displayed interest in participating, they were given the opportunity to do so, but as teachers began to participate, emails sent to potential new participants were focused on characteristics of teachers that would create a more heterogeneous sample. Among the ten participants, there were at least two teachers from a school in each of the following categories: elementary (grades K-5), middle (6-8), high (9-12), public, and private or magnet. In addition, there were multiple teachers with at least 20 years of teaching experience, multiple teachers with no more than 10 years of teaching experience, and multiple teachers with 10-20 years of teaching experience. This purposive and heterogeneous sample was included in the design of the study because it is able to illustrate both the uniqueness of the context at each school and the similarities and patterns that may exist (Patton, 2002) across all schools and teachers in the study. Table 4.1 (on the next page) illustrates the demographics of the participants in this study, including their school, grade taught, and number of years of teaching experience.
Table 4.1

**Participant Demographics**

<table>
<thead>
<tr>
<th>Name</th>
<th>School</th>
<th>Grade(s) Taught</th>
<th>Number of Years of Teaching Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Hammons</td>
<td>1</td>
<td>3 &amp; 4</td>
<td>10</td>
</tr>
<tr>
<td>Mrs. Brown</td>
<td>2</td>
<td>K-5 Mathematics Interventionist</td>
<td>30</td>
</tr>
<tr>
<td>Mrs. Paige</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Ms. Cole</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Ms. Davis</td>
<td>3</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Mrs. Stockton</td>
<td>3</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Ms. Markova</td>
<td>4</td>
<td>9-12</td>
<td>10</td>
</tr>
<tr>
<td>Mr. Thomas</td>
<td>5</td>
<td>10-12</td>
<td>11</td>
</tr>
<tr>
<td>Mr. Anderson</td>
<td>5</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Mr. Reynolds</td>
<td>6</td>
<td>9-12</td>
<td>10</td>
</tr>
</tbody>
</table>

*Note.* All names of participants are pseudonyms to protect their identities.

**School Profiles**

Descriptions of the six schools in this study are included below to provide additional context into the school settings for each of the participants.

*School 1* is a private K-8 school located in a suburban region of the Northeast United States. There is one class of 10-20 students per grade in the school. Since the school is private, no students receive free or reduced lunch. Mr. Hammons is the 4th grade teacher at the school who also teaches mathematics for the 3rd grade class.

*School 2* is a public K-5 school located in an urban region of the Northeast United States. There are 4-5 classes of 15-25 students per grade and 70% of the school’s students receive free
or reduced lunch. The school has a dual-language program in which students spend half of each school day speaking in English and the other half speaking in Spanish. Mrs. Brown is the mathematics interventionist in the school, Ms. Cole is a 1st grade teacher, and Mrs. Paige is a 4th grade teacher whose students are enrolled in the dual-language program.

School 3 is a public middle school serving grades 6-8 in an urban region of the Northeast United States. Students are organized by “teams” in which different subsets of each grade share the same group of teachers and classes contain 15-25 students. Seventy-five percent of the school’s students receive free or reduced lunch. The teachers are specialists and both Ms. Davis and Mrs. Stockton teach 6th grade mathematics at the school.

School 4 is a magnet high school located in an urban region of the Northeast United States. This school only offers STEM courses and programs to prepare students for STEM-related careers and college majors. Students must apply for admission into the school and the classes contain 10-20 students each. All students at the school receive free lunch due to the average income of the town. Ms. Markova teaches multiple mathematics classes at the school, including AP BC Calculus.

School 5 is a public high school located in an urban region in the Northeast United States. More than half of the students are Hispanic and the school receives state funding for all of its students to receive free and reduced lunch. The school has over 2,000 students and class sizes range from 15 to 30 students. All students at the school receive free lunch due to the average income of the town. Mr. Thomas teaches multiple mathematics classes at the school, including AP Statistics. Mr. Anderson teaches freshman-level mathematics courses, including a STEM course that he created in which students use engineering principles and participate in regional team competitions.

School 6 is a magnet high school located in an urban neighborhood of a city in the Midwest United States. More than half of the school’s students are Black and classes contain
20-30 students. All students at the school receive free lunch due to the average income of the town. Mr. Reynolds teaches many different mathematics classes at the school, including Algebra I & II, Geometry, and AP Calculus.

Data Collection

Of the many different forms of qualitative data, interviews, observations, and documents (Merriam, 2002) were each conducted and collected for this study. Semi-structured interviews served as the primary form of data for the first two research questions of the study, classroom observations supported all three research questions, and mathematics tasks were the focal point of the analysis of the third research question. Table 4.2 below displays the sequence of study procedures and the data that was collected from each participant at each stage of the study.

Table 4.2

<table>
<thead>
<tr>
<th>Study Procedure</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview 1</td>
<td>Interview responses, mathematics tasks</td>
</tr>
<tr>
<td>Classroom Observation</td>
<td>Observation protocols, mathematics tasks</td>
</tr>
<tr>
<td>Interview 2</td>
<td>Interview responses, mathematics tasks</td>
</tr>
</tbody>
</table>

Interview 1

Each initial interview with teachers was conducted using a semi-structured format, in which the interviewer (researcher) prepared a set of topics and questions to be asked and then during the interview, directed the topics, follow-up questions, and conversations based on the responses of the participant. This gives the researcher more flexibility but keeps the interactions “focused while allowing individual perspectives and experiences to emerge” (Patton, 2002, p. 344).
The purpose of the first interview with each teacher was to gain an understanding of their existing thoughts on the possible integration of global citizenship education (GCE) and mathematics. The questions sought responses relevant to each of the first two research questions through a teacher’s existing thoughts that may illuminate global education objectives in their mathematics classrooms and/or factors that influence their own existing or potential process in creating mathematics tasks which align with global education.

Each interview followed the general format found in Appendix B, with the researcher maintaining flexibility via the semi-structured format. Each interview began by asking the teacher about their definition and understanding of “real-world problems”, done as an entry point for teachers that may not be familiar with the ideas or frameworks of global citizenship, global competence, or global education. During the interview, each teacher was provided with a copy of a purposeful subset of the UN document on GCE (UNESCO, 2015; see Appendix C for the pages provided to the teachers), selected to provide a brief overview of the three main categories of GCE objectives (as according to the UNESCO framework). After the researcher presented a brief overview of the document’s contents, the teachers were then asked about their thoughts and reactions towards each category of GCE objectives and their existing and potential roles in mathematics. After the interview, the teachers retained the subset of the UN document to serve as a resource on global education.

The interview guide was developed by the research team prior to the pilot study and then streamlined and modified following the analysis of the pilot study to best address the emerging research questions of the dissertation study (see Appendix B for the full interview protocol). Each interview was conducted in-person at the teacher’s school, at a restaurant, or through Skype. The audio of each interview was recorded using a researcher’s computer and a backup audio recording device, with the files only accessible to the researchers. The duration of each interview was between 30 minutes and one hour and the audio files were transcribed soon after
with names and identifiers replaced by pseudonyms. All ten teachers that participated in the study completed the first interview.

**Classroom Observation**

After completing the first interview, teachers were asked to select a time and mathematics task for the researcher to visit and observe their classroom. When scheduling the classroom observation, teachers were given the option of creating a new mathematics task or use an existing mathematics task that they believed contained topics and/or objectives related to global education. In general, observations provide researchers a lived experience of an environment in which they are able to perceive details and events which may be unintentionally or intentionally ignored by those who regularly participate in that particular environment (Patton, 2002). In this study, the purposes of the lived experience in the classroom were to identify the presence of global education objectives among students (the first research question), detect factors associated with the teacher’s implementation of their selected task (the second research question), and inform the interview guide and specific questions for the second interview with each teacher.

During the observation, the researcher recorded field notes that described the sequence of events and interactions that occurred in the classroom during the implementation of the selected mathematics task. In general, the purpose of taking field notes is to fully describe both the classroom setting and the details of the class period so that a researcher can return to an observation at any time during data collection and analysis (Patton, 2002). The field notes were written by hand during the observation, and later typed and privately stored so that only the researchers could access the data.

A total of six observations were conducted during this study. During her first interview, Ms. Cole expressed her belief that the context of the study was not applicable to the age of her 1st grade students and as a result, elected to not participate in the subsequent study.
procedures. Due to the geographic distance between the researchers and Mr. Reynolds, an observation of his classroom did not occur, but he did participate in all other study procedures, and his interviews were conducted via Skype. Ms. Davis and Mrs. Stockton were each willing to participate in the classroom observation, but were unable to take away classroom time from the preparation of their students for year-end examinations. As a mathematics interventionist, Mrs. Brown does not have a standard class of students, but was able to complete the classroom observation by participating in one of Mrs. Paige’s class periods. As a result, Mrs. Paige was the teacher during two classroom observations – one in which she alone could reflect on the task and another in which both she and Mrs. Brown could reflect on the task.

Collection of Mathematics Tasks

At various times during the study – after the first interview, after the classroom observation, and before the second interview – teachers were asked to provide examples of mathematics tasks, lesson plans, projects, or activities that they identified as integrating global education or “real world problems” into mathematics according to their understanding. These documents were collected to build a collection of examples to draw from for the analysis of the third research question. A total of 33 tasks and resources were collected during the study and three of these were ultimately selected for further analysis (see Appendix E for the selected tasks). The collection of the mathematics tasks also informed the second interview and provided additional context into a teacher’s interview responses (Patton, 2002).

The tasks were received either in-person or via email and nine of the ten teachers in the study submitted at least one task. The lone exception is Ms. Cole who elected to not participate in any study procedures following the first interview, but consented to use her first interview as part of the study nonetheless.
Interview 2

The second and final interview with each teacher was also conducted with a semi-structured format and was catered to the classroom observation and tasks submitted unique to each teacher. The purposes of the second interview were to lead the teacher in a guided reflection about the mathematics task that occurred during their classroom observation, to obtain their perspectives on any additional tasks submitted, and to further understand their (possibly evolving) thoughts on the integration of global education into mathematics classrooms. These purposes aligned with the first two research questions of the study as questions targeted the identification of global education objectives through a teacher’s perspectives, observation, and tasks, as well as factors that influenced the ways in which a teacher created and implemented a mathematics task related to global education.

A broad interview guide was developed by the research team prior to the pilot study and then modified following the analysis of the pilot study (see Appendix D for the full interview protocol). Before the second interview with each teacher, the research team prepared specific questions based on the previous data collected from that teacher. Similar to the first interview, each second interview was conducted in-person at the teacher’s school, at a restaurant, or through Skype. The audio of each interview was recorded using a researcher’s computer and a backup audio recording device, with the files only accessible to the researchers. The duration of each interview was between 30 minutes and one hour and the audio files were transcribed soon after with names and identifiers replaced with pseudonyms.

Seven of the ten teachers completed the second interview. Ms. Cole declined to participate in any study procedures after the first interview. Ms. Davis and Mrs. Stockton were unable to complete the classroom observation due to the timeline of their academic year, which led to the decision of the researchers to not conduct their second interviews. Mr. Anderson and Mr. Thomas separately completed their first interview and classroom observation but due to
their schedule restrictions preferred to complete their second interview together. This joint interview was conducted in a similar manner to those with other teachers and Mr. Anderson and Mr. Thomas were asked one at a time about their observation and submitted tasks. The one difference in their interview was the added dynamic in which they were able to listen to each other’s answers before providing their own response to any of the general questions that were not specific to their own tasks.

Data Analysis Procedures

The overall nature of qualitative research is interpretative (Patton, 2002) and different data analysis techniques exist depending on the data collected and research question(s) of interest. In this study, the data analysis procedures were different for each research question and based on the goals and data collected specific to each question. For the first research question, a deductive (qualitative) approach was utilized to identify and classify the application of global education objectives in mathematics education. An inductive (qualitative) approach was used for the second research question to describe and categorize factors associated with the design and implementation of mathematics tasks through the responses and perspectives of the teachers. The analyses of the first two questions were conducted using the full set of interview transcripts as the primary data, which consist of 16 interviews and 170 single-spaced pages of text. The third research question was analyzed through an application of the existing inductive and deductive codes obtained from the analysis of the first two research questions to highlight the relevant global education objectives and factors of design and implementation associated with a particular mathematics task. Three of the 33 mathematics tasks collected in this study were selected by the research team for the analysis of this question. The data analysis procedures of all three research questions are explained in detail below.
Research Question 1

To determine which global education objectives were applicable to the interview data, a hybrid of Hypothesis Coding and Protocol Coding (Saldaña, 2013) schemes were employed. Each form of coding is deductive; that is, a researcher begins with a predetermined set of codes which are applied to a set of data. The list of codes to be used can either be created by the researcher (Hypothesis Coding) based on their experiences or predictions or can come directly from research (Protocol Coding) in the form of a protocol or theoretical framework (Saldaña, 2013). For this study, an existing framework of global education objectives was applied to the data. Following a review of the literature, an existing framework was modified to facilitate the coding stages and capture all objectives relevant to this study. The process of modifying and creating the framework is described below. The coding process and steps taken to move from the codes to the findings is also described in detail.

Global Education Framework. The global education framework which served as the set of codes to analyze the interview transcripts was created by starting with the competences identified by the Council of Europe framework (COE, 2016) and then modified to condense certain objectives and to include objectives identified by other theoretical models, including the models sponsored by the UN (UNESCO, 2015) and the Asia Society (Boix Mansilla & Jackson, 2011). The final framework used for coding contains six categories and a total of twenty objectives (see Appendix A for the full framework). The theoretical derivation of each category and objective is described below.

Knowledge. All of the analyzed frameworks contain some form of Knowledge as a category of objectives. For this framework, the objective measuring knowledge of global issues and history was divided into three separate objectives – Knowledge of Global issues, Knowledge of National issues, and Knowledge of Local issues – following the UNESCO (2015) framework which distinguishes scales of knowledge. The Interconnectedness of the different
scales of knowledge as well as the interconnections that exist between different global issues was also derived from the UNESCO model. Finally, reflective knowledge or Knowledge of Self was taken from the COE (2016) model. To provide an example of an objective that was not retained from one of the theoretical frameworks, Knowledge of Language (from the COE model) was not included in the framework for this study due to the focus on mathematics.

**Skills.** Taken from the COE framework, the skills of Self-Directed Learning, Critical Thinking, and Effective Communication were retained and the skills of Cooperation and Conflict Resolution were merged into one objective as each involves characteristics of communication and negotiation in group settings. Skills associated with linguistics were removed due to the mathematics focus of the study.

**Values.** Three values of humanity - Human Rights, Cultural Diversity, and Justice, Fairness, and Equality – were retained from the COE model.

**Attitudes.** The objectives of Curiosity and Openness and Civic-Mindedness were retained from the COE model. The attitude of respect was grouped into a wider objective of Care, Empathy, and Respect derived from the UNESCO framework. Attitudes of responsibility, self-efficacy, and tolerance of ambiguity were removed due to the classroom environment of interactions in this study.

**Action.** The category of Action was adopted from the UNESCO model with codes of Opportunities to take action, and tangibly Taking Action to improve conditions.

**Mathematics Context.** The Mathematics Context category was derived from the Asia Society model and these codes describe the context in which mathematics is used in the teaching and learning of global issues. The two contexts of Disciplinary and Interdisciplinary learning were adopted directly from the Asia Society framework, and the third context of Content Knowledge was added by the research team to include instances in which global issues were a part of a mathematics task, but the primary purpose of the task was to develop
the students’ content knowledge and skills rather than using mathematics as a tool to investigate the global issue(s).

**First Round Coding.** After creating the framework containing the list of codes (see Appendix A), I coded a subset of the interview transcripts by assigning one or more of the twenty codes to a segment of text through my interpretation of the text and the definitions of the codes. This coding was done by hand with an interview transcript side-by-side with the framework and definitions of codes.

To increase the reliability of my findings and ensure my understanding of the codes, my advisor and another member of my dissertation committee each independently coded the same interview transcript. In separate meetings with each researcher, I compared my codes to theirs to confirm my codes and discussed nuances of interpretations of the codes to ensure a shared understanding of the codes and their application throughout the data set (Merriam, 2002).

**Second Round Coding.** Coding is a cyclic process (Saldaña, 2013); that is, while I was applying the codes to the transcripts, I constantly referred back to previous instances of a code to observe any patterns found among the segments of text with the same code. In going through each of the transcripts and comparing codes across transcripts, I realized that there were many instances in which the same code (objective) was applied to selections of text in which a teacher described characteristics of an objective in a positive manner as well as selections of text in which a teacher felt challenged by the relationship between an objective’s characteristics and mathematics. As a result, in consultation with my committee members, I decided to add a sub-layer of codes to the framework to bring additional clarity to the data and to inform the findings.

The different contexts in which the codes appeared led to three sub-codes: (1) instances in which a global education objective was present in a student at some point in the teacher’s classroom (coded as Y = yes), (2) instances in which opportunities to address a global
education objective were identified (coded as O = opportunity), and (3) instances in which challenges to address a global education objective were identified (coded as C = challenge). Each of the sub-codes were applied by the interpretation of the researchers or directly through the perspectives of a teacher.

To complete the second round of coding, I went through each of the interview transcripts a second time and attached one of the three sub-codes (Y / O / C) to each of the codes I had initially applied. In doing so, the initial codes were also fluid and some were added, removed, or modified in accordance with the added perspective required to apply the sub-codes.

**Third Round Coding.** To continue the cyclical nature of coding, I added a third round of coding with an additional perspective to further strengthen the codes. In this round, rather than look at each transcript and apply the set of twenty codes (objectives) and three sub-codes, I focused on a single code and went through each of the 16 transcripts only applying that one code with one of the sub-codes attached. This process was repeated for all twenty codes and in some instances, codes in the text were added, removed, or modified in accordance with the additional, focused perspective on a single code. This round of coding also served as a link to the development of the findings for this research question as the applications of each code were constantly organized in this process.

**Coding Example.** The next page displays an excerpt from one of the interview transcripts after the final round of coding which contains the codes from the framework and their associated sub-codes. The underlined segments of text are followed by their corresponding code(s) and sub-code(s) (in parentheses and bolded). See Appendix A for the abbreviations and definitions of the codes. Note that there were also codes from the second research question in this text, but only the codes for the first research question appear in the example.
So for me it's almost like more of the big picture, I'm hopefully leading them on the way of figuring out what we're doing to contribute to climate change and so I think at the end of it I wanted them to have a deeper understanding of the debate that's going on in the world (K-G / Y) right now 'is there climate change? Or how is climate change really happening? is global warming really affected by people or is just the natural going through the years of the Earth cooling and getting hotter?' ultimately that's what I would want down the road and I think that the data from this lesson and the different lessons we're doing in reading will hopefully build on that knowledge, (Indis / O) obviously you want them to be able to go home and start making smarter choices (Opp / Y) and maybe think about as they're plugging into their game every night how much that's actually taking up energy (KS / O, IC / Y) or just the ability to say 'wow we live in a country that I can just plug in and get energy like that'.

Source: Mrs. Paige, Interview 2, page 2

From Codes to Findings. Through the coding process, I recorded noteworthy statements that illustrated the teachers' perspectives on the different emerging aspects from the analyses. I also observed patterns within each code to create a narrative account that captured the essence of the number of times a code and its sub-codes appeared. A frequency table for each code and sub-code was also generated to provide additional context for the findings (see Chapter 5) and to guide the discussion of the findings (see Chapter 6).

Research Question 2

To determine the factors that influence the way K-12 teachers integrate global education objectives into their mathematics classes, inductive qualitative data analysis procedures were followed. In an inductive analysis, the codes are derived from the data and patterns are drawn
from the codes to create categories and findings (Merriam, 2002). The data used to answer this research question consisted of the complete set of 16 interview transcripts.

**Coding.** In an inductive analysis, codes are words or phrases that “assign units of meaning to the descriptive or inferential information compiled during a study” (Miles & Huberman, 1994, p. 56). To attach codes, I printed out each interview transcript and wrote initial codes by hand that best captured the ideas in the text as related to the research question. The excerpt below provides an example of this inductive coding process. The underlined segments of text are followed by their corresponding code (in parentheses and bolded). Note that there were also codes from the first research question in this text, but only the codes for the second research question appear in the example.

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I think we need to be responsible, *(teacher responsibility)* we can’t just teach what we want to teach, I personally don’t wanna talk about that, not don’t wanna talk about it but because I don’t believe doesn’t mean I would only show my side, I would do both and I think a lot of people don’t do both, *(teacher dependent)* and so I think when we talk about globalization, global things and things in the classroom, because most teachers are very liberal and liberal-minded, *(impact of teacher viewpoints)* they do only teach one side and I think a lot of the universities do the same thing so I just think we need to be *(K: careful)* careful and purposeful and not just teach, let kids be their own...start to think for themselves, we don’t need to be thinking for them all the time. *(view towards student learning)*

Source: Mrs. Brown, Interview 2, page 5
---

The coding of the data occurred simultaneously with data collection previous codes were always subject to change following the collection of new data. Changing codes during the
overall process of analysis reflects evolving interpretations of the growing set of data (Miles & Huberman, 1994) and when coding a new transcript, I constantly went back to previous transcripts to compare and adjust codes.

To increase the reliability of my codes and findings, my advisor and two other graduate students studying mathematics education each independently coded three of the interview transcripts. After each transcript, the four of us met as a group to compare and discuss the codes we had each individually obtained. In each meeting, we found strong agreement in the independent codes, and nuanced choices in wording as well as fresh perspectives supported the progression of my own thinking and coding processes.

**From Codes to Categories.** Throughout the coding process, I maintained a written list of codes I had created and their frequencies. To organize the codes into categories and sub-categories, I used pattern codes which "identify an emergent theme, configuration, or explanation" (Miles & Huberman, 1994, p. 69) among initial codes. These pattern codes were also created throughout the data collection and analysis processes to constantly search for patterns within the data and initial codes. Similar to the initial codes, the pattern codes were subject to change as new data, patterns, and ideas emerged. The pattern codes then became the categories and sub-categories and were constantly compared, organized, and discussed with colleagues until the final set of categories was reached that best captured the data and addressed the research question. Throughout each step of the coding process, I also identified potential excerpts to include in the narrative account of each category and sub-category in the findings (see Chapter 5).

After the first round of coding, there were a total of 63 codes and eight pattern codes which were condensed into four main categories and additional sub-categories. Originally, the four main categories included Teacher Disposition, Student Considerations, School Factors, and Lesson Planning. Through the constant comparison of codes and categories and a peer
debriefing process, I decided to subsume Student Considerations and School Factors under the new main category of Contextual Factors. I also condensed some codes within a few of the sub-categories and changed the wording of some categories to best reflect the dimension it represents. The findings for this research question contain the three main categories of Teacher Disposition, Contextual Factors, and Mathematics Task Design and Table 4.3 below displays these categories and their corresponding sub-categories.

Table 4.3

*Categories for Research Question 2*

<table>
<thead>
<tr>
<th>Main Category: Teacher Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-category: Towards the Role of Mathematics</td>
</tr>
<tr>
<td>Sub-category: Towards Global Issues</td>
</tr>
<tr>
<td>Sub-category: Towards Connecting Mathematics to Global Issues</td>
</tr>
<tr>
<td>Sub-category: Towards Students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main Category: Contextual Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-category: School Factors</td>
</tr>
<tr>
<td>Sub-category: Local Population</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Main Category: Mathematics Task Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-category: Guiding Approaches</td>
</tr>
<tr>
<td>Sub-category: Pedagogical Considerations</td>
</tr>
<tr>
<td>Sub-category: Time and Resources</td>
</tr>
</tbody>
</table>

**Research Question 3**

To determine which global education objectives are addressed and which factors influenced how a teacher designed and implemented a specific mathematics task, the collected tasks and the classroom observations were utilized as the primary data. In addition, the interview protocols and existing codes from each of the first two research questions now served as tools used to analyze these forms of data. The analysis of this research question can be viewed as an application of the previous research questions. It also provided new perspectives from the observations that were not captured in the interviews.
Classroom Observation Coding. Immediately following each of the six classroom observations, field notes were coded using the same deductive coding scheme and framework as described in the analysis of the first research question. These codes also served as a form of triangulation when compared to the same list of codes from the corresponding interviews.

Selection of Mathematics Tasks. After completing the coding for the set of classroom observations, three mathematics tasks were selected from the total of 33 collected tasks in which an in-depth profile and application of the first two research questions could be offered. This selection was made after consultation with my advisor and relied on both the depth and breadth of codes which appeared in the classroom observations and/or the interview transcripts of a particular teacher when describing one of their submitted tasks.

The three mathematics tasks selected for this analysis were designed and implemented by Mr. Hammons, Mrs. Paige, and Mr. Reynolds. For Mr. Hammons, the classroom observation and his second interview were used in the analysis of his task. Since Mrs. Brown also observed and was interviewed about Mrs. Paige’s task, the classroom observation and the second interviews of both Mrs. Paige and Mrs. Brown were used in the analysis of her task. Mr. Reynolds was unable to complete the classroom observation due to geography, but one of his collected tasks was selected for further analysis with both of his interviews used to support the analysis of the task.

From Codes to Findings. For each of the three selected observations and mathematics tasks, I first retrieved the corresponding interview transcripts and isolated the codes from each of the first two research questions that pertained to the selected task.

The global education objectives and their sub-codes were previously identified through the deductive coding process and framework used in the analysis of the first research question. These codes, along with the codes from the classroom observation, were then used to create an
account of which objectives were present or have the potential to be addressed in each selected task.

The factors influencing the teacher’s design and implementation of tasks were also previously identified through the inductive coding process and analysis of the second research question, but were filtered so that only the codes corresponding to the selected tasks remained. These codes from the interview transcripts formed the basis of an account describing which aspects from each of the three main categories (from the findings of the second research question) were applicable to the design and implementation of each selected task.

**Trustworthiness**

According to Lincoln and Guba (1985), there are four major components one needs to address to build the trustworthiness of any qualitative study: credibility or internal validity, dependability or reliability, transferability or external validity, and conformability or objectivity. Each of these components is described below with the measures taken in the study that address these criteria.

**Credibility**

The credibility of a qualitative study is a measure of how believable or credible the research findings are based on the data collected and the perspective of the researcher (Merriam, 2002). Common procedures to ensure credibility in qualitative studies include triangulation and peer review. In this study, I used methods triangulation, or the collection of multiple forms of data (Patton, 2002), specifically interviews, observations, and mathematics tasks. Each form of data provided an opportunity to enrich the data by offering an additional perspective and to confirm information obtained through the other forms of data (Merriam, 2002).

In addition, I used peer review techniques (Merriam, 2002) or triangulation with multiple analysts strategies (Patton, 2002) by having members of my dissertation committee and
graduate students researching mathematics education independently code a subset of my interview transcripts using each of the two coding schemes described in the analysis of the first two research questions. The comparison of codes and discussions with others helped to limit my own personal bias in creating or applying codes and moved my own thinking forward.

**Dependability**

The dependability (or reliability) of a qualitative study refers to the repeatability of a study, or “the extent to which research findings could be replicated” (Merriam, 2002, p. 27). In any qualitative study, the data is contextual and depends on the particular research sample. In this study, I provided details about each of the participants and the characteristics of their schools and districts to provide all readers with the context in which this study was conducted and findings were obtained.

The use of an audit trail, or a detailed account of the data collection and data analysis procedures, also builds the reliability of a study so that they could be understood and potentially repeated by another researcher. I maintained informal memos or notes to record the progression of the procedures I used as well as my own thoughts and questions. In this chapter, I also presented a complete and detailed account of the data collection and analysis procedures followed.

**Transferability**

The transferability of a qualitative study is a measure of how the research can be applied to contexts that may be different. The use of thick description (Merriam, 2002), or providing a detailed account of the research sample and methods of data collection and analysis, allows readers to determine how similar or transferable the study settings and findings are to their own context.

I built transferability of this study through the inclusion of all relevant characteristics of teachers in the study as well as their associated schools and communities to provide readers
and researchers with the context(s) of the study. I also included excerpts from the interviews with the teachers in the findings (see Chapter 5) to provide additional context and insight into the sample of this study. Lastly, I described each step of the procedures of data collection and data analysis for each research question in this chapter.

**Conformability**

Conformability refers to the extent to which the findings are obtained from the data collected and depend on any potential bias from the unique perspective of the researcher. In qualitative research, “researchers are the primary instrument for data collection and analysis” (Merriam, 2002, p. 25). In this study, I was the only researcher collecting data and was the primary researcher analyzing the data. Since I bring my own experiences and perspectives to these processes, it is important to include a measure of reflexivity by providing a subjectivity statement. The goal of this statement is to “report any personal and professional information that may have affected data collection, analysis, and interpretation” (Patton, 2002, p. 566) and my subjectivity statement is included below.

**Subjectivity Statement**

Since the focus of this study is global issues and their role in mathematics education, it is important to acknowledge my own experiences with issues of global (or national or local) importance. I grew up in a suburban middle-class household and have certain privileges associated with my status as a white male. As a result, many issues that have affected a large number of people have not directly impacted my life. I have not been personally victimized by any injustices or prejudice, and while these only represent a subset of issues related to the global education objectives, my experiences affect my overall worldview and perspectives towards other global issues. At the same time, I am socially conscious and bring an awareness and baseline knowledge of current events and issues that exist on the global, national, and local scales. Although I regularly keep up with current events and issues, I have not actively
participated in any groups or events that promote change related to a social, environmental, medical, or human rights issue.

My experiences as a student consist of a public school education in a suburban town with a fairly homogeneous student population and an undergraduate education at a private, Catholic institution with a heavily homogeneous student population. My lack of familiarity with other school structures and student populations led to more questions asked to particular teachers in the study and truly allowed the teachers to be the expert as I came in with limited knowledge about certain school logistics.

The incorporation of global issues in any subject area was not a feature of my education at any level, and global issues have never been discussed in a mathematics class setting at any point in my life. Although I have never been on the receiving end of such instruction, I entered this study with research experience in incorporating objectives of intercultural competence into mathematics and interdisciplinary K-12 tasks. I also carried a personal optimistic outlook and belief that the future of (mathematics) education will be increasingly tied to issues of global importance and the cultivation of global citizens.

Chapter Summary

This chapter describes the motivation for a qualitative study design. This is followed by a provided a full description of the sample including the schools and the recruitment process. Next, details of both the data collection and data analysis procedures are provided. The data collected in this study include interview transcripts, classroom observations, and mathematics tasks collected from the teachers. Different methods of data analysis were applied for each of the three research questions. A framework created by the researchers following a review of the literature was used as a deductive coding scheme to identify objectives of global education through the perspectives of the teachers. Sub-codes were then added to these codes (objectives) to further classify whether the global education objectives were present in students,
had the opportunity to be addressed, or faced challenges to be addressed in mathematics classes through the perspectives of the teachers. Inductive coding methods were used to determine the factors which influenced the design and implementation of the mathematics tasks observed and collected from teachers in this study. The findings of the first two research questions were then applied to selected mathematics tasks to focus on the global education objectives and factors influencing the design and implementation of a single task to complement the holistic view provided by the original findings. Lastly, measures used in the study to address issues of trustworthiness are described, including a statement of my own perspectives and subjectivities.
CHAPTER 5
FINDINGS

In this chapter, the findings obtained through the data collection and analysis of this qualitative study will be presented in order to address the three research questions:

1. Which global education objectives can be incorporated in K-12 mathematics classes and in what ways are the objectives meaningfully addressed by students?
2. What factors influence the ways in which K-12 mathematics teachers integrate global education objectives into their mathematics classes?
3. When analyzing specific mathematics tasks, which global education objectives do students address and what factors influence how teachers design and implement the task?

The findings are separated by research question and presented in a manner that is consistent with the data analysis methods employed for each question. A deductive coding scheme using the framework described in Chapter 4 was utilized to address the first research question. For each category of objectives in the framework, a synthesis of the findings with respect to each objective and a frequency table of the codes will be presented. A basic interpretative inductive analysis was conducted for the second research question and each of the three main categories that emerged are defined and explained in the context of the study. For the third research question, three different mathematics tasks provided by the participants were selected codes from each of the first two research questions were applied to the tasks to highlight elements of specific tasks which may benefit both researchers and practitioners.

Research Question 1

To answer how global education objectives can be incorporated in students in K-12 mathematics classes, first a deductive coding scheme was created following a literature review and analysis of existing frameworks of global education. The final coding scheme used in this
study contains six categories – Knowledge, Skills, Values, Attitudes, Action, and Mathematics Context - and a total of twenty objectives (see Appendix A for the full framework). Each objective was also coded with one of the three following additional labels – (1) the objective was present in the classroom according to the teacher or the interpretation of the researcher, (2) an opportunity to address an objective was referenced by the teacher, or (3) a challenge existed in addressing the objective in the mathematics classroom. Each of the six categories and objectives within the categories will be presented and defined one at a time along with results and relevant excerpts to support the ways the objective was achieved in the classroom. In some instances, excerpts that showcase opportunities and challenges for the objectives to be addressed are also included to provide a representative depiction of the context of each objective. Although some of the challenges are included in these findings, further challenges identified by teachers appear in the findings of the second research questions and in the discussion of the findings (see Chapter 6). In addition, a frequency table displaying the number of times each code appeared throughout the interview transcripts is included following each category along with a few observations, patterns, or trends associated with each table to provide further guidance for the discussion of the findings (see Chapter 6).

**Knowledge**

The category of knowledge in the context of this study refers to the knowledge associated with global issues and not the knowledge of mathematics concepts. Rather than simply having information, knowledge here also encompasses understanding, or the “comprehension and appreciation of meanings” (COE, 2016, p. 51). The knowledge and understanding of various global issues and concepts can take different forms depending on the level of the issue – one whose focus is on its global implications (Global Knowledge), an issue whose primary focus is from a national perspective (National Knowledge), or an issue that is local and occurring in one’s own town, community, or village (Local Knowledge). These levels
naturally overlap and one might explicitly explore how a local issue affects the world or how an issue in another country affects your own (Interconnectedness). The interconnections that exist between multiple global issues are also encompassed by this objective as for example, one might explore the relationship between climate change and the economy. Lastly, knowledge can occur in a reflective manner in which an individual has an understanding of their own culture or perspectives on the world which can directly influence their view towards a particular global issue or concept (Knowledge of Self).

**Global, National, and Local.** Specifically, the types of knowledge and information to be attained by emerging global citizens “subsumes a large and complex range of knowledge and understanding in a variety of domains” (COE, 2016, p. 14) including politics and law, human rights, cultures, religions, history, media, economics, and the environment and sustainability. The first three objectives in this category all refer to these categories of information, but they are differentiated by the different perspectives inherited by the global, national, and local levels. This differentiation is adapted from the UNESCO model which emphasizes the various levels and their associated perspectives. While this knowledge does not contain mathematics content knowledge, participants identified existing instances and opportunities for the integration of such topics into a mathematics class.

**Global.** Of the participants in the study, some of the teachers identified instances in which they previously integrated global knowledge into their mathematics classrooms (prior to participating in this study). For example, Mr. Hammons used manipulatives and multiplication to demonstrate the six million Jews killed in World War II, Mr. Anderson used exponential functions to model and predict the possible extinction of a bear species, Mrs. Paige used subtraction to investigate the differences in years that women have been allowed to vote in various countries, and Mr. Reynolds used rational functions to explore the number of Syrians that migrated into European countries. Other topics incorporated into these mathematics
classes include American imports, climate change, world flags, and the use of renewable energy.

Of the three levels (global, national, and local), more teachers focused on opportunities to integrate knowledge from the global perspective than either of the national or local perspectives and their ideas spanned a wide range of topics. To illustrate, Mr. Hammons believed that global immigration, a topic which is already a theme in other subject areas that he teaches, could be brought into his mathematics classes. Ms. Markova entertained the idea of adding a global and research perspective to radioactive decay by making the connection to the Chernobyl disaster. In addition, Mr. Anderson showed an interest in connecting various Algebra topics to the Fiji water crisis to give a more meaningful context to his students’ learning. Other topics from a global perspective that were mentioned as candidates for a mathematics task include natural disasters, global disease rates, global wages and cost of living, endangered species, and general human rights issues.

**National.** Teachers also acknowledged existing tasks in their mathematics classes that have incorporated current or historical issues in the United States. Mr. Reynolds created a worksheet that integrates quadratic functions and the Dakota Access Pipeline and another one that investigates national homelessness through reading graphs and data. In Statistics, Mr. Thomas has looked at issues such as the prominence of Ebola in New York City and presidential approval ratings using authentic data. Mrs. Paige has also used her mathematics time to explore the history of slavery in the country and the mathematics behind the Electoral College. Other national topics already used in classes by teachers include immigration to the United States (both in general and specifically by refugees), Indian reservations, and police profiling.

Opportunities to integrate knowledge of issues from a national perspective were also discussed by teachers. For example, Mr. Thomas suggested looking into statistics taken from
biomedicine such as national disease rates and errors associated with testing for certain diseases. He also brainstormed looking at probability by using casino games and then further discussing or researching the history of Indian casinos in the United States. In addition, in reflecting on her task about carbon emissions which compared different countries, Mrs. Paige suggested another version of the task in which her students could study the emissions by state in the United States rather than by country. Teachers also identified national poverty levels, slavery, and election results as possible topics specific to the United States that could be examined in a mathematics task.

**Local.** Although the connections to mathematics are less explicit in the examples teachers provided in which they incorporated a local issue, Mr. Anderson’s students completed a large project analyzing and reporting on the water quality at their school, and Ms. Cole has talked about recycling on the school level. Mr. Anderson also proposed using local environmental issues, Mr. Thomas had an idea to explore their school’s graduation rates, Ms. Davis thought her students could investigate their town’s water quality, and Mrs. Stockton was interested in having students create a survey about bullying at their school and using mathematics to analyze the results.

Each of these levels of knowledge demonstrate ways in which global knowledge and understanding have been or have the potential to be incorporated in a mathematics class but do not singlehandedly address the context in which connections are made to the mathematics content. The different types of connections can be found in the final category of objectives in this section (Mathematics Context).

**Interconnectedness.** The interconnections between the aforementioned types of knowledge (as defined in this study) can appear in two different ways. First, teachers might look to explicitly direct students to the ways a single issue can affect at least two of the three levels of knowledge (global, national, and local). Second, teachers may focus on the relationships
between multiple issues. While these two forms of interconnectedness are different, they are coded together as each aims to broaden the perspectives of students and reinforce the idea that global issues often do not happen in a vacuum.

To investigate multiple levels of a single issue, Mr. Reynolds discussed the age distribution of the United States compared to the age distribution of other countries as well as the ways in which immigration is similar and different in the United States compared to the rest of the world. One focus of Mrs. Paige’s task was to compare carbon emissions from the United States to those of other nations using the authentic data that she provided. This mathematics task enabled a link to multiple issues as the national population and carbon emissions statistics produced a statistic which provided students with the carbon emissions per person of multiple countries. Mr. Reynolds also connected multiple issues in a task about climate change which led to a class discussion comparing the concept of climate refugees to economic and political refugees. Lastly, Mr. Hammon’s task did not solely focus on imports and exports as he was able to bring in multiple related concepts, including the manufacturing process, natural resources in different countries, and the economics of profit and loss in selling products.

There were additional opportunities to make connections between either levels or issues recognized by the teachers. To bridge the global to the national to the local, possible topics included the comparison of poverty in the United States to global poverty, disease rates in the United States to global disease rates, and bullying at your school to bullying around the world. To span multiple global issues (while still applying mathematics), topics included the relationship between natural disasters and immigration, exports and the global economy, and climate change and energy sources.

**Knowledge of Self.** The final objective in the category concerns knowledge and understanding of one’s own “world”, or their own culture and recognizing their own views, beliefs, and perspectives towards the world and global issues and how those views have been
shaped in their lives. This type of knowledge is reflective in nature and seeks to develop learners and individuals who are self-conscious about their views, ultimately leading towards understanding others’ point of view and how those views have been shaped as well.

In discussing previous instances of using social justice issues during mathematics time, Mrs. Paige pointed out that “a lot of our population are immigrants...also looking at where they’re now compared to the countries they came from,” (Interview 1, p. 5) alluding to past reflections of her students about conditions they may have faced in the different countries they or their families previously resided.

The opportunities to incorporate reflection were not specific to any topic, but were mentioned when teachers were speaking in general terms about linking mathematics to global issues. While reflecting on ways to make the connections, Mr. Hammons noted that one benefit would be “having kids look into a mirror and see their reflections but then looking through a window and seeing outside of themselves” (Interview 2, p. 9) and Ms. Davis offered that “[global education] could actually support a lot of their personal, interpersonal self-awareness” (Interview 1, p. 4). Although these comments are broad, each supports the idea that explicit connections between global issues and mathematics would provide an entry point for increased and beneficial self-reflection in their students.

**Frequency Table.** The frequency table below shows the total number of times each of the five objectives in the Knowledge category was coded in the full set of interview transcripts. In addition, each of the five objectives were coded with three sub-codes with Y representing “yes” or that the objective has been addressed by the teachers, O representing “opportunities” or that the teachers identified an opportunity for that objective to be included in mathematics, and C representing “challenges” or that the teachers identified a challenge in developing that specific objective in mathematics.
Table 5.1 below shows that teachers exhibited a greater propensity for discussing issues on a global level (K-G, Y: 16) than on a national level (K-N, Y: 13) and much more than on a local level (K-L, Y: 2). The margin between global and national issues is much closer when referring to what teachers have already done in their classrooms, but when brainstorming opportunities for future inclusion and connections, teachers mentioned issues on a global level (K-G, O: 35). The smaller frequencies that appear in both the interconnectedness and self-knowledge objectives (IC, Y: 6; KS, Y: 2) each show the larger focus placed on the issue itself as opposed to making connections between multiple issues, multiple levels, or back to oneself in a reflective manner. Despite the lower frequencies of their occurrence in classrooms, opportunities for the various forms of connections outlined by the last two objectives exist (IC, O: 8; KS, O: 8) and show potential for inclusion through a mathematics task.

Table 5.1

Knowledge Codes and Frequencies

<table>
<thead>
<tr>
<th></th>
<th>K-G</th>
<th></th>
<th>K-N</th>
<th></th>
<th>K-L</th>
<th></th>
<th>IC</th>
<th></th>
<th>KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>16</td>
<td>Y</td>
<td>13</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>O</td>
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<td>O</td>
<td>12</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>1</td>
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<td>0</td>
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<td>1</td>
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<td></td>
</tr>
</tbody>
</table>

Key. K-G = Knowledge – Global, K-N = Knowledge – National, K-L = Knowledge – Local, IC = Interconnectedness, KS = Knowledge of Self, Y = Yes (the objective was addressed), O = Opportunities (there is a potential to address the objective), C = Challenges (associated with addressing the specific objective)

Skills

The second category of global education objectives is skills, where a skill is defined as “the capacity for carrying out complex, well-organized patterns of either thinking or behavior in an adaptive manner in order to achieve a particular end or goal” (COE, 2016, p. 44). Many attributes can fit this definition, and the following four skills were identified and used in this study, and can operate in pairs. First, **Critical Thinking** and **Self-directed Learning** skills refer to
higher-order thinking abilities and a self-motivation that may exist for learning or accomplishing a given task. Second, Effective Communication and Cooperation and Conflict Resolution skills are both communicative in nature, with the former referring to an individual’s own ability to communicate and the latter referring to communication in group settings. It is important to note that these skills can occur independent of the inclusion of global issues in mathematics and some of the coded occurrences of the skills are in reference to more traditional mathematics classes.

**Critical Thinking.** Critical thinking skills encompass a set of higher-order thinking skills which include the logical or systematic organization of information, the comparing and contrasting of various pieces of information, the formation of logical arguments or conclusions, and the evaluation and creation of judgments about a given set of information. The field of mathematics may naturally lend itself to these skills, which were coded both in discussions of the use of mathematics as well as the use of global issues in a mathematics classroom.

When discussing the use of critical thinking, teachers often mentioned its application in the context of mathematics. In multiple instances, teachers referenced data analysis and making connections between mathematics content and the context of a particular problem, even if the context was not related to a global issue. Mr. Anderson’s belief in the importance of critical thinking led him to create his own engineering class which heavily relies on mathematics in an effort for his students to “actually learn how to think as opposed to what to think” (Interview 1, p. 9).

These skills have also been developed in the context of exploring global issues in mathematics. Reflecting on her task working with carbon emissions, Mrs. Paige stated: “I like the idea that they’re thinking deeper...about why the certain data points were what they are” (Interview 2, p. 2), exhibiting the deeper thinking that took place during the task surrounding the global issue that was presented. Critical thinking also took place during Mr. Reynolds’s class in
the comparison of different types of refugees, specifically economic refugees and climate refugees. This example also demonstrates one instance of many in which codes from different categories were applied to the same response as this comparison of refugees was also coded as the Interconnectedness of global issues from the Knowledge category. Generally, since part of the definition of critical thinking includes comparing and contrasting, a natural connection may exist between these two objectives.

Whether strictly in mathematics or in the use of global issues, teachers provided many examples of opportunities to include further critical thinking in their classes. Oftentimes, this took the form of having students perform research, including through project-based learning, as a way to evaluate and logically organize information. For example, Mr. Thomas suggested using a database to investigate world health statistics and having students perform statistical analyses to compare disease rates of different countries. Along with research and comparing and contrasting examples, both Mrs. Brown and Mr. Thomas welcomed the idea of argumentation in which students could use mathematics to support a claim. Mr. Thomas offered: “I could give the students numbers and basically have them make contradicting arguments to each other with the same data” (Interview 2, p. 6) which would support all components of critical thinking.

Self-directed Learning. Self-directed learning skills involve the ability of an individual to identify their own learning needs and the motivation and the wherewithal to address those learning needs, including through the use of reliable sources of information. Once again, these skills may present themselves when solving a purely mathematics problem or when examining a global issue.

Teachers only sparingly mentioned these skills as ones that have been present in their classes, but Mrs. Paige felt that her students were motivated and driven on their own in each of the two tasks that were observed. In discussing her task involving blueprints and
area/perimeter, she noted that “they weren’t able to finish the lesson and the next day they were like ‘we’re not done, we wanna get back to doing it, can we do it more?’” (Interview 1, p. 6) showing the desire of the students to address their learning goals without the teacher’s prompts. In addition, Mrs. Paige noticed that in her lesson about carbon emissions: “[the students] might not have drawn the specific conclusions I wrote as a question but I think that they were also drawing other conclusions...I’m ok with that because they were still able to make their own connections” (Interview 2, p. 4), once again displaying the ability of her students to direct their own learning with respect to the context of the mathematics.

About half of the teachers also expressed the desire for their students to be more independent and to conduct more of their own learning, particularly with respect to the investigation of global issues in a mathematics setting. This is best illustrated by Mr. Hammons’s reflection: “…letting kids lead the way, giving them some tools, some empowerment and autonomy to say ‘hey I’m really interested in how these two things [mathematics and global issues] connect’” (Interview 2, p. 11) and further supported by Mrs. Brown’s thought: “Let kids start to think for themselves, we don’t need to be thinking for them all the time” (Interview 2, p. 5). Mrs. Brown’s idea of allowing students to think for themselves was also echoed by Mr. Anderson but labeled as a challenge as he mentioned that his students have “never had to think for themselves” (Interview 2, p. 11), making it more difficult for his students to increase their independence related to learning.

**Effective Communication.** Skills of effective communication consist of the ability to communicate clearly through means such as reasoning, clarifying, and discussing, and include the effective use of both linguistic and oral/written discourse abilities. Whether referring to mathematics or a global issue, a student is incorporating these skills if they are able to produce verbal and/or written language that successfully articulates and communicates their knowledge or point of view.
For a few teachers, communication is already a natural part of their mathematics classes as they have their students communicate their mathematical approach or way they arrived at their answer to others. This is a regular part of Ms. Cole’s classroom routine as she explained: “So they had to share the strategy with the person next to them, the person next to them either had to agree or disagree with them and then together they had to come up with another way to solve the problem” (Interview 1, p. 2). Mrs. Paige even hinted at a possible relationship between communication inside and outside of mathematics in stating: “The ability to communicate is definitely something I find I need to teach, so in math you have a different answer, let’s talk about the way that we got to that answer which could kind of parallel to the same thing as the politics” (Interview 1, p. 11). Finally, Mr. Thomas acknowledged the importance of communication in mathematics class even if it does not necessarily benefit the mathematics ability of his students:

I always try to push them that even if the content isn’t something that necessarily applies to you, even if you feel like the only time you’re ever going to do this content piece is in this math class that’s fine but you’re going to need to be able to do a lot of these other things, be honest, be fair, communicate with other people. (Interview 1, p. 8)

Further opportunities for incorporating effective communication in mathematics classes often took the form of pedagogical strategies. Ideas among teachers included group work in which each group would then report out their findings to the entire class, more writing prompts in mathematics such as writing a letter, providing sentence starters to younger learners to develop their writing ability, and analyzing data in order to communicate a position statement based on the results.

**Cooperation and Conflict Resolution.** Skills of cooperation and conflict resolution can be defined as the ability to successfully work with others on shared tasks and resolve any conflicts that may arise in an effective manner. These scenarios often involve effective communication,
creating a close relationship with the previous objective, but cooperation and conflict resolution require an interaction between at least two people whereas effective communication can be displayed individually through writing.

While each teacher discussed the use of group work in their mathematics classes, group work in and of itself does not necessarily mean that students are developing skills of cooperation and conflict resolution. As Mr. Anderson pointed out, “so many teachers believe group work is just putting kids in a group and telling them to work together and it is so much more than that” (Interview 1, p. 7), but even considering these words of caution, a few teachers did provide specific examples of these skills being developed in their classes. In reflecting on his task about exports and pricing, Mr. Hammons touched on the ability of his students to cooperate: “…helping kids to negotiate, to listen to each other and to be able to exchange ideas and at some times kids needed to explain their rationale” (Interview 2, p. 5) as well as the ability of his students to resolve conflicts: “The dynamics went really well, surprisingly well because I’ve been a 5th grade teacher at this school where…they’re constantly bickering and they’re not able to compromise, I liked seeing them work through that” (Interview 2, p. 5). Lastly, Mrs. Paige added a comment that may not have been specific to her mathematics time in class, but still provided insight into the developing group dynamics of her students:

They became a lot more understanding of the different perspectives and you could hear that in the way they talked to each other too, it wasn’t so much ‘you’re wrong’, it was more like ‘Why do you say that? Can you give me an example?’ (Interview 1, p. 12)

Only a few instances of including more opportunities for cooperation and/or conflict resolution were mentioned and almost all were general comments rather than specific tasks or content. For example, multiple teachers mentioned the use of a social-emotional curriculum as one that could align with communicative goals in group settings, another mentioned how more focused group work would align with the goals of their school, and a different teacher
suggested the use of question starters to facilitate effective group work and communication among younger learners.

**Frequency Table.** Table 5.2 below shows that while the frequencies are not overwhelmingly large, they suggest that these skills are already present to an extent in mathematics classes. The nature of mathematics can account for the presence of critical thinking (CT, Y: 18), with the integration of global issues adding to the opportunities for further developing those skills. The frequencies in the effective communication (EC, Y: 17) and cooperation and conflict resolution (CCR, Y: 14) objectives each speak to efforts teachers are already making in incorporating group work in their classes and more generally, having students explain their reasoning behind their answers. Among the skills, those of self-directed learning occurred the least (SD, Y: 6) and had a higher number of challenges identified (SD, C: 5), which suggests that teachers struggle to connect this objective directly to mathematics.

Table 5.2

**Skills Codes and Frequencies**

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>SD</th>
<th>EC</th>
<th>CCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>18</td>
<td>6</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>O</td>
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</tr>
<tr>
<td>C</td>
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<td>5</td>
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</tr>
</tbody>
</table>

*Key.* CT = Critical Thinking, SD = Self-directed Learning, EC = Effective Communication, CCR = Cooperation and Conflict Resolution

**Values**

Values, the third category of objectives, is defined in this study as “general beliefs that individuals hold about the desirable goals that should be striven for in life...and they also serve as guiding principles for deciding how to act” (COE, 2016, p. 36). The three objectives in this category – Human Rights, Cultural Diversity, and Justice, Fairness, and Equality – each refer to beliefs individuals hold about others which can then guide specific actions. The presence of
these values in a mathematics classroom largely depend on the inclusion of global issues containing a human imperative so that beliefs about others can be explored and developed.

**Human Rights.** For an individual to value human rights, they must hold the belief that every human is of equal worth, should have the same set of fundamental rights and freedoms, and should be treated accordingly. In other words, one should recognize and appreciate the similarities we all have as members of the same human species.

These common rights were discussed in Mr. Reynolds’s class in completing a worksheet about rational functions and Syrians migrating to Europe with Mr. Reynolds explaining a conversation in his class about the right to life:

It was something like 2% of the people die in crossing [from Syria to Europe] so when we looked at these and 2015 you have 200,000 people attempting to cross and so that was like 4,000 people died in 1 month and that was a shocking type of conversation for a lot of them. (Interview 2, p. 4)

A few teachers also discussed the potential of integrating global issues into mathematics that contain a human rights component. For example, in talking about modifying an existing task, Mr. Anderson noted that “You could do it on water conservation, especially things like Fiji and its water crisis yet we’re buying their bottles of water off of them while half the island is dying of thirst” (Interview 2, p. 10), referencing the common human right to water in order to live. Mrs. Brown took this idea even further in discussing human rights to food, education, and technology in suggesting a new mathematics task:

...how many kids in Indonesia have cell phones, how many have and do we need them, should they have them, let’s talk about who has free lunch, who’s getting that choice, things that really affect them, who’s getting snacks, do people in Indonesia get snacks in school, do they go to school? (Interview 2, p. 4)
This multifaceted suggestion is illuminating in that it shows the potential for mathematics to make connections to beliefs that students hold and advocates for the connections to human rights to be made through children of the same age living in other countries and cultures.

**Cultural Diversity.** Valuing cultural diversity consists of appreciating other cultural perspectives, views, and practices so that people can learn from the diverse perspectives of others. In other words, one should recognize and appreciate the differences that exist in making each human and group of humans unique.

The only instance mentioned in which cultural diversity was developed in a mathematics classroom was through the personal background of Ms. Markova who explained that “[my students] all work together and knowing me and that I come from a completely different background it also opened their eyes” (Interview 2, p. 5), meaning that her European background and teaching style have influenced the interactions with and among students in her classroom.

There were a few teachers that mentioned opportunities to include the appreciation of other cultures into mathematics. Many of these cases involved the incorporation of a global issue surrounding another culture, but Mrs. Paige provided an enlightening comparison between mathematical perspectives and cultural perspectives by stating:

> In math...there's many different ways to solve the problem, and being able to take that idea and apply it to that maybe there's different point of views and necessarily we maybe use these point of views to come to an answer to the problem. (Interview 1, p. 13)

This quote hints at a larger idea to use mathematics and the thought processes associated with the discipline to inform the way students value others. In this example, the diverse solution paths that may exist for a mathematics problem can be thought of as parallel to the diverse perspectives different people or cultures may hold about a global issue or a lifestyle, with none of these perspectives being viewed as “wrong.”
Justice, Fairness, and Equality. The values of justice, fairness, and equality collectively represent the belief that all humans should be treated fairly and equally regardless of race, gender, national origin, religion, sexuality, age, socioeconomic status, etc. This objective also includes the recognition of acts of discrimination and injustices that have occurred and the outrage associated with those actions against others.

Almost all of the mentioned occurrences of this objective were attached to the inclusion of a global issue whose focus was discrimination, such as the Holocaust, racial profiling, and women’s voting rights. Although this objective can be addressed through the teaching of examples of discrimination, it can also be achieved through the actions and communication that regularly occurs between students that are diverse in their traits. This accounts for the lone exception as Ms. Markova mentioned that “All of my classes are very diverse and you could see when you were watching the lesson you don’t see any difference in the way they treat each other” (Interview 2, p. 5). This may also exist among other teachers, but was the only explicit mention of the relationship between the diversity of students and their actions towards one another.

Frequency Table. Each of the objectives in Table 5.3 (on the next page) occurred in relatively low frequencies (HR, Y: 4; CD, Y: 1; JFE, Y: 5) with the opportunities to address them in mathematics classes appearing only slighter higher (HR, O: 7; CD, O: 10). With a few exceptions mentioned above, most of the occurrences of these objectives are tied to particular global issues that concern human similarities, differences, or discrimination, but comparing the frequencies below to those found in Table 5.1 (Knowledge) show that a relatively low percentage of the global issues used or suggested actually include aspects of humanity or values associated with other groups of people.
Table 5.3

Values Codes and Frequencies

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<th>JFE</th>
</tr>
</thead>
<tbody>
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<td>O</td>
<td>C</td>
</tr>
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<tr>
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</table>

Key. HR = Human Rights, CD = Cultural Diversity, JFE = Justice, Fairness, and Equality

Attitudes

In the context of global education, the fourth category of Attitudes is defined as “overall mental orientations which an individual adopts towards someone or something (e.g. a person, a group, an institution, an issue, an event, a symbol)” (COE, 2016, p. 39). The three objectives contained in this category – Curiosity and Openness, Care, Empathy, and Respect, and Civic-mindedness and Citizenship – each contain beliefs one holds about others and can include action but not necessarily towards other people. In mathematics classes, the appearance of these objectives may not be directly tied to mathematics content but can impact the engagement with the content through its global context and the atmosphere in the classroom.

Curiosity and Openness. Attitudes of curiosity and openness are the interest in discovering and learning about cultural perspectives and practices other than your own as well as showing a willingness to suspend judgments and preconceived notions about the views of others or your own. This is separate from students’ interest in learning about mathematics as the definition and context are specific to cultures and global issues.

In most occurrences of these attitudes, teachers provided an example of a task in which students were genuinely engaged in the global issue associated with the mathematics. For example, in discussing the way her students interacted with the carbon emissions data, Mrs. Paige noted that “some of the conversations coming out of it were not about the questions at all but just kinda their own shock factor kind of questions” (Interview 2, p. 1) displaying the natural
interest and engagement level of the students in the global issue at hand. Mr. Reynolds had a more general comment about his students’ interest in global issues he has presented: “They’re hesitant at first but then they’re really interested and it goes well, there’s stuff they don’t know and they know they don’t know” (Interview 1, p. 5) which suggests the growth of curiosity in his students.

Mrs. Brown also identified the purposeful selection of global issues as an opportunity to develop curiosity while developing mathematics skills: “If you could get things that they’re interested in, that they care about, that they know about, they’re going to buy into it, they’re going to have commitment and want to see the answer and figure it out” (Interview 1, p. 10).

**Care, Empathy, and Respect.** The attitudes of care, empathy, and respect refer to the positive regard for other people as human beings and the ability to “put yourself in someone else’s shoes” and relate to the thoughts, beliefs, and feelings of others with care and compassion. This objective is different than that of valuing human rights in that it can apply to many interactions rather than those strictly associated with fundamental freedoms and rights.

The development of these attitudes appeared in two different ways. First, while discussing the use of a task in which students interpreted data related to homelessness, Mr. Reynolds identified that “My goal...was to destigmatize homelessness or conversation that would break down some myths about it” (Interview 2, p. 3) by sparking a conversation in which students put themselves in the shoes of other members of their community. On the other hand, Mrs. Paige described an interaction in which her goal was to have her students relate to each other: “…kind of also put yourself in a ‘why does he feel this way?’ and ‘why do you feel different and where are you coming from with your family dynamics to make you maybe feel different?’” (Interview 1, p. 11).

**Civic-mindedness and Citizenship.** Civic-mindedness and citizenship collectively encompass the feeling of belonging to a community or a social, cultural, or political group and
the willingness to participate and actively contribute to community life. This objective can also be viewed as the attitudes associated with taking action as a citizen, which is the next category of objectives.

In each of his tasks that connected a mathematics topic to a global issue, Mr. Reynolds included a brief section at the bottom of the page titled “What can you do about it?” containing references, events, and/or actions that students could utilize to contribute to the cause associated with the issue. This places the role of the student as an active citizen rather than simply a learner and is further enforced by a conversation in his class “about what it takes to be a good person, a good citizen” (Interview 1, p. 7) again developing his students’ understanding of the role of citizenship.

**Frequency Table.** The relatively low frequencies that appear in Table 5.4 on the following page (CO, Y: 8; CER, Y: 3; CM, Y: 4) show the relative lack of attention that has or could be given to developing these specific attitudes in mathematics classes. Furthermore, the equal number of occurrences and challenges in the objective of care, empathy, and respect (CER, Y: 3; CER, C: 3) identify an objective that may require additional attention in a mathematics context. These frequencies also reflect the struggle that a few teachers experienced in their first interviews in making any connections from socio-emotional characteristics to mathematics. Each of these teachers believed that these attributes are important and should be developed in their students, but could not come up with examples specific to mathematics, representing a challenge towards the objectives in this category.
### Table 5.4

**Attitudes Codes and Frequencies**

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<thead>
<tr>
<th>CO</th>
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<tr>
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</table>

Key. CO = Curiosity and Openness, CER = Care, Empathy, and Respect, CM = Civic-mindedness and Citizenship

**Action**

Action, the fifth category of objectives, consists of integrating one’s knowledge, skills, values, and attitudes to create positive behaviors and outcomes for a group or community. The two objectives associated with action are that students can either “learn about opportunities for engagement as citizens at local, national and global levels, and examples of individual and collective action taken by others to address global issues and social injustice” (UNESCO, 2015, p. 24) (Opportunities to take action) or are actually engaged and taking action, personally or collaboratively, to improve conditions (Take Action).

**Opportunities to take action.** In connecting global issues to mathematics, there were a few examples in which teachers provided information about what students or any individuals can do in addressing the global issue. These examples occurred across the developmental spectrum as Mrs. Paige discussed the impact of using electronic devices on carbon emissions and Mr. Reynolds highlighted when discussing his goals associated with integrating global issues in mathematics:

They might not be super active now but they’re going to have the opportunity later, the biggest part is just awareness, ‘you don’t even know that this issue is happening and you would probably be mad if you did, so let’s make sure you know about it.’ (Interview 2, p. 7)
Here, Mr. Reynolds is referencing the fact that his students are not far away from attending college or simply encountering more opportunities to take action in the ‘real world’ and make a difference in their community or the world. This quote also demonstrates that Mr. Reynolds had embraced his own role in increasing the awareness of his students to global issues and opportunities for action that may exist.

There were a few examples of views held by teachers related to the education of how students can engage as citizens, with the most noteworthy coming from Mr. Thomas. He reflected on the role of action with his claim: “You can’t make anybody do anything, a lot of this [action] is kind of on them, you can talk about it and you can try your best to encourage it, but really that’s your responsibility” (Interview 1, p. 10). Mr. Thomas exhibits apprehension towards the relationship between formal classroom learning and meaningfully taking action outside of the classroom, but does believe that there are opportunities to learn about and encourage ways in which one can take action.

**Take Action.** The only occasion in which students took action as a part of a mathematics-based class was in Mr. Anderson’s class in which his students worked together on a project to address the water quality in their school, including a presentation they gave to the district Board of Education on their findings. Mr. Anderson described that “the purpose of [the water project] is to take action, to make a change at your school...at least one change, a real change not a fake change” (Interview 2, p. 10).

Based on her experiences on mission trips, Ms. Davis also presented water quality as an opportunity for her students to take action through the use of mathematics and also suggested a connection between action and mathematics in stating: “They wouldn’t even know they’re doing math, they would just be so focused on helping...the community” (Interview 1, p. 8).

Multiple teachers also identified taking action through mathematics as a challenge in classroom settings due to the role of other subjects in the curriculum. By way of his tasks, Mr.
Reynolds has provided many examples of opportunities for his students to take action by asking “What can you do?” but when reflecting on the role of action in his mathematics classes, he answered: “…so not to pass the bucket but I feel like the students already get the action part as a part of the curriculum” (Interview 1, p. 8). This reference was made towards English and Social Studies classes in particular and he did not feel that it was necessary for mathematics to add to action taken by students which already exists in their holistic educational experience. Even if tangible action is addressed in other subject areas, this view still represents a challenge towards addressing the objective in the context of mathematics education.

**Frequency Table.** The frequencies in Table 5.5 below (Opp, Y: 7; TA, Y: 2) are lower than those in Table 5.1 (Knowledge), suggesting that when global issues are presented in mathematics, they are not often tied to ways in which students can develop agency and contribute to the improvement of a particular issue. Furthermore, the table shows a higher frequency of challenges than occurrences of taking action (TA, C: 4; TA, Y: 2), which illuminates the difficulties encountered in producing tangible actions strictly in the context of mathematics classes.

Table 5.5

**Action Codes and Frequencies**

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<td>2</td>
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<tr>
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Key. Opp = Opportunities to take action, TA = Take Action

**Mathematics Context**

The final set of objectives separate the various contexts in which mathematics and global issues appear together in a mathematics task. These objectives are derived from the Asia Society model of global competence which states that “understanding the world demands
both **Disciplinary** and **Interdisciplinary** approaches" (Boix Mansilla & Jackson, 2011, p. 13). A third approach or objective was added to acknowledge that while some tasks include global issues, they are not significantly explored as the primary purpose is the mathematics content and skills (**Content Knowledge**). The contexts are separated to highlight the different lenses in which both students and teachers view the relationship between mathematics and the world.

**Disciplinary.** A disciplinary understanding of the world can be applicable to any discipline such as language, history, or the arts with each discipline providing “thinking tools that our societies construct and revise to make sense of the world” (Boix Mansilla & Jackson, 2011, p. 13). The focus of this study is on the discipline of mathematics which provides tools such as data collection and analysis, logical and analytical thinking skills, and a physical and theoretical understanding of our world. Using a disciplinary approach to address global issues in mathematics means that a given global issue is investigated almost exclusively using skills that are specific to the discipline of mathematics.

In the tasks that involved global issues, a few of the teachers meaningfully incorporated the teaching and learning of the issue primarily using mathematics skills. For example, Mr. Reynolds’s task on homelessness relied on data and graphs to provide insight into the issue, Mr. Thomas examined presidential approval ratings through data analysis, and Mr. Anderson discussed extinction of animal species through modeling data with different types of functions.

Of the many suggestions for global issues that could be used in a mathematics task, almost all of them were discussed through a disciplinary lens. These examples include the understanding of election outcomes through studying their data, the comparison of HIV rates over time and location to contextualize global health, and a general suggestion of creating a new textbook that explicitly links each section of mathematics content to the world in the body of the text.
The majority of the challenges associated with a disciplinary approach were general statements concerning the difficulties of investigating global issues in a mathematics class such as the comfort level of the teacher or the pressure of the curriculum. These and other challenges and factors identified by teachers in connecting global issues to mathematics are explained in further detail in answering the second research question of this study.

**Interdisciplinary.** Many global issues require the use of multiple disciplines to fully understand the issue, and this interdisciplinary approach calls for students to “integrate knowledge, methods, and languages from different disciplines to solve problems” (Boix Mansilla & Jackson, 2011, p. 13) and make sense of the world in ways that would not be possible with the use of only a single discipline. In a mathematics class, an interdisciplinary approach would entail the use of mathematics skills as well as knowledge, skills, or tools obtained from another discipline or subject area to explore a global issue.

The only teacher to employ an interdisciplinary approach in connecting global issues to mathematics (and other subject areas) was Mrs. Paige in previous thematic units about slavery, the right of women to vote, climate, and in her task on carbon emissions. In describing her goals for the carbon emissions task, she said: “I think that the data from this lesson and the different lessons we’re doing in reading will hopefully build on that knowledge” (Interview 2, p. 3), referencing her integration of multiple subject areas in the teaching and learning of the particular global issue.

Many of the teachers discussed possible topics that could be explored in mathematics and other subject areas simultaneously. To illustrate, Mr. Hammons felt that his task on exports could be designed to include maps and develop his students’ understanding of the world through geography and mathematics. While secondary teachers identified different logistical challenges than elementary teachers, Mr. Reynolds maintained that an opportunity existed to intersect mathematics and social studies content. As social studies is the more traditional
realm for the inclusion of global issues in education, other teachers also acknowledged that despite logistical concerns, the subject lends itself to increased purposeful connections to mathematics.

**Content Knowledge.** In both disciplinary and interdisciplinary approaches, mathematics skills are employed to make sense of the world through a particular global issue. However, this does not include the possibility that global issues are included in mathematics classes but not more than minimally addressed or explored with mathematics. In this context, global issues can be seen as a placeholder in a mathematics problem where the goal of the task is the development of a student’s mathematics content knowledge or skills rather than their exploration of a global issue.

In describing previous tasks that have incorporated global issues, Mr. Thomas mentioned and shared a task on various disease rates in which the goal was to develop skills of determining different types of probabilities that happened to have a biomedical context. Mr. Thomas did offer suggestions for modifying the task such as exploring global disease rates by country, but the primary purpose of the original task was to develop the mathematics content knowledge of his students. Another example was a task used in Mr. Reynolds’s class which used quadratic equations and explored the Dakota Access Pipeline controversy. During class, students solved problems involving quadratic equations akin to a word problem with the Dakota Access Pipeline as the context, and then a class discussion was led by Mr. Reynolds about the issue itself. In this scenario, both mathematics skills and objectives of global education were addressed in class, but were accomplished separately as each set of goals did not directly reinforce each other.

**Frequency Table.** In Table 5.6 below, the roughly equal number of occurrences of the disciplinary and content knowledge contexts (Dis, Y: 10; CK, Y: 8) suggest that a fine line may exist between token mentions of a global issue in mathematics and the use of mathematics as
a tool to investigate a global issue. In addition, the relatively high frequencies of opportunities and challenges in both the disciplinary and interdisciplinary contexts (Dis, O: 17; Dis, C: 10; Indis, O: 25; Indis, C: 10) express both the intrigue and concerns expressed by teachers towards many factors which will be highlighted in the findings of the second research question of this study.

Table 5.6

*Mathematics Context Codes and Frequencies*

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<thead>
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<tr>
<td>C</td>
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Key. Dis = Disciplinary, Indis = Interdisciplinary, CK = Content Knowledge

**Research Question 2**

To investigate the factors which influence the ways K-12 mathematics teachers integrate global education objectives into their mathematics classes, an inductive coding scheme was used in which codes, and ultimately categories and sub-categories, were derived from the data. Initial coding took place following the transcription of interviews and codes / emerging categories from each piece of collected data were constantly compared to existing codes and preliminary categories. At the conclusion of the analysis, three categories emerged – **Teacher Dispositions**, **Contextual Factors**, and **Mathematics Task Design** – that each describe a different set of factors that affect a teacher’s approach to making connections between global education objectives and mathematics content. First, an individual’s overall disposition towards particular characteristics of teaching greatly shape their views on the role of global education in the mathematics classroom. Second, there are many contextual factors specific to a given teacher’s town and school that affect their day-to-day teaching and the worldview of their students. Lastly, there were many factors associated with the design and implementation of specific mathematics tasks which are also naturally related to and influenced by a teacher’s
dispositions and the context of the school and town. Each of the three categories is presented below with their sub-categories and/or codes and each category is supported by key quotations from the teachers in the study.

**Teacher Dispositions**

Throughout the interviews, the teachers made statements that displayed their overall dispositions or attitudes towards various components of their teaching, including as it relates to the inclusion of global education topics or objectives into their mathematics classes. Teachers shared their views on the general role that their mathematics class plays in the lives of their students, their thoughts on using global issues in education, their beliefs on the potential for connections to be made between mathematics and global issues, and their opinions about their students in terms of their engagement with global issues.

**Role of Mathematics.** Understanding a teacher’s perspective on the role or purpose of their mathematics class can be crucial in understanding what global education objectives they may bring or are willing to bring into their classroom. Ms. Markova takes on a more traditional view of mathematics and sees “beauty in pure math and how math evolved from one stage to another and how you can connect different math knowledge” (Interview 2, p. 1). This perspective does not necessarily inhibit the use of global education objectives into her class, but is a perspective likely shared by others that may influence both teacher and student engagement with forms of content that are not aligned with traditional mathematics.

Along the spectrum of views, other teachers were found to hold more progressive perspectives about the role of their mathematics classes. In reflecting about what he looks for in his students, Mr. Reynolds stated: “I'm under no delusion that most of my students are gonna use math regularly in their life, that’s not the point of the class, you learn numerical, analytical, and logical thinking skills by applying them to math” (Interview 1, p. 11).
Mr. Thomas expressed a similar view of the relationship between what students learn in his class and what they use in their lives:

...the average person isn't going to use any of these skills again outside of this classroom and no matter how I teach it to them, no matter what show I put on, no matter what problems I introduce to them, they're not gonna be as engaged if they don't care.

(Interview 1, p. 7)

This perspective also hints at the possible use and purpose for global issues as a means of engagement in mathematics content that may not otherwise exist.

Mrs. Brown also provided a unique perspective on the role of mathematics as compared to other subjects taught in school: "Math is a forum where you can debate and argue and figure out problems and then debate about it because so much of math in the standards is communication and having data to back up what you’re saying” (Interview 1, p. 9). This displays the value that she places on the communicative role of mathematics and also suggests an avenue for engagement in global issues through a lens of mathematics.

**Global Issues.** There were a wide range of comfort levels shared on the idea of using global issues, particularly ones that may be controversial, in their mathematics classrooms. For example, Ms. Davis expressed that she enjoys “deep conversation, but not with students, I don’t feel comfortable” (Interview 1, p. 7) and Mr. Anderson said that if he were to include global issues in his classes that he “would want the [topics] that are less controversial” (Interview 1, p. 10). In his second interview, Mr. Anderson discussed using environmental issues in his classes because of his own passion for those issues, demonstrating the importance of a teacher’s personal passions and beliefs in the topics that they decide to include in an educational setting.

On the other hand, other teachers felt quite comfortable with discussing a wide range of global issues with their students. As an example, Mr. Reynolds expressed that the general motivation behind his tasks which include global issues was to “talk about something that I
thought was important that I want them to care about” (Interview 2, p. 1), once again exhibiting the role of a teacher’s personal interests which is shown in their tasks. He also showed passion and self-awareness for racial issues in saying: “...my students aren't usually seeing a white person who speaks very bluntly about racial issues” (Interview 1, p. 5) and noted that his students quickly adapted to his comfort level and passion for discussing that particular set of issues.

While some teachers felt comfortable and knowledgeable about the use of global issues in their classes, they provided words of caution to encourage the removal of bias or the separation of their own personal beliefs from what is expressed in the classroom. Mr. Thomas made it clear that in his teaching, “I try to as much as I can at least keep myself unbiased as much as I can and not interject my opinions into the idea” (Interview 1, p. 3) and this was echoed and reinforced by Mrs. Brown in stating: “When you're gonna teach [global issues] you need to be unbiased and you need to teach all facts...I think we need to be responsible, we can’t just teach what we want to teach” (Interview 2, p. 5).

A teacher’s views on global issues may also be influenced by their own personal background. The teachers in the study with unique backgrounds mentioned how it shapes their worldview as Mr. Hammons noted: “...just my background as a Jewish-American, as a second generation Holocaust survivor...I bring a lot of personal understanding about how I see the world” (Interview 1, p. 9). Similarly, Ms. Markova described that “…coming from another part of the world and living in the United States for 12 years” (Interview 2, p. 4) has naturally shaped her own personal beliefs and approaches to education.

**Connecting Mathematics to Global Issues.** In addition to their separate views on the general role of mathematics and generally towards global issues, teachers also had specific perspectives towards the connections that can be made between mathematics and global issues in their classrooms. This includes their beliefs on the nature of making the connections
as well as their own self-efficacy, or belief in their own ability (Bandura, 1982) to create connections and then embed them into mathematics tasks.

Looking at the connections from a wider perspective, Mr. Hammons felt that: “The trick is not to do these isolated mathematics and global citizenship lessons, it’s really to do it, embed mathematics as another discipline within interdisciplinary units” (Interview 2, p. 1). Similarly, Mrs. Paige agreed that the connections should be made more consistently rather than as a “one-off” lesson in and mentioned that she “absolutely would love to incorporate these [connections] a lot more especially seeing the reaction from the lesson I just did” (Interview 2, p. 8). These statements do not ignore the challenges associated with integrating global issues in mathematics, but speak to the willingness of some of the teachers to create or use certain tasks in their classes.

When engaging with global issues and attempting to make connections to mathematics, the self-efficacy of some teachers was higher than others. When speaking to the mathematics topics that he has used in the context of global issues, Mr. Reynolds noted that he “can’t imagine anything harder than synthetic division to think of a word problem that applies to it so if I can do that one I can do all the rest” (Interview 2, p. 11), representing his confidence in tying together a wide range of topics and issues. Despite her experience with creating and implementing these tasks, Mrs. Paige was honest about her struggles in the process: “I’m struggling with not having these [objectives] tied so in the meantime I’m tying them and then from there I have to create lessons” (Interview 2, p. 8). This challenge may represent a barrier that prevents teachers from tying objectives from mathematics and global education, but as Mrs. Brown (the mathematics interventionist) pointed out, “Teachers and I get in a comfort level and you feel like you can’t but we need to do this” (Interview 2, p. 11), highlighting the need for persistence and an increase of the self-efficacy of some teachers.
Students. Lastly, teachers shared holistic perspectives relating to their students and the value in using global issues in classroom interactions. Many teachers mentioned that an immediate benefit to integrating global issues and mathematics would be another opportunity for the teachers to connect to the students and continue to build student-teacher relationships via the global issues. As an example, Mrs. Paige attempted to connect issues to her personally to further engage her students: “...so connecting it to me on a personal level, usually when you connect students to you they're like 'oh you do actually get to do these things in the real world’” (Interview 1, p. 6).

A few teachers also noted the importance of using global issues in mathematics as a way to develop skills and traits for the future careers and lives of their students. Teachers hope that increased exposure to global issues and using data from real world scenarios will develop personal and quantitative skills that will be beneficial for their students’ futures. Having this perspective and a thought towards what his students will take from his class, Mr. Reynolds said, “...this is what we’re trying to do, to make our students into good people with the ability to make the world better” (Interview 1, p. 6).

Contextual Factors

When considering how to link objectives from mathematics and global education, there are also considerations that are dependent on the specific school, district, and town where a given teacher works. This includes whether the school is a high school or elementary school, a public or private school, and the demographics of the local population and students in a particular class. Each of these factors along with a teacher’s disposition(s) will contribute to the design of their mathematics tasks and the way(s) in which they unify global issues and mathematics.

School. Although every teacher has standards to adhere to, there is a difference between the actual standards and the pressure associated with them for teachers working at a public
school compared to teachers working at a private school. It is important to note that all of the public schools of teachers who participated in this study use the Common Core State Standards for Mathematics and comments such as “we have curriculum maps that we have to move through” (Mrs. Paige, Interview 1, p. 1), “some of the classes have very tight and restricted curriculum and pacing guides…” (Mr. Thomas, Interview 1, p. 11), and “…it’s also hard to keep regular time in class devoted to [global citizenship objectives] when there’s some other forces acting on your time” (Mr. Reynolds, Interview 2, p. 13) were quite common and speak to the reality of the current education system. In contrast, Mr. Hammons works at a private school and labeled the pace of his curriculum as a “self-induced pressure” (Interview 1, p. 1) compared to the external pressure that the other teachers experience. In either case, teachers prioritize their curriculum and can view the addition of global issues as a burden or a challenge in accomplishing their curriculum goals or remaining on schedule.

Even without yet considering the age and developmental level of the students, the difference in the structure of a school day at an elementary school compared to a high school also affects the way teachers create and implement tasks. All of the secondary teachers in the study only taught mathematics and all of the elementary teachers taught their students in every subject area. This results in elementary teachers agreeing that the logistics of creating an interdisciplinary task by incorporating global issues from another subject area are easier than the collaboration that would be necessary at a high school. This structure was identified as challenge by the secondary teachers with Mr. Anderson suggesting that “…really the best way to do it is have one teacher teach everything” (Interview 1, p. 6) as a way to simplify the process of creating a task integrating ideas from multiple subject areas.

In addition to a school’s status as public or private and secondary or elementary, there can also be other characteristics unique to a particular school or district that affect the day-to-day teaching and learning. For example, one of the elementary schools in the study has a dual-
language program in which students take half of their classes in Spanish and half of their classes in English and the classes regularly alternate; that is, that half of their mathematics class periods will be taught in each language. This adds an additional component to the classroom dynamic and as Mrs. Brown notes, “The math is hard because of the language that’s impeded” (Interview 2, p. 3) for some students. In addition, the teachers in the dual-language program “work very closely with a partner so we have to keep on the same path” (Mrs. Paige, Interview 1, p. 1), presenting another potential logistical challenge.

The middle school in this study is in the same district as the elementary school with the dual-language program and although this program is not a part of the middle school, financial challenges exist, leaving certain programs unfunded. In describing her students, Mrs. Stockton explained that “Because there’s no summer program for our kids it all goes out the window, and our numeracy skills we have to work on those in all grades because they’re lacking that” (Interview 1, p. 4), suggesting that the lack of continuity has an effect on the content that can integrated in mathematics among students that may lack basic numeracy skills.

**Local Population.** The discussion or inclusion of global issues in a classroom can also be dependent on a student’s family background as well as the demographics of the local community. At one of the high schools, Mr. Thomas recognized that the background of his students impacts their perspectives: “...some of these kids have so many personal issues and things like that in their little bubble...they just don’t have the ability to see the bigger picture” (Interview 1, p. 7). This was also true at the elementary level as Mrs. Paige explained that “A lot of our population are immigrants...and also looking at where they’re now compared to the countries they come from” (Interview 1, p. 5), acknowledging that their background is related to their engagement with certain global issues. At the private school in the study, the students pay tuition to attend the school and often come from wealthier families. Mr. Hammons further
explained their background and part of his goal in including particular global issues in the curriculum:

Our private school students orbit in the same socioeconomic level so they go skiing on the weekends, they go to their house in [another State], they come back, they have all of their needs met and more and so being appreciative of what they have here and understand being grateful for what it’s like to live in this country and then thinking about what other people have or don’t have in other places culturally. (Interview 1, p. 11)

In addition to an awareness and understanding of a student’s background and cultural values, most teachers were aware of the local population and current events on a local level. To provide an example, Mr. Reynolds remarked that “[City] can be insular in its problems and since my students live in segregated communities they often don’t know other people’s issues” (Interview 1, p. 4) and felt that he had a responsibility to include global issues in his mathematics classes due to their day-to-day lifestyle and experiences living in that city.

**Mathematics Task Design**

When designing and implementing tasks that integrate objectives of global education and mathematics, teachers addressed both practical and pedagogical considerations. These factors, when combined with a teacher’s disposition and their environment, all contribute to a final product, both on paper and in the classroom. When designing a task, there were a few different guiding approaches discussed by teachers that facilitated their thought process. In addition, many pedagogical considerations were given as they apply to these integrated tasks, and each teacher also added their thoughts about the time and resources needed to support global issues in mathematics.

**Guiding Approaches.** A few of the teachers mentioned general approaches that may be necessary in practice while creating the tasks as opposed to simply generating ideas. First, Mr. Thomas suggested altering the data linked with a global issue to more closely align with his
mathematics goals: “...so that’s why as a teacher sometimes I say it’s real data but obviously it’s a little bit contrived to get to the point I’m trying to get to” (Interview 2, p. 1). Second, Mr. Anderson proposed using existing tasks and modifying word problems to include a global issue: “…the idea of making it more thematic instead of random problems but the theme could be an issue like world hunger” (Interview 2, p. 9). Although this idea suggests beginning with mathematics and then bringing in a global topic, Mr. Reynolds felt more comfortable beginning with a global issue and then integrating the mathematics content: “…most of the time I start with the topic I wanna talk about and try to come up with ways to fit in the [mathematics] content” (Interview 2, p. 8). These approaches varied by teacher but each display the desire for meaningful applications of mathematics to issues of global significance.

**Pedagogical Considerations.** There are many pedagogical factors that impact the design of any task created by a teacher, and many were discussed in the context of bringing global issues into mathematics. First, Mrs. Brown mentioned the importance of scaffolding content, not only for the mathematics, but also for the content associated with global issues: “You don’t wanna give them a snowstorm where they’re plowing through the math...and then have them thinking about the global issues, one thing has to be easy, you can’t give them two tough things” (Interview 2, p. 8). This was linked to the idea of differentiation and providing different entry points to a task for various learners and ability levels. Given her role as an interventionist, Mrs. Brown was especially keen to this, but the role of differentiation is applicable to many classrooms.

The appropriateness of a task or topic was judged not only by different types of learners, but also different ages of learners. While not all of the secondary teachers were themselves comfortable with the teaching of global issues, none of them felt that the issues would be inappropriate for their students. Alternatively, the elementary school teachers felt that the age and developmental level of their students affected the connections that could be made to
mathematics. For 4th graders, Mrs. Brown felt strongly that “…[the global issue] really has to be concrete and relevant to them…” (Interview 1, p. 2) as it might be difficult for younger students to engage with global issues which are abstract and foreign to them based on their lived experiences. And in 1st grade, Ms. Cole was confident that her students were not ready to engage with global issues in mathematics or any subject area: “So I think the big picture then for 1st grade it almost doesn’t apply because everything is very skill-based because it’s more teaching them how to be a student” (Interview 1, p. 6).

Other pedagogical considerations in designing tasks were mentioned multiple times but not by the majority of the teachers. These include the integration of technology, such as “going on the computers and researching their own information” (Mrs. Stockton, Interview 1, p. 5), the use of authentic resources, the use of project-based learning, and the role of assessment in measuring the global education objectives.

**Time and Resources.** In many instances, teachers identified the challenge of the lack of prep time necessary to create these tasks given their existing tight schedule. This was true across the spectrum from high school: “Yes a lot more time, especially if we’re gonna be coming up with it from nothing” (Mr. Anderson, Interview 2, p. 12) through middle school: “But it comes down to time, I could do all that stuff, I don’t have the time to do it” (Ms. Davis, Interview 1, p. 2) and to elementary school: “I think the answer to the problem is time constraints…” (Mrs. Brown, Interview 1, p. 7). Another concern associated with time was the duration of a class period as Mr. Thomas believed that “...there’s not enough classroom time to get [mathematics with global issues] done” (Interview 2, p. 12).

To support the concerns teachers raised with prep time, each was asked about what existing or potential resources would be most beneficial to make global issues in mathematics a reality. Some teachers expressed a desire to use existing mathematics tasks or textbooks that already make connections to global education while others preferred the use of exemplar tasks
or webinars that would provide a template for teachers to create their own tasks. Furthermore, a few teachers believed that the difficulty in designing the tasks was the explicit linking of global issues to mathematics topics in their courses and that if these links already existed, they would have no concerns about designing the tasks themselves. While the suggested resources somewhat varied by teacher, the commonality was that each believed some form of support would be necessary to meaningfully and consistently integrate global issues into their mathematics class.

**Research Question 3**

The third research question of this study focused on the mathematics tasks submitted by teachers and the goal of the analysis of the tasks was to connect theory to practice and to link results from the first two research questions to specific tasks. From the collection of tasks submitted by the teachers, three mathematics tasks were selected and are presented to display the findings to this research question. For each task, a description of the task and classroom activity will be given along with the global education objectives that were met in designing and implementing the task (with codes taken from the analysis of the first research question) and the factors that influenced the teachers in designing the task (with codes taken from the analysis of the second research question). The deductive coding scheme used for the first research question was also applied to the classroom observation field notes and the deductive codes from the interviews were used to support the global education objectives found in the tasks. In addition, the inductive codes and findings from the second research question were used to isolate which of the factors and considerations from the results were applicable to the selected task and specific teacher.

**Mathematics Task #1** (Teacher: Mrs. Paige, Grade: 4\textsuperscript{th}, Topic: CO\textsubscript{2} emissions)

**Overview.** This task consisted of a packet given to students containing authentic data on the carbon dioxide emissions of three different countries (the United States, Sweden, and
Students were asked to analyze the data by answering a set of questions which targeted both mathematics skills such as division and drawing conclusions from the data and their context. During the classroom period, the teacher first used the data from another country (Brazil) to acclimate students to the context of the numbers and then students worked in groups to first understand the data given to them before attempting to answer some of the questions. Mrs. Paige acted as a facilitator for each group and due to her role as a mathematics interventionist at the school and not having her own class, Mrs. Brown also assisted during the lesson and both teachers were able to reflect about the task in their second interviews for the study.

This task was selected for further analysis because of its alignment with many of the global education objectives, the fact that the teacher designed and implemented this task inspired by this study, and the engagement of the students with the content in the task. The full task and lesson plan can be found in Appendix E. Note that the full lesson took place over multiple class periods and included a writing prompt (found in the task) as an assessment piece, but that the class observation done by the researcher and Mrs. Brown occurred only during the first class period of the task.

Global Education Objectives. In applying the categories and global education objectives outlined in the analysis of the first research question to this task, many of the objectives were present. In the knowledge category, the information on carbon emissions and energy sources for various countries including the United States resulted in the application of the codes Knowledge – Global and Knowledge – National to this task. Furthermore, in asking the students to consider their own energy use at home, Mrs. Paige was addressing Knowledge of Self and was also able to reach the Interconnectedness of knowledge by linking global and national emissions and linking the ideas of emissions and their effect on the economy.
Many objectives from the other categories were also addressed in Mrs. Paige’s task and classroom. The Effective Communication of ideas among students and to the teacher, the positive and on-task interactions in group settings (Cooperation and Conflict Resolution), and the higher level connections and ideas created by the students (Critical Thinking) targeted objectives from the category of Skills. The students engaged in Curiosity and Openness (in the Attitudes category) in the task with their eagerness to learn about countries outside of the United States and genuine interest in the task. Through information provided by Mrs. Paige, students also learned about Opportunities (in the Action category) to take positive action and reduce their own personal carbon emissions at home. Although the objectives associated with the category of Values were not coded as having occurred in the observed class period, the task displayed a potential to address Human Rights and Cultural Diversity if the teacher had a pointed conversation or discussion with students about the human element of carbon emissions and the lifestyles and cultures of people living in the countries whose data was provided.

The context of the mathematics in this task was Interdisciplinary as the teacher integrated information about types of energy sources which students had previously learned outside of mathematics. In this context, students learned about energy through a different lens and required the mathematics skills of interpreting and analyzing data to fully engage with the data and complement their evolving knowledge on energy obtained through other subject areas.

**Teacher Factors.** Following the findings from the second research question, Mrs. Paige’s various dispositions, contextual factors at her elementary school, and pedagogical and practical considerations each contributed to the design and implementation of this task. In reflecting on her task, Mrs. Paige cemented her view of mathematics as a discipline that provides additional context to issues that may be encountered in other disciplines: “[The students] are just completely using mathematical concepts in a way that’s going to help them become better with
the world or with each other” (Interview 2, p. 8). This also supports her view that the infusion of global issues in her mathematics tasks should occur more frequently and the perspective that these topics can strengthen relationships not only between the teacher and the students, but among students as well.

While Mrs. Paige believes that these connections should occur more frequently which inspired the design of this task, the contextual factors at her school and district present a challenge. As noted by other teachers, Mrs. Paige felt that tasks such as this one do not happen more often due to the “time constraints of the pacing guide of the curriculum” (Interview 2, p. 4). Although the dual-language program at her school can present a challenge in coordinating with a partner teacher, it also presents an opportunity to develop communication skills and achieve language objectives which are a part of each lesson, including the one for this study.

On a pedagogical level, Mrs. Paige made a few decisions that were specific to this task. These include the use of authentic data in the packet given to the students, incorporating a writing component both as an assessment piece and to develop the ability of students to write in the context of mathematics, and the use of group work to facilitate communication and collaboration among the students. Lastly, in describing the time and resources utilized to design this task, Mrs. Paige offered the following explanation:

So trying to really come up with the actual idea I think took me a little while, and it was coming not from any source, it was just coming from my head and then trying to figure out what kind of data I needed to collect myself in order to create these worksheets for the kids to use. (Interview 2, p. 2)

This explanation demonstrates Mrs. Paige’s general process for designing interdisciplinary mathematics tasks and also supports her desire for additional resources that would streamline her process.

Mathematics Task #2 (Teacher: Mr. Hammons, Grade: 3rd, Topic: Manufacturing/Exports)
Overview. In this task, students learned about the import and export of goods, the manufacturing of products, and the concept of profit. First, students were split into groups and asked to complete puzzles in which each piece contained the name of a product or service, its country of origin, and its price. The completed puzzle displayed a completed item which was manufactured using each product or service on its respective pieces. After agreeing on prices that were missing from some of their pieces, the students then added the prices, including decimals, to determine the total price of their completed item. Lastly, students discussed and set a price in which their item would be sold at in order to make a profit. Mr. Hammons concluded the task with a class discussion about each item and their associated prices as determined by each group.

This task was selected for further analysis because it exhibits the way in which the teacher adapted and modified an existing task on global knowledge to fit his students. The original task (found in a textbook) was designed for 5th grade students, so Mr. Hammons modified the task to be appropriate for 3rd grade students while also incorporating mathematics content which did not exist in the original task. Note that Mr. Hammons is a 4th grade teacher, but also teaches mathematics for the 3rd grade class at his school, and this observed task took place with the 3rd grade students. In addition, this was a one-day lesson and the entire activity was observed by the researcher. Relevant components from the original task (not the complete modified version) can be found in Appendix E.

Global Education Objectives. The level of the information in this task was global as students learned about the location of various goods and services around the world as well as the concept of international imports and exports (Knowledge – Global). In addition, an Interconnectedness of ideas was present through the teacher’s linking of raw materials, manufacturing, exports, and the economy. Students also developed Skills of Cooperation and Conflict Resolution in negotiating missing prices and costs as a group. Producing these
missing variables and adding decimals, which was a concept that the students had not yet learned in their mathematics class, each demonstrated the Critical Thinking abilities of the students and groups. For the majority of the lesson, the students remained on-task and displayed Attitudes of Curiosity and Openness based on their engagement and willingness to learn about knowledge on a global level. Additionally, the teacher made a brief connection to his school’s socio-emotional curriculum which represented an opportunity to further develop the objective of Care, Empathy, and Respect. In this task, no objectives from the Values category were identified as present due to the focus on the manufacturing and economic process rather than the associated human component. In addition, neither of the objectives in Action were addressed as this task involved the acquisition of global knowledge which was likely new to the students, but did not require action.

The context of the mathematics in this task was Disciplinary as the teacher used an isolated task to develop and apply mathematics skills to global topics and information that students had not learned in any of their other classes. It is worth repeating that the addition of decimals was also a new concept for the students. That is, that they acquired new knowledge and skills both in mathematics and about global information.

Teacher Factors. In designing this task, Mr. Hammons naturally brought his dispositions which include a willingness and a self-efficacy for integrating mathematics and global issues to make each more meaningful for his 3rd and 4th grade students. Teaching at a private school, Mr. Hammons also felt more comfortable in using a day of class time to implement a task aligned with this study without feeling the intense curriculum pressure that other teachers in the study expressed. In his class, the majority of the students come from wealthier families and Mr. Hammons was keenly aware of this factor when discussing their understanding of price and the purchase of certain products.
There were also pedagogical considerations made by Mr. Hammons in his process of adapting the original task. First, his general approach was to take a task involving global knowledge and modify the task by incorporating mathematics content, and he mentioned feeling more comfortable employing this approach. Second, the original task was intended for a 5th grade audience, so Mr. Hammons was careful in adjusting particular aspects of the task to match the developmental level of his 3rd grade students. After considering his audience, one component which remained unchanged was the use of the puzzle and in his reflection, he felt strongly about its benefits: “I know this age is particularly keen to use games...they don’t even realize they’re learning” (Interview 2, p. 7).

Mr. Hammons also identified two changes that he would implement in any future use of the task. The first was the struggle in appropriately scaffolding the information as this was truly implemented as a “one-off” lesson and one in which he felt students could have benefitted from having more background information before engaging in the activity. The second was the in-class time allocated for the entire task and each of its components. Due to the critical thinking involved and the multiple components of the task, Mr. Hammons believed that his students could have further benefitted from having “more time on the back end of the lesson for kids to report out, to share their thinking process, to have kids ask each group questions, instead it was very rushed” (Interview 2, p. 7).

Mathematics Task #3 (Teacher: Mr. Reynolds, Class: Algebra II, Topic: Dakota Access Pipeline)

Overview. This task was a one-day worksheet and in-class discussion about the Dakota Access Pipeline. On the worksheet, students were provided with some brief background information and a map of the pipeline and then were asked questions about a quadratic formula which modeled the depth of the river where the pipeline would be constructed. Lastly, students were provided with more information if they wanted to learn more or take action to support the protesting of the proposed pipeline. During the class period, students completed the worksheet
and took part in a class discussion led by Mr. Reynolds in which he provided more information and asked students for their thoughts and opinions regarding the controversy surrounding the Dakota Access Pipeline issue.

This task was selected for further analysis because it provides an example of a high school mathematics task. Another interesting aspect that this task brings to the study is that it was designed and implemented before the study was conducted and the teacher had not any exposure to any global education frameworks. The worksheet used for this task can be found in Appendix E. It was part of a short series of worksheets designed and implemented by the teacher in which global issues were discussed and analyzed in his mathematics classes. It is important to note that due to Mr. Reynolds working in the Midwest, this task was not observed by the researcher and all codes were determined using the worksheet and the second interview with the teacher. As a result, a larger number of the global education objectives were only able to be coded as potentially addressed as many of the objectives lack the context of classroom interactions that were not able to be observed. In addition, this worksheet was used in multiple class sections and as a result, class discussions may have varied from section to section and addressed different objectives.

**Global Education Objectives.** The level of the information contained in this task was national as the focus was the controversial Dakota Access Pipeline issue in the United States (**Knowledge – National**). Depending on the nature of the discussions and whether they were dominated by the teacher or by the students, there was the potential to develop Skills of both **Effective Communication** and of **Critical Thinking**. Similarly, there was an opportunity to address Values such as **Justice, Fairness, and Equality** depending on the direction of the conversation and whether the human imperative associated with the Native Americans was discussed. In his interviews, Mr. Reynolds reported that his students exhibited **Curiosity and Openness** and a genuine interest in learning about an issue that was effectively foreign to them.
and once again, there was a potential to address Attitudes of Care, Empathy, and Respect depending on the nature of the in-class discussion. Lastly, by including sections titled ‘Want to learn more?’ and ‘What can you do about it?’ on the bottom of the worksheet, Mr. Reynolds was providing an Opportunity to take Action for his students.

The context of the mathematics in this task was to further develop the Content Knowledge of his students. In this example, students are using mathematics skills to answer questions about a quadratic formula, but these questions are not a part of learning about or investigating the Dakota Access Pipeline issue. Through the other information provided on the worksheet and the class discussion, students learned about the Dakota Access Pipeline, but this learning was separate from the mathematics skills utilized in this task which focused on the reinforcement of skills students had practiced in previous class periods.

Teacher Factors. This task was designed and implemented before Mr. Reynolds participated in this study and was a product of his own personal passion for global and social justice issues. He believed that his comfort level in discussing these issues in class was critical to the manner in which his students consistently engaged with the various issues. This particular task had a corresponding worksheet, but Mr. Reynolds often holds discussions in his mathematics classes as he feels a personal responsibility to inform students of current events happening around the world. He also feels that this responsibility is partially a product of the population of students at his school. Working in a large city, Mr. Reynolds has observed that students are often unaware of the world outside of their city due to some of the struggles and issues that the city regularly faces, such as high levels of poverty and crime.

In creating the worksheet about the Dakota Access Pipeline (and other similar worksheets), Mr. Reynolds’s approach was to first select the issue and then incorporate mathematics skills that his students had recently learned. In doing so, he modified authentic data so that it would suit the mathematics goals of the task: “Yes, I researched the actual width
and depth of the river and then just made a quadratic function that fit that. I’m aware that it’s not actually a quadratic function generally” (Interview 2, p. 2). The class discussions were less structured in his planning but Mr. Reynolds strategically adjusted the nature of the conversations after teaching each class section: “usually I let that first conversation guide how the next one is structured...I have an idea of what was already interesting to their peers and I guide them in that direction” (Interview 2, p. 1). Lastly, although Mr. Reynolds did not commit a significant amount of time to the design of this worksheet, he noted that similar worksheets required more research and preparation time and contributed to his decision to generally only have class discussions which are not accompanied by a structured worksheet about a global issue.

**Chapter Summary**

This chapter presented the findings for all three research questions of this study. For the first research question, global education objectives derived from existing theoretical frameworks were identified as addressed in students through the perspectives of the teachers. Furthermore, the objectives were separated by whether they were present at some point in a mathematics class, whether teachers saw potential in addressing an objective in their mathematics class, or whether teachers offered challenges for addressing an objective in their mathematics class. Each of the twenty objectives are defined (see Appendix A for the full global education framework), include a frequency table to display how often and in which contexts the objectives appeared, and are supported by specific instances and quotations from the teachers in this study.

The factors that influence a teacher’s design and implementation of a mathematics task which contains a global issue (the second research question) are found in three main categories. These tasks are influenced by a teacher’s dispositions or attitudes towards the role of mathematics in education, their views on global issues, their thoughts on the connections
that may exist between mathematics and global education, and their perspectives on their relationship with their students. Tasks are also affected by the environment in which they are situated, including the type of school (elementary, secondary, private, public) and the demographics and setting of the local population and community (urban, suburban, rural). Lastly, teachers identified important elements of designing mathematics tasks, including overall guiding approaches, many specific pedagogical considerations, and the time and resources necessary to create a final product (task).

The third research question is an application of the findings from the first two research questions to selected tasks collected in this study. The isolation of a task’s relevant global education objectives and factors which influenced the teacher’s design and implementation provide a focused view on the features of a particular task to complement the holistic view provided by the first two research questions.
CHAPTER 6

DISCUSSION

As referenced in earlier chapters, the demand for global education has increased across the disciplines. As a result, there exists a need to critically examine the relationship between mathematics education and global education. Mathematics educators and researchers have long responded to the need for a mathematics education which addresses issues of global importance (see TMfSJ in Chapter 2), but as global education initiatives and frameworks (UNESCO, 2015; Boix Mansilla & Jackson, 2011; OECD, 2016; Council of Europe, 2016) continue to be disseminated around the world, what role does or could mathematics play in the future of global education?

The recent global education frameworks provide a new lens in which to critically view mathematics education. With that view in mind, the purposes of this study were to examine the theoretical and practical implications of the connections between global education and mathematics education among K-12 teachers and classrooms. The three research questions guiding this study were:

1. Which global education objectives can be incorporated in K-12 mathematics classes and in what ways are the objectives meaningfully addressed by students?
2. What factors influence the ways in which K-12 mathematics teachers integrate global education objectives into their mathematics classes?
3. When analyzing specific mathematics tasks, which global education objectives do students address and what factors influence how teachers design and implement the task?

In this chapter, the major findings related to each research question are summarized and interpreted to offer additional thoughts, reasoning, and connections to existing literature. In addition, limitations of this study’s methods and findings are presented. Lastly, ideas for future
directions of research are also offered both within the discussion of particular findings and as a separate section. Possible implications for practice are also presented throughout the chapter. It is important to clarify that these implications are not necessarily recommendations but should be considered as questions, considerations, and ideas for researchers and practitioners.

**Research Question 1**

The findings for the first research question include ways in which the data collected and analyzed from the teachers relate to the six categories and twenty objectives from the global education framework designed for this study (see Appendix A for the full framework). In addition, the presence of each objective was categorized into three distinct contexts – (1) the objective was addressed through the perspective of a teacher and/or the researchers, (2) the objective was identified by teachers as one that had the potential to be addressed in a mathematics classroom, and (3) teachers referenced challenges in addressing the objective in the setting of a mathematics classroom. The discussion of the findings is separated by the six categories of objectives and each category is further separated by each of these three contexts. A discussion of the framework used for this study is also presented.

**Knowledge**

Based on the findings, knowledge can be considered the foundational category for teachers to engage in the global education objectives because they often selected a global issue to accompany particular mathematical skills. Among the objectives within this category, Knowledge of Global issues was present the most often and this may be due to the name “Global” (Citizenship) education. While the term “global issues” does include national and local issues, this did not seem to be clear to the teachers in this study. Hence it might be important to make this clearer in the dissemination of information to teachers so that a wider range of issues can be considered and used in the classroom. Terms such as “glocal” (Tichnor-Wagner, 2017) can be used more often to emphasize the spectrum of issues associated with the goal of
developing students who are responsible citizens in their community, country, and world. This would in turn support learning according to studies and projects conducted in mathematics education (Gonzalez, 2009; Barta & Kyriopoulos, 2014) that have demonstrated benefits of using local issues that are more relevant to the students’ world.

While teachers provided many examples of potential topics (on the global, national, and local levels), there were different goals associated with these ideas. In some cases, it was clear that a teacher wanted to integrate a global issue to increase awareness of the issue among their students. On the other hand, some teachers embedded their ideas into actionable outcomes in which their students can make a difference with their work. For example, Mr. Thomas suggested that his students could analyze the graduation rates at their high school to begin a larger dialogue on how to improve conditions at their school. This idea is similar to the context of the project in Gonzalez’s (2009) study which resulted in increased empowerment and action in the students. As a result, goals of mathematics and global education tasks can be made explicit as teachers identify their location on an “awareness to action” spectrum.

One of the major challenges identified in addressing various objectives of Knowledge was the pressure to stay current as global issues change. Many current events are fluid and ensuring that tasks and projects continue to reflect evolving global issues requires additional preparation for teachers and/or curriculum developers. Many K-12 teachers, especially in mathematics, reuse curriculum materials over multiple academic years, but the implementation of authentic tasks embedding fluid global issues requires caution in the reuse of tasks from one year to the next.

Another major challenge in incorporating Knowledge of global issues in mathematics was finding an appropriate time within an already tight mathematics curriculum to implement these tasks. This result confirms the findings from Gregson’s (2013) case study. Many teachers expressed the pressure they experience throughout the school year in ensuring that their
students are adequately prepared for standardized examinations. If these tasks are viewed as “separate” from the standards-based curriculum or simply as an enrichment opportunity, then teachers may struggle in incorporating knowledge of global issues.

**Skills**

Within this category, the objective of Critical Thinking was observed more than any other objective. This might be explained by an existing comfort level in teachers as critical thinking is encouraged in mathematics teaching and learning. However, the framework used in this study did not differentiate critical thinking in the context of mathematics and critical thinking applied to global issues. One way to address this issue would be to redefine the objective so that it addresses each context of higher-order thinking skills. An increased focus on these contexts may illuminate nuances of the relationship between critical thinking skills in mathematics and critical thinking skills applied to global issues as well as the ways in which these skills might occur simultaneously.

The objectives of Effective Communication and Cooperation and Conflict Resolution also were present with relatively high frequencies and they were often found to overlap with each other. In many discussions and observations involving group work in class, students exhibited characteristics of communication that fit the definition of both objectives. In the frameworks of global education, all of the objectives are interconnected in some way and the development of some objectives can increase the development of others in a learner. Furthermore, the identification of pairs or sets of objectives that are intimately related can support the future design and implementation of mathematics tasks which may seek to target sets of objectives more efficiently.

Another example of objectives which were found to occur together in this study is found in the skill of Self-directed Learning and the attitudes of Curiosity and Openness. Each can stem from the passion of the teacher and the ways in which a teacher motivates their students to
achieve academically and care about particular issues. Whether intimately related objectives are from the same category or from different categories, the continued identification of these relationships can support future mathematics task design.

Many of the skills which were identified with the potential to be addressed in mathematics classrooms were a result of the teachers’ brainstorming of new or modified mathematics tasks. This distinction is made because the potential to address any objective includes past or “missed” opportunities in previous tasks as well as the prospects of future tasks designed with global education frameworks in mind. Each of these contexts is important as the analysis of existing tasks can build understanding of existing practices and help generate modifications of tasks or the design of new tasks.

Some of the challenges mentioned by teachers in addressing Skills, in particular the objective of Self-directed Learning, were related to the desire to change the classroom culture. Students may not be adequately trained to direct their own learning in mathematics or in any subject area. Although the traditional classroom structure and the developmental level of students may provide an explanation, this leads to other questions of interest. In what ways are these Skills addressed and developed in formal educational settings as opposed to outside of school? And if the Skills are addressed in different ways to accommodate the context, how do they transfer across contexts?

Values

In this study, the role of Values and the human imperative associated with global issues were not present in the findings with a few exceptions of global issues used by teachers that contain a human rights or discrimination context. Although these instances were identified as the objectives being addressed, further research can clarify the ways in which human rights issues are embedded and explored within mathematics content. There are also benefits to the extent in which these issues are incorporated in class. For example, a teacher in Stinson’s
(2012) study reported significant gains in student engagement with mathematics and the desire to discuss issues of discrimination during a 3-day lesson analyzing data collected on racial profiling at traffic stops.

Cultural Diversity was mentioned as having the potential to be addressed more than the other two objectives in this category. Although many of these instances were in the context of selecting a global issue in another cultural context, a few mentioned the potential to leverage the diverse backgrounds of their own students. Teachers cannot control how diverse their students are, but lived experiences and communication among students provide a unique opportunity for the appreciation of other cultures.

One way to address this is through the research done in ethnomathematics (D’Ambrosio, 1985; Powell & Frankenstein, 1997), or the mathematics taught in other cultures, that provide opportunities to develop students’ appreciation and understanding of other cultures through a context which is unique to the discipline of mathematics. Ethnomathematics also highlights the contributions of mathematicians from other cultures and civilizations, and if consistently addressed throughout K-12 mathematics, may change the misconception of mathematics as a field whose contributions throughout history are the work of white males (Gutiérrez, 2017).

The primary challenge in addressing Values was the comfort level of the teacher. Some teachers simply felt uncomfortable discussing human rights issues in their classes and believed they did not have the proper training. Teachers in Bartell’s (2013) and Gonzalez’s (2009) studies also mentioned feeling uncomfortable incorporating particular global issues due to their own lack of training and potential administrative implications if they were to receive backlash from parents. This demonstrates a need for an increased focus on human rights issues and discrimination in teacher preparation programs and professional development, particularly in the context of mathematics teaching and learning.
When designing resources for teachers, the challenges identified with these objectives should be addressed. First, depending on the background of the students, it can be difficult for them to actually see and experience a lack of human rights or various advantages of diversity in a classroom setting. Second, some teachers were open about their lack of comfort in addressing human rights issues in a mathematics class and their own comfort level is paramount in normalizing these discussions and topics among students. Lastly, the message to teachers should include reasoning and support for the role of mathematics specifically in developing the Values objectives. This can be true of any category, but is even more essential in certain categories where teachers may need to be convinced on the potential benefits of the integration of mathematics and global issues.

**Attitudes**

The presence of these objectives were relatively infrequent in this study, with the exception of Curiosity and Openness which was addressed by multiple teachers. This engagement and interest in other cultures was often tied to the objectives of Cultural Diversity and Self-directed Learning as curiosity about other cultural practices and contexts led to students asking their own questions and directing their learning. This provides another example of objectives which are more intimately related and can support future design and implementation of mathematics tasks.

Another one of these direct connections can be found in the opportunities mentioned by participants to address the attitudes of Civic-Mindedness and Citizenship. Although the definition provided in the framework encompasses a feeling of belonging to a community and a willingness to actively contribute to that community, each of the opportunities mentioned by teachers in this study to address citizenship contained a component of action. While action is a primary goal of global education, prerequisite attitudes can be foundational towards enacting responsible action and for developing the other categories of objectives in global education. As
a result, it may be beneficial to include citizenship and attitudes on an “awareness to action” spectrum which would acknowledge that the goals of incorporating global issues may range from an awareness of global issues and injustices to a sense of belonging to a local, national, or global community to ultimately taking action to improve conditions (Bartell, 2013).

The largest challenge in addressing this category was the feeling amongst some teachers that developing positive attitudes towards cultures and global issues was not a responsibility specific to mathematics. Many identified existing school programs or initiatives to address general attitudes which they believed was independent of their mathematics curriculum and content. As a result, one question to consider is how the discipline of mathematics can address the objectives contained in Attitudes in ways that are unique to the discipline or can complement existing schoolwide initiatives.

**Action**

When including global issues in mathematics tasks, a few teachers in this study included opportunities for their students to take action related to the global issue. For example, Mr. Reynolds ended each worksheet with two sections titled “Want to learn more?” and “What can you do about it?” containing links to resources for students and information about any local events relevant to the issue that students could attend. These sections also suggest an “awareness to action” spectrum of global education goals and shed light on an important distinction to be made. The objective of Opportunities for learners to take action in educational settings is defined as exposure or awareness of what others have done to act on a particular global issue while opportunities to address the objective of Taking Action include chances for students to tangibly participate in taking action.

Another distinction to be made in Taking Action is that opportunities and possibilities to address this objective (as identified by the teachers in this study) included two different contexts. First, action may be taken with other students in an educational setting, such as
writing a letter to an elected official or solving a water usage and quality problem in their school. Second, action may be taken outside of school settings if students are able to employ their mathematics tools and global education skills to solve an issue encountered in their lives.

The different contexts associated with taking action are important because some teachers held the idea that action is something that takes place outside of school and as a result, believe that these objectives would be a challenge to address in school settings. According to the teachers, this challenge is logistical as it can be difficult to organize trips or events outside of the classroom and is also a product of the belief that teachers cannot (and should not) force students to take action (in the context of improving a global issue) outside of school. Finally, an additional challenge identified was the struggle in connecting actionable items directly to a mathematics class as opposed to a holistic set of knowledge from many disciplines often needed to act on a global issue. To address these concerns, mathematics teachers may consider working and brainstorming with other mathematics teachers and teachers from other disciplines to create interdisciplinary opportunities and to uncover ways in which skills unique to mathematics can contribute to taking action.

**Mathematics Context**

Each of the three contexts in which mathematics and global education were integrated – using a Disciplinary approach, using an Interdisciplinary approach, and for mathematics Content Knowledge – were present in relatively similar frequencies in this study. The appearances of disciplinary and interdisciplinary techniques were largely due to the differences in the school structures of elementary and secondary schools. Elementary teachers are generalists and because they teach every subject to the same students, they found it much easier to integrate multiple subjects, including mathematics, with a global issue. On the other hand, secondary teachers are specialists and because they only teach mathematics to many different groups of
students, their classes are more conducive to the unique tools offered by mathematics to understand a global issue.

Although a disciplinary approach was much more prevalent among secondary teachers and an interdisciplinary approach was more prevalent among elementary teachers, all teachers mentioned opportunities to integrate mathematics and global issues using both perspectives. These two approaches were adapted from the Asia Society model of global competence, which emphasizes the importance of each since “disciplines provide powerful lenses through which to interpret the world” and “too often issues of local and global significance cannot be approached through a single discipline” (Boix Mansilla & Jackson, 2011, p. 13). It is encouraging that when brainstorming possible mathematics tasks, the use of either of these approaches significantly outweighed the suggested use of Content Knowledge, which was added to the framework to address the use of global issues in mathematics in which the mathematics content is not directly used to understand or analyze the global issue(s). The development of students’ understanding of mathematics content is essential, but in the context of using mathematics to develop global citizens, this content knowledge should accompany the use of mathematics as a tool to understand, analyze, and act on global issues.

Many of the challenges addressed by teachers in this study were applicable to a wide range of categories and objectives. Although the frequencies for challenges associated with Disciplinary and Interdisciplinary approaches are higher than the challenges identified for any other objective in the framework, this can be explained by teachers offering challenges that are more general towards the holistic use of global issues in mathematics. Difficulties that were previously mentioned in other categories, such as a teacher’s comfort level with global issues and the pressure they feel to get through their mathematics curriculum, also reflect a challenge in a teacher’s ability to use mathematics in the context of global issues. Similarly, school structures and logistical factors of preparation and collaboration with teachers in other
disciplines negatively impact a teacher’s ability to use mathematics in an interdisciplinary context. Many of the challenges may be general in nature because teachers were not provided with the framework of categories and objectives used in this study. As a result, teachers were (by design of the study) not responding to specific objectives but rather providing personal and structural hindrances towards the inclusion of global issues in mathematics.

**Research Question 2**

The findings of the second research question were the result of a qualitative inductive analysis and consist of three main categories of factors that most influence a teacher’s design and implementation of tasks that integrate global issues into mathematics. The three categories include (1) Teacher Dispositions, such as their thoughts, beliefs, and attitudes towards global issues and the role of global education in mathematics, (2) Contextual Factors unique to each teacher such as the grade level of their students, type of school (public, private, or magnet), and local population where a teacher works, and (3) Mathematics Task Design, which contains factors such as pedagogical considerations that influence the design and implementation of specific tasks. The discussion of these findings are separated by these three main categories.

**Teacher Dispositions**

In this study, there was a range of comfort levels with global issues in mathematics among the teachers. Some embraced the inclusion of these issues while others felt less confident to integrate or discuss particular issues in their classroom. This is similar to research studies in the literature that have explored exemplar teachers who are activists in their community (Gregson, 2013) and teachers who may be skeptical or not aware of the role that social justice issues can play in mathematics (Gonzalez, 2009). In the latter study, the researcher reported changes in the attitudes and beliefs of the teachers towards engaging in the teaching of Mathematics for Social Justice following their 10-week professional
development group meetings. This suggests that widespread professional development which includes frameworks of global education has the ability to benefit teacher dispositions towards mathematics and global issues.

The findings of this study also point to the fact that personal background and beliefs (including political beliefs) of teachers played a large role in their use (or lack thereof) of global issues in mathematics. This is supported by the literature as each study mentioned in Teaching Mathematics for Social Justice (TMfsJ) section of Chapter 2 provides a detailed personal and professional background of the participating teacher(s) to contextualize their perspectives. The information provided often included a teacher’s educational background and experiences (in general and with social justice issues), their demographic information such as race, ethnicity, and gender, and any personal views (political or otherwise) that each impact their attitudes towards global issues in mathematics and any tasks that are produced. Each of these characteristics are worth reporting and further exploring their impact on the design and implementation of tasks, and also lead to additional questions worth considering. As professional development may seek to shape a teacher’s views, what impact does shaping their personal views towards a global issue have compared to shaping their views on the importance of global education (within a mathematics context or in general)? Do teachers first need to “feel something” on a personal level towards a given global issue before presenting and engaging with the issue in the classroom?

To address the impact of a teacher’s views and dispositions on their mathematics tasks, any professional development or teacher resources may ask teachers to identify their own perspectives or potential biases towards particular global issues. In doing so, teachers themselves would be displaying an objective of global education (Knowledge of Self) which might clarify the objectives or spark ideas on how to address the objectives in their classrooms and among their students. For researchers, it may be valuable to not only identify objectives as
addressed by the teachers towards the goal of developing the objectives in their students, but to also identify the objectives in the teachers themselves and the impact of a teacher’s own global citizenship and global competence on the appearance of the associated objectives in their classroom.

**Contextual Factors**

Just as detailed descriptions of teachers contextualize their impact on mathematics tasks, detailed descriptions of their schools and towns also affect tasks (or lack thereof) produced by teachers. This study and each study highlighted in the TMfSJ section of Chapter 2 provided descriptions of participating schools and their student populations to address this impact. Naturally, whether a school is an elementary school, middle school, or a high school will affect both the mathematics content and the global issues present in tasks. For curriculum developers, this means designing resources that align with the Common Core State Standards for Mathematics and the spectrums of development identified by global education frameworks. Furthermore, each school has unique administrators with varying levels of interest in incorporating global or social justice issues into mathematics. A couple of teachers in this study mentioned potential resistance from higher administration because the focus of the administrators was strictly on mathematics content in order to achieve or improve scores on standardized exams. As a result, it may be important that the dissemination of any tasks and curriculum materials are complemented by resources addressing the benefits, both to mathematics and to society, of the inclusion of global issues into mathematics classrooms.

Although it is common for teachers to have a personal understanding of their students, their families, and issues in their community, this takes on a heightened importance when addressing global issues. This does not require teachers to be an activist in their community (Gregson, 2013), but rather to possess an understanding of where students come from and how their families might be affected by any local, national, or global issues. With this knowledge,
teachers can be conscious of opportunities to make connections between mathematics content and authentic issues that directly affect their students.

Many of these issues occur on a local level, which may present a challenge to national curriculum developers, but the developers can provide guidance for tasks and projects that can be adapted for local issues. As a result, some of this work would shift to state and district curriculum leaders as well as teachers, each of whom may require additional preparation time and support. In addition, local issues are often fluid and an increased demand would be placed on the creation of new tasks or projects that reflect current events and authentic issues which often change from year to year.

While the understanding of students’ demographics and the communities they live in is important, it is worth noting that the goal of global education or social justice issues in mathematics is to serve and address global education objectives in all students. This statement is a result of mathematics education researchers (Simic-Muller et. al, 2015; Brantlinger, 2013) who have observed that many of the existing studies in the literature have been conducted with students of underserved populations and minority backgrounds in urban settings. The findings of this study addressed the impact of global education on these students as well as on students in classrooms that are predominantly White and in suburban or rural settings. Further research is needed on the opportunities and impact of global education in mathematics on students with the latter set of characteristics.

Mathematics Task Design

Pedagogical considerations, strategies, and challenges found in this study align with those found in previous research studies. In this study, Mrs. Brown discussed the importance of designing tasks that are either challenging in their mathematics content or in the application of mathematics to a global issue, and that if each of these components was challenging, then students would struggle with the task at a rate that is detrimental rather than productive.
Gregson (2013) also identified the importance of creating tasks that are “just right” and offered potential negative implications. Tasks that are “too mathy” may prevent students from recognizing mathematics as a tool to analyze global issues, and tasks that are not “mathy enough” may result in lost time in the preparation of students for standardized exams. The balance of difficulty levels in tasks is crucial, and although the global education framework in this study was and can continue to be used to analyze tasks, a complementary framework to evaluate the mathematics content (or “mathy-ness”) may be useful to examine this relationship in practice.

Teachers in this study also navigated the mathematics content and the global issues component of their tasks in different ways. To some, these sets of knowledge and skills were not viewed as separate components, but were linked through the application of mathematics to the global issue. To others, these disciplines were seen as two separate components of the task, as evidenced by their reflections on task design and even the physical layout of questions on worksheets (see Appendix E for sample tasks and their layouts). This separation of content was also observed by Bartell (2013) as one group of teachers in her study initially designed lessons in which the first half of the lesson was the “math piece” and the second half was the “social justice piece.” As a result, professional development and teacher resources may seek to emphasize the connections between mathematics content and global issues to design tasks that demonstrate the necessity of the relationship between the two disciplines in consonance.

Whether prompted or unprompted, teachers in this study often discussed the time and resources needed to make meaningful connections between mathematics and global issues a reality in their tasks and classrooms. Teachers already have many demands on their time, and this needs to be taken into consideration when discussing the future of this work. There are teachers that are intrinsically motivated to integrate global issues into mathematics, such as Mrs. Paige in this study or Ms. Myles in Gregson’s (2013) study, but even these teachers often
lack the time to translate their ideas into a concrete mathematics task. This represents a challenge to a more widespread use of global issues in mathematics and also illustrates the importance of creating resources, such as task templates or textbooks, to be used or adapted by teachers. Furthermore, many teachers may not be motivated to make connections from mathematics to global issues and may benefit from professional development and collaborative work with motivated teachers so that designed tasks are implemented in more classrooms.

Research Question 3

Three tasks that included the use of a global issue in mathematics were selected from a collection of 33 mathematics tasks provided by teachers in this study to answer the third research question. This question served as an application of findings from each of the first two research questions and utilized the global education framework created for this study and the inductive categories and codes from the second research question. The set of codes (from each of the first two research questions) were applied to each of the three selected tasks to highlight the ways global education objectives and teacher factors associated with task design can be situated within a particular task as opposed to the holistic view provided by the findings of the first two research questions.

Mathematics Task #1

The first mathematics task selected in this study was Mrs. Paige’s 4th grade task in which her students analyzed carbon dioxide emissions from various countries using mathematics skills and knowledge from other disciplines (see Appendix E for the full task). She was able to address the following 4th grade mathematics standards: (1) the generalization of place value understanding for multi-digit whole numbers, (2) the understanding of place value and properties of operations to perform multi-digit arithmetic, and (3) the representation and interpretation of data (NGA, 2010). This task also addressed a significant number of global education objectives and if the framework was extended to account for the students’
developmental level, it is possible that additional objectives were addressed in the task’s implementation. Furthermore, the task was a product of Mrs. Paige’s original ideas, but she acknowledged that the prep time required to design the task and the pressure to move through the standardized curriculum were challenges both for the task in this study and her future implementation of mathematics and global education tasks. As a result, resources and supports such as sample tasks, templates, and collaborative planning time will be crucial to ensure a wider implementation of these tasks.

Many of the existing research studies and tasks which explore mathematics and a global or social issue have been conducted or implemented with middle school or high school students. However, global education frameworks include objectives on the developmental spectrum for students as young as 5 or 6 years old (UNESCO, 2015; P21, 2014b; Asia Society, 2015) and research studies (Chao & Jones, 2016; Felton-Koestler et. al, 2016) have demonstrated connections between mathematics and global education with elementary students between Pre-Kindergarten and 4th grade. In fact, the project designed by Mrs. Sutherland in Felton-Koestler’s study (2016) shares many characteristics with the task designed by Mrs. Paige in this study as each 4th grade teacher used authentic data and age-appropriate mathematics skills to compare a social or global issue (Mrs. Sutherland used teacher pay around the world and Mrs. Paige used carbon dioxide emissions) across multiple countries, including the United States.

While additional studies and examples of tasks are needed to leverage the potential of integrating global education into elementary mathematics, Mrs. Paige’s task provides an excellent example of what can be implemented with younger learners. Her task provides insight into how (age-appropriate) mathematics can be used as a tool to analyze a global issue and how to create interdisciplinary connections with global issues that were originally presented in the context of another discipline.
Mathematics Task #2

The second task selected in this study was Mr. Hammons’s 3rd grade task in which his students applied mathematics skills to the global context of importing and exporting products around the world. He was able to address the following 3rd and 4th grade mathematics standards: (1) the understanding of place value and properties of operations to perform multi-digit arithmetic, and (2) the understanding of decimal notation (NGA, 2010). Although this task was completed as a “one-off” lesson with students not receiving any requisite knowledge of imports and exports, the engagement of the students with the task was reported to be significantly higher than average, and multiple global education objectives were addressed. Similar to Mrs. Paige’s task, a framework which explicitly accounts for the developmental level of the students may reveal further objectives addressed or with the potential to be addressed among Mr. Hammons’s 3rd grade students. One major difference between the two tasks is that Mr. Hammons decided to modify an existing lesson plan found in a textbook. This textbook was designed for a 5th grade social studies class with a goal of making increased global connections and Mr. Hammons modified the lesson by adjusting for the different developmental level of his students and by integrating mathematics content, which did not exist in the original lesson plan (see Appendix E for relevant components of the lesson plan from the textbook).

Beyond the studies mentioned in the discussion of Mrs. Paige’s task, another resource for elementary mathematics exists in the Partnership for 21st Century Learning’s “lesson abstracts” (P21, 2014c). These lesson starters provide outlines of various 4th grade level, 8th grade level, and 12th grade level mathematics tasks and include how each task aligns with the Common Core State Standards for Mathematics and skills associated with global education. A teacher utilizing this resource must still design the task, but additional templates may promote increased global connections to elementary mathematics and inspire teachers to create their own connections and tasks.
While templates can provide a structure and outline for a task, teachers maintain the flexibility and control to produce a task that is best suited to their unique set of students. As a result, there exists a need for additional research to investigate the ways in which teachers modify and implement global education and mathematics tasks based on provided templates. Due to the lack of this work in the literature, Mr. Hammons’s task provides valuable perspectives on his process of modifying an existing task and how objectives of global education and the Common Core State Standards for Mathematics can both be addressed. In addition, his task also provides insight into the opportunities and challenges of implementing global issues into elementary mathematics with a Disciplinary context.

Mathematics Task #3

The third task selected in this study was Mr. Reynolds’s high school Algebra II task in which his students interpreted quadratic functions and learned about the Dakota Access Pipeline issue (see Appendix E for the full task). He was able to address the following high school mathematics standards related to functions: (1) the analysis of (quadratic and constant) functions using different representations, and (2) the interpretation of functions that arise in applications in terms of its context (NGA, 2010). This task was motivated by Mr. Reynolds’s own passion towards global and social justice issues and was one of a series of weekly “Activism and Mathematics” tasks that he designed and implemented on his own. Although implementation of this task was not observed (due to geographical constraints), many of the global education objectives had the potential to be addressed depending on the implementation and classroom interactions. The potential presence of these objectives were identified through the interpretation and analysis of Mr. Reynolds’s interview responses and suggest an additional research question to explore. If teachers are aware of objectives of global education, what are their perceptions of what qualifies as addressing an objective in a student or amongst an entire
class of students? Furthermore, how could mathematics teachers be supported in measuring or assessing global education objectives in their students?

The context of the mathematics in Mr. Reynolds’s task differs from the context found in Mrs. Paige’s and Mr. Hammons’s tasks. Mr. Reynolds had his students first answer mathematics content questions about a quadratic formula modeling the depth of a river (in which the Dakota Access Pipeline would be constructed) and then informed them about the issue and why it is controversial before engaging in a class discussion in which his students shared their thoughts and opinions about the issue. Since the mathematics did not serve as a tool to analyze the issue, the context of the mathematics in this task was coded as Content Knowledge as opposed to a Disciplinary or Interdisciplinary context. However, Mr. Reynolds was still able to address many of the global education objectives within a mathematics class.

Although the Asia Society framework emphasizes the importance of “understanding the world through disciplinary and interdisciplinary study” (Boix Mansilla & Jackson, 2011, p. 11), further research may be useful in identifying any benefits or shortcomings of embedding global issues into mathematics without necessarily utilizing the mathematics content to engage with the global issue.

Sample projects and tasks (Gutstein & Peterson, 2013) and research studies (Bartell, 2013; Stinson, 2012) demonstrate ways in which high school mathematics content can be applied to a global issue. Mr. Reynolds’s task contributes to these resources, but it is important to consider the various goals and purposes associated with global education contained in these tasks. Some tasks focused on developing students’ awareness and understanding of issues, such as Carla’s task (Stinson, 2012) which contained goals of increasing students’ understanding and highlighting their perceptions on the issue of racial profiling. Other tasks or projects focused on using mathematics to take action and create positive change, such as Beatriz’s unit on overcrowding in her school in which her students applied mathematics and
then disseminated their findings to the school and district to promote change (Gutstein & Peterson, 2013). The task implemented by Mr. Reynolds had goals of increasing awareness of the Dakota Access Pipeline and providing resources and motivation to take action in the future.

When setting the goals of tasks and their location on the “awareness to action” spectrum, there are additional considerations. First, Gutstein (2006) states that one of the goals of educators (in mathematics or otherwise) is to develop students into individuals with agency which will likely manifest outside of the classroom. This sentiment was shared by Mr. Reynolds as he expressed the desire to develop students into future leaders and makers of change as college students or in their careers. Second, Wamsted (2012) mentions that although teachers may set a goal of having students take action to address a global or social justice issue, “you might be shocked to find out that your students may not consider their situation to be all that unjust” (p. 177). This places a heightened importance on designing or modifying tasks to suit the perspectives of a specific set of students. In addition, this quote acknowledges the potential role of global education objectives from the categories of Values and Attitudes in the goals and design of mathematics tasks.

**Mathematics Task Analysis**

Other than analyzing tasks by identifying the global education objectives and the factors that influenced a teacher’s design and implementation of the task, there are additional questions that may be of interest when analyzing tasks or projects. First, how are the global education objectives found in a single task? Are some objectives more commonly grouped and found together than others? Conversely, are some objectives rarely found together and if so, why?

In addition, the global education framework in this study was primarily used to analyze interview transcripts and when analyzing tasks, the data obtained from the corresponding interview(s) and classroom observation supported the deductive coding process of applying the
framework to the task. Although the additional data was beneficial for this study, future work and studies may focus only on analyzing any tasks that integrate mathematics and global education. If doing so, what modifications may need to be made to the framework used in this study? As found in Mr. Reynolds’s selected task, some objectives may appear to be addressed in theory, but without an observation, it can be difficult to determine if the objective was actually addressed or present in classroom practice. As a result, a degree of caution is required when applying the framework to analyze a task without its associated observation or teachers may need to supply extra information to provide further context to the implementation of a task or project.

**Discussion of Frameworks**

**Global Education Framework**

The modified global education framework was effective in this study, but there are elements that are worthy of discussion for future use. Based on the findings of this study, there may be value in filtering certain objectives for their appearance in the context of mathematics in addition to their appearance in the context of exploring a global issue. This would potentially provide more information on how global education objectives can be addressed uniquely in the discipline of mathematics. Some of these examples, such as the appearances of Critical Thinking in both a mathematics context and as applied to global issues, are discussed in the above sections. Each example leads to questions of transferability that warrant further research. If students achieve an objective strictly in the context of mathematics, will that objective also be present in the context of a global issue? Similarly, if learners achieve objectives of global education outside of a mathematics classroom or context, will the objectives also appear as they relate to mathematics?

Furthermore, this framework was designed for mathematics by including the Mathematics Context category and removing certain objectives such as linguistic skills, but it
may be beneficial to include additional mathematics-specific components and language in the framework, such as a student’s procedural and conceptual understanding of mathematics or their problem-solving skills and strategies. This is beyond distinguishing particular objectives by their contexts in mathematics and as related to global issues and could serve the purpose of further contextualizing mathematics in the development of one’s global competence and highlighting more connections.

In using the framework as a coding scheme, the primary challenge was in isolating the objectives because many are intimately connected. These connections are emphasized in the existing frameworks of global education as globally competent individuals are defined as ones who successfully integrate their knowledge, skills, attitudes, and values to lead to taking action (COE, 2016). As a result, it should be expected that objectives occur simultaneously, but more refined definitions of the objectives may support identifying the unique characteristics of each objective and can include nuances of objectives that were unanticipated entering this study.

In addition, the second layer of coding for this framework (which served to identify whether a given objective was (a) present, (b) had the opportunity to be developed, or (c) challenges existed in addressing that objective), was effective for the purpose of this study but warrants discussion. In this study, the framework was primarily used to code the responses of teachers in their interviews, but if the framework is used in the future to evaluate responses among students, an additional level of coding may be necessary to separate objectives observed in students as opposed to as identified by their teachers. In addition, careful consideration should be given for the students’ developmental level and ways in which each objective might present themselves at different stages of development. This would further align the structure of the framework used in this study with the frameworks of global education that include spectrums of development (UNESCO, 2015; Oxfam, 2015; Asia Society, 2017).
Mathematics Task Protocol

As briefly mentioned in the discussion of the second research question, a framework or protocol to evaluate mathematics tasks would provide value when used in conjunction with the global education framework. The protocol used to analyze the tasks collected in the pilot study (see Appendix G for the full protocol) was not retained for the dissertation study because of the difficulties in attempts to identify components of global education in tasks without observing their associated implementation. These difficulties also led to the development of the global education framework which benefitted the task analysis in the dissertation study. The original protocol used in the pilot study also lacked analysis of the mathematics content in the task beyond the classification of its cognitive demand level. This classification can be useful, but the analysis of additional components of the mathematics embedded in the task is necessary to further understand the use of mathematics content as a tool to analyze a global issue.

A revised Mathematics (and Global Education) Task Protocol could inherit the Mathematics Context classification from the global education framework and retain its identification of cognitive demand level from the original protocol. Additional components may include the standards and practices addressed from the Common Core State Standards for Mathematics (or other sets of standards), a further unpacking of the procedural and/or conceptual knowledge (beyond the simple labeling of cognitive demand level) contained in the mathematics content of the task, and whether the mathematics content and skills contained in the task are requisite or new to the students at the time of the task’s implementation. These components could be complemented with an expanded version of the global education framework that also contains mathematics-specific language in the global education objectives to offer detailed insights into the components of tasks and the relationship between the mathematics content and the global issues presented in the task. In addition, a revised protocol
can provide a resource for teachers and researchers alike to illuminate and evaluate the ways in which mathematics content is utilized in a given task.

**Limitations**

The methods and findings of this study contained limitations that can inform future research designs. First, as previously mentioned, one feature of qualitative studies is sample sizes that are smaller to capture in-depth and rich data. Thus, the sample size was appropriate for this study and while there were benefits to having multiple grade levels and types of schools represented, the trade-off was that each type of school (elementary, middle, and secondary as well as public, private, and magnet) only had 1-3 teachers to represent schools of that type. Future studies may hone in on a particular grade level or type of school to obtain a larger sample of teachers from similar school settings.

In addition, some selection bias may have been present among the participants in this study. This is a result of the recruitment process in which the secondary teachers were obtained from a group that participated in workshops for Advanced Placement (AP) classes. Furthermore, since any teachers that were contacted had the option to participate in the study or not, many of the teachers that decided to participate may have a higher level of interest in global issues and may not represent the perspectives of the general teacher population.

Another limitation of this study can be found in the way that teachers chose and used tasks that they felt incorporated global issues into mathematics. Of the seven observations that were completed, there was only one instance in which the teacher created a new task on their own specifically for this study. Another teacher tried a new task for this study by adapting an existing one that was found in a textbook. Each of the remaining observations utilized an existing task in the teachers’ curriculum which included word problems and fell in line with my timeline of conducting the study. Future research may include a longer timeline and additional teacher support towards the creation and implementation of new tasks. Any new tasks could
then be analyzed for their effectiveness and the ways in which the global education objectives are present.

This study focused on the teachers’ interview responses and choices made in designing and implementing tasks, but the data did not include any student perspectives or work samples. While the findings related to the global education objectives in this study are rich, data from students would only increase the presence and viability of the objectives observed as present among the students. In the future, student work samples may be collected along with student interviews or focus groups so that researchers can observe the global education objectives directly from students and understand their perspectives on the ways mathematics can be used to understand and act on global issues. A survey mechanism may also be useful for gathering data on the objectives in students. It is important to note that any data collected on students’ work and perspectives utilizes frameworks of global education that account for the developmental level of the students.

A final limitation comes from the perspectives held by myself as the researcher. My background and views are described in detail in my Subjectivity Statement (see Chapter 4) and these are important to acknowledge particularly since I was the only researcher that conducted the interviews and classroom observations. The data was discussed with members of my committee and other graduate students, but other researchers may have asked different questions during the interviews or compiled additional notes during the classroom observations. Other researchers may also have obtained different codes, categories, and findings through the data analysis process. Steps taken to address these issues are included in the Validity and Reliability section (see Chapter 4).
Future Research Directions

This study gives rise to many important questions that warrant future research and exploration. Some of these directions for future research were mentioned in the previous sections of this chapter, and are expanded upon below.

In conducting a similar study in the future, an intervention in the form of professional development or other resources to support teachers such as mathematics task templates would be useful in determining how teachers incorporate global issues and ideas from the global education framework into their mathematics tasks. This study provided examples of teachers designing new tasks as well as modifying an existing task and each approach warrants additional research and examples to understand the associated benefits and challenges. In either approach, an extended version of the global education framework along with a new mathematics task protocol (as mentioned above) would then be used to analyze the tasks and their associated implementation.

As global education objectives, their contexts, and their interconnections continued to be identified and studied within mathematics, it is important to recognize how the discipline of mathematics may uniquely address any of the objectives. There is research on global competence in education in the subjects of social studies and foreign languages and a review of the literature may yield similarities and differences to what the subject of mathematics can offer to global education.

A wider sample of teachers lacking experience or a natural interest in using global issues in mathematics would provide an opportunity to determine whether a teacher’s dispositions and attitudes towards the connection of the two topics could be positively impacted through professional development or other interventions. These dispositions would include their views towards the use of mathematics in the “real world”, the role of mathematics in understanding and acting on global issues, and the role of global issues in education.
Further, a wider sample of students as compared to the literature may provide new insights into the various contexts of global education in mathematics. Many existing studies have been conducted with underserved populations and students from minority backgrounds, predominantly in urban settings (Brantlinger, 2013). One of the selected tasks and observations in this study (from Mr. Hammons) provides an example of a classroom of students that are primarily White and from higher socioeconomic backgrounds and their engagement with global education content in a mathematics class. Additional research and examples with these student populations may reveal if there is a relationship between the impact of global education and various forms of privilege.

In researching students in addition to teachers, one could also ask questions about changing dispositions from the student’s point of view. If mathematics and global issues are increasingly integrated, does a student’s view of mathematics change? Would students feel empowered by seeing ways in which mathematics is used authentically in real world issues? These questions would also be interesting to explore in a longitudinal study to determine the change in student attitudes towards mathematics following a prolonged use of mathematics as a tool to analyze global issues.

Just as a new mathematics task protocol looks to increase the focus on the mathematics content, there is the larger question of whether the inclusion of global issues supports the development of a student’s mathematics skills. Can the authentic use of mathematics applied to global issues raise the mathematics achievement of students? This is a difficult question to answer and would likely require a large-scale study, but it is ultimately the goal of studies such as the one presented here.

Global education objectives are certainly not limited to mathematics classrooms, but one might ask how a mathematics classroom fits in the larger picture of developing a student’s global competence. Would an objective present in a mathematics classroom also be present in
the same student in another classroom or subject area? Furthermore, would that same objective be present in a similar situation outside of school or any formal environment? Finally, if the objectives are present in a student, where did they develop them – from a certain class or teacher, at home, through the media, or some combination of resources? These are all big picture questions, but speak to the importance of discovering more information about the overall development of global competence.

We are also interested in how to best support teachers in making connections between mathematics and global issues. When referring to in-service teachers, what existing resources are best? What would be included in a professional development session to maximize the understanding of global education from both a theoretical and practical point of view? Can textbooks or other resources be created and disseminated to support interested teachers, schools, and districts? And when referring to pre-service teachers, how can global education and its relationship with mathematics be incorporated in college courses?

This study investigates K-12 teachers, but a natural extension would be to the undergraduate curriculum and the ways that undergraduate mathematics is used critically and meaningfully as a tool to understand and interact with the world. This is applicable to service-level courses in which college instructors often bear the burden of being the last formal mathematics instruction that most people are exposed to in their lifetimes, as well as mathematics major courses where students have more tools available to them in which to analyze the world. In either case, this relationship between mathematics and global issues on the undergraduate level is one that has yet to be significantly explored. Part of this research would also come back to instructor knowledge and preparation on the undergraduate level as college mathematics instructors have likely not received formal training on the use of global issues in the mathematics classroom.
Lastly, once again mathematics is not the only subject that can integrate global issues into its curriculum. As the demands exist to include these issues in all subjects, there will also be an increased demand for interdisciplinary collaboration. This is true on the K-12 level through teams of teachers and thematic units, and is also true on the university researcher level. Analyzing global issues often requires skills obtained from many disciplines and experts in each discipline coming together can greatly benefit global education and its place within and across all disciplines on the full P-20 spectrum.

**Chapter Summary**

This chapter contains interpretations and discussions of the findings for each of the three research questions of this study. The discussion of the first research question considers the future creation of resources and potential research to be conducted to best support inservice teachers. As similar studies are conducted, ideas for modifications and uses of the global education framework and a modified mathematics task protocol are offered in hopes of maximizing their future effectiveness.

Connections to the existing Teaching Mathematics for Social Justice (TMfSJ) literature can be found among the findings for the second research question along with possible implications for teacher practice. Many of the findings in this study align with findings from the TMfSJ literature, and offer new examples, perspectives, and questions.

The three selected tasks used for the third research question in this study provide a comparison of each Mathematics Context in this study. In addition, differences between tasks designed and tasks modified by teachers are considered. The selected tasks are also compared to existing social justice mathematics tasks and projects found in the literature.

Lastly, the limitations of this study and many ideas for future research are presented. In the future, researchers might be interested in conducting similar studies with teachers but with the use of an intervention and work samples and perspectives from students to get a more
holistic view on the ways in which global education objectives are present and developed in students in mathematics classes.
References


Appendix A

Global Education Framework

Knowledge

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-G</td>
<td>Knowledge – Global/National/Local - a large and complex range of knowledge and understanding in a variety of domains, including all of the following - politics and law, human rights, cultures, religions, history, media, economics, the environment and sustainability</td>
</tr>
<tr>
<td>K-N</td>
<td>Knowledge of Self - the knowledge and understanding of one’s own culture and perspectives on the world</td>
</tr>
<tr>
<td>K-L</td>
<td>Interconnectedness - the knowledge and understanding of the connections between multiple issues (such as the relationship between climate change and the economy) or multiple spheres, for example how a local issue affects the global scale or vice versa</td>
</tr>
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</table>

Skills

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>EC</td>
<td>Effective Communication – the ability to communicate clearly through reasoning, clarifying, discussing, etc. and the effective use of linguistic and discourse (oral and written) skills</td>
</tr>
<tr>
<td>CT</td>
<td>Critical Thinking - the ability to organize information in a logical manner, compare/contrast/connect pieces of information, construct logical arguments or conclusions, and evaluate and make judgments about information</td>
</tr>
<tr>
<td>CCR</td>
<td>Cooperation and Conflict Resolution - the ability to successfully work together with others on shared tasks and resolve any conflicts in an effective manner</td>
</tr>
<tr>
<td>SD</td>
<td>Self-directed Learning – the ability to identify one’s own learning needs and acquire reliable sources of information to address those needs</td>
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</table>

Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
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<tbody>
<tr>
<td>HR</td>
<td>Human Rights – the belief that every human is of equal worth and is entitled to the same set of fundamental rights and freedoms</td>
</tr>
<tr>
<td>Code</td>
<td>Definition</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>CD</td>
<td>Cultural Diversity – the belief that other cultural perspectives, views, and practices should be appreciated so that people can learn from the diverse perspectives of others</td>
</tr>
<tr>
<td>JFE</td>
<td>Justice, Fairness, and Equality - the belief that all members of society should be treated fairly and as equals, regardless of race, gender, national origin, religion, sexuality, age, socioeconomic status, etc.</td>
</tr>
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</table>

**Attitudes**

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
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<tbody>
<tr>
<td>CO</td>
<td>Curiosity and Openness – interest in discovering and learning about other cultural perspectives and practices and willingness to suspend judgment about views of others</td>
</tr>
<tr>
<td>CM</td>
<td>Civic-mindedness and Citizenship – feeling of belonging to a community or social/cultural group and a willingness to participate and actively contribute to community life</td>
</tr>
<tr>
<td>CER</td>
<td>Care, Empathy, and Respect - positive regard for other people as equal human beings and the ability to relate to the thoughts, beliefs, and feelings of others</td>
</tr>
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</table>

**Action**

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Opp</td>
<td>Opportunities to take action – “they learn about opportunities for engagement as citizens at local, national and global levels, and examples of individual and collective action taken by others to address global issues and social injustice” (UNESCO, 2015, p. 24)</td>
</tr>
<tr>
<td>TA</td>
<td>Take Action - actually engaged and taking action - personally or collaboratively - to improve conditions</td>
</tr>
</tbody>
</table>

**Mathematics Context**

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<tr>
<th>Code</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Dis</td>
<td>Disciplinary – mathematics-specific skills used to make sense of the world</td>
</tr>
<tr>
<td>Indis</td>
<td>Interdisciplinary – mathematics skills supporting integration of knowledge from different disciplines to make sense of the world</td>
</tr>
<tr>
<td>CK</td>
<td>Content Knowledge - the use of the context of a global issue to apply and develop mathematical skills without exploring or meaningfully engaging with the global issue</td>
</tr>
</tbody>
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Appendix B

Interview 1 Protocol

Interview 1 semi-structured protocol

1) I would like to start by asking about your background with global education.
   a) First, is your background in the area formal or informal? (University course, professional development training at school, professional development training outside of school, self-learned course/module/etc., other, none)
   b) Can you tell me, in your own words, what global citizenship means to you?
   c) In your view, what are “global citizen” qualities you expect students to exhibit?
   d) Is global citizenship necessary in education?
   e) Are you familiar with any frameworks or pedagogical strategies related to global citizenship and if so, have you used them in any way?

2) Let’s now think about the students and some of your experiences.
   a) Does the background and diversity of your students play a role in your classroom?
   b) In your opinion and understanding, does the diversity represented by the students in your classrooms impact mathematics learning in any way? And global citizenship education, how?
   c) Can what students learn in the classroom lead them to take action and improve their community, country, or world? Why or why not and if so, in what ways?

3) Let’s move this conversation into mathematics.
   a) What things can be done in the mathematics classroom to develop students into global citizens?
   b) Does mathematics offer something that another subject cannot in terms of an individual’s development of global citizenship?
   c) Can students learn about local, national, and global issues in a mathematics classroom? Can they think critically about these issues there?
   d) Are students that exhibit qualities of a “global citizen” any more or less likely to succeed in mathematics? Why?
   e) Does including global issues affect student attitudes towards mathematics? Why or why not?
   f) Are there any particular topics in mathematics that are a better fit for including global (or local or national) issues?
   g) Are there any particular topics in mathematics that are more difficult or do not make sense to include global (or local or national) issues?
   h) Can mathematics be used to learn about or discuss any global issue or only particular issues? Why? If only particular issues, which ones?
i) What advantages would you see in including global citizenship in a mathematics curriculum? What about disadvantages?

Depending on the time left, the interviewer would skip any of the following questions as needed to ensure that the set of questions in Section 7 and Section 8 are addressed.

4) I would like to ask about your familiarity with existing pedagogies.
   a) Are you familiar with culturally relevant/responsive pedagogies? If so, please tell me what you know and if you’ve used them in any way.
   b) Are you familiar with teaching mathematics for social justice? If so, please tell me what you know and if you’ve used it in any way.

5) Let’s talk about this at the school and district level.
   a) Can you talk about any initiatives in your school or district to incorporate global citizenship into mathematics or other subject areas?
   b) Have there been any discussions by curriculum or other math leaders at your school or district about global citizenship (or a related concept: use what participant offers in Section 1) and mathematics?
   c) Can you talk about any collaborations or shared ideas with other teachers or curriculum leaders that include global (or local or national) issues in mathematics or other subject areas?

6) I want to understand your confidence and comfort with global citizenship education.
   a) Do you (or would you) feel prepared incorporating global (or local or national) issues in your mathematics classroom?
   b) Do you (or would you) feel comfortable talking about and discussing global (or local or national) issues in your mathematics classroom?
   c) Can you help develop students’ attitudes towards others, such as empathy and respect for differences and diversity in your classroom? If so, in what ways?
   d) How do you (or would you) balance the time in the classroom if global issues are included?

7) I would like to finish by asking about your ideal student.
   a) What does your ideal student look like in your classrooms? What things are they doing during class time?
   b) Would anything change about this ideal student if global issues were included in the mathematics curriculum? Why or why not and if so, in what ways?

8) Is there anything else that you’d like to add or discuss that we haven’t talked about?
Appendix C

UNESCO Excerpt

The following graphics are an excerpt from the UNESCO document on Global Citizenship Education (2015) and was presented to each teacher during their initial interview.

**Box 1: Core conceptual dimensions of global citizenship education**

**Cognitive:**
To acquire knowledge, understanding and critical thinking about global, regional, national and local issues and the interconnectedness and interdependency of different countries and populations.

**Socio-emotional:**
To have a sense of belonging to a common humanity, sharing values and responsibilities, empathy, solidarity and respect for differences and diversity.

**Behavioural:**
To act effectively and responsibly at local, national and global levels for a more peaceful and sustainable world.

**Box 3: Key learning outcomes**

**Cognitive**
- Learners acquire knowledge and understanding of local, national and global issues and the interconnectedness and interdependency of different countries and populations
- Learners develop skills for critical thinking and analysis

**Socio-Emotional**
- Learners experience a sense of belonging to a common humanity, sharing values and responsibilities, based on human rights
- Learners develop attitudes of empathy, solidarity and respect for differences and diversity

**Behavioural**
- Learners act effectively and responsibly at local, national and global levels for a more peaceful and sustainable world
- Learners develop motivation and willingness to take necessary actions
<table>
<thead>
<tr>
<th>Global and local issues and the relationships between them/Local, national and global governance systems and structures/Issues affecting interaction and connectedness/Underlying assumptions and power dynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- citizenship, employment, globalization, immigration, interconnections, interdependence, migration, mobility, North-South relationships, politics, power relations</td>
</tr>
<tr>
<td>- access to justice, age of consent, decision-making, democracy, democratic processes, food security, good governance, freedom of expression, gender equality, humanitarian law, peace, peace-building, public good, responsibilities, rights (children’s rights, cultural rights, human rights, indigenous rights, right to education, women’s rights), rule of law, rules, transparency, well-being (individual and collective)</td>
</tr>
<tr>
<td>- atrocities, asylum seekers, child labour, child soldiers, censorship, conflict, diseases (Ebola, HIV &amp; AIDS) economic disparities, extremism, genocide, global poverty, inequality, intolerance, nuclear power, nuclear weapons, racism, refugees, sexism, terrorism, unemployment, uneven resources, violence, war</td>
</tr>
<tr>
<td>- civil society, corporate social responsibility, multi-national corporations, private sector, religious vs secular, stakeholders, state responsibility, youth</td>
</tr>
<tr>
<td>- biodiversity, climate change, disaster risk reduction, emergencies, emergency responses, environment, natural disasters, sustainable development, water quality</td>
</tr>
<tr>
<td>- geography, history, legacy of colonialism, legacy of slavery, media literacy, social media</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivating and managing identities, relationships and respect for diversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>- community, country, diasporas, family, indigenous populations, minorities, neighbourhood, school, self and others, world</td>
</tr>
<tr>
<td>- attitudes, behaviours, beliefs, culture, cultural diversity, diversity, gender, identity (collective identity, cultural identity, gender identity, national identity, personal identity), intercultural dialogue, language(s) (bilingualism/multilingualism), religion, sexuality, value systems, values</td>
</tr>
<tr>
<td>- care, compassion, concern, empathy, fairness, honesty, integrity, kindness, love, respect, solidarity, tolerance, understanding, world-mindedness</td>
</tr>
<tr>
<td>- assertiveness, communication, conflict resolution, dialogue, inclusion, intercultural dialogue, life skills, managing difference (e.g. cultural difference), managing change, mediation, negotiation, partnership skills (international and local), prevention (conflict, bullying, violence) relationships, reconciliation, transformation, win-win solutions</td>
</tr>
<tr>
<td>- animal cruelty, bullying, discrimination, racism, violence (including gender-based violence, school-related gender-based violence (SRGBV))</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engagement, action and ethical responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>- consumption habits, corporate social responsibility, ethical questions, ethical responsibility, fair trade, humanitarian action, social justice</td>
</tr>
<tr>
<td>- entrepreneurship, financial skills, innovation</td>
</tr>
</tbody>
</table>
Appendix D

Interview 2 Protocol

Interview 2 semi-structured protocol

1) I’d like to start by asking about the lesson that I observed in your classroom.
   a) In terms of mathematics, what were the learning goals you wanted to achieve with the lesson? And for global citizenship?
   b) What was your overall impression of the lesson?
      Supporting questions to use if not addressed by the participant:
      • What do you think worked well in the lesson?
      • What do you think did not work well in the lesson?
      • Did anything happen during class that you did not anticipate?
   c) Did the students meet the mathematics goals for the lesson? How about the global citizenship goals?
   d) How would you describe the engagement of the students with the material in this particular lesson?
      Supporting questions to use if not addressed by the participant:
      • Were the students motivated to accomplish the mathematical content?
      • Were the students motivated to learn about and/or discuss the global issues?
      • Did the students ask meaningful questions to each other?
      • Did the students ask you (the teacher) meaningful questions?
   e) Would you change this lesson if you were to use it again? Why or why not? If yes, then how would you change it?
   f) Were there any challenges in designing this particular lesson?
   g) Were there any (other) challenges in implementing this particular lesson?

Note: If the teacher chooses not to participate in the classroom observation portion of the study, Section 1 above would be skipped and Section 2 below would be repeated for each of the three tasks sent by the teacher prior to the second interview.

2) I’d also like to ask you about the different tasks that you have sent me.
   The interviewer will ask the following questions in reference to the first or third task sent by the teacher.
   a) How is global citizenship education incorporated in the lesson?
      Supporting questions to use if not addressed by the participant:
      • What knowledge did (or would) students acquire about global issues?
      • Is any part of the task designed to develop attitudes in students such as empathy and respect for differences and diversity?
      • Is any part of the task designed for students to take action in their community (or country or world)?
b) How does the mathematics in the task (if at all):
   - Support students’ knowledge about global issues?
   - Help develop attitudes in students such as empathy and respect for differences and diversity?
   - Support students to take action?

c) Based on their previous knowledge, how cognitively demanding is the mathematics in the task?
   Supporting questions to use if not addressed by the participant. Will students primarily focus on:
   - Using mathematical facts, rules, or formulas that they already know?
   - Learning a new algorithmic procedure(s) and trying to gain procedural fluency?
   - Using procedures or multiple representations to develop deeper understanding of the mathematical concept(s) or make connections with other mathematical concepts?
   - Exploration and discovery of new mathematical concepts and relationships to other concepts they know?

d) How does the mathematics, in particular the [interviewer uses the math specific to each lesson], interact with your goals regarding global citizenship in the lesson? [Interviewer refers to (a) here to remind participant of ideas mentioned and to ensure all the different aspects mentioned in (a) are addressed]

e) What is the teacher’s role in the task?

f) What is the student’s role in the task?

g) Have you implemented the task and if so, what did and did not work?

h) How (if at all) would you change the task?

i) What similarities and differences do you think exist among the three tasks?

Note: If the teacher chooses not to participate in the classroom observation portion of the study, the following questions would be added to Section 2 if not already addressed by the participant and if time permits:

a) What similarities and differences exist among the three tasks in terms of the ways students interact with global issues?

b) What similarities and differences exist among the three tasks in the ways that the mathematics supports the global issues?

c) What similarities and differences exist among the three tasks in the ways that the global issues support the mathematics?

3) Now that some time has passed, I would like to know if your thoughts and/or definitions have changed at all.

a) Can you tell me, in your own words, what global citizenship means to you?
b) Has your understanding of global citizenship education changed at all since our first interview and if so, in what ways? And why? (Discussion with others, reading on the subject, our conversation, etc.)

c) Can global citizenship be incorporated into every mathematics lesson? Why or why not and if no, then which particular topics in math can be used? Why, what does global citizenship add to the understanding of those math topics?

d) Does mathematics lend itself to discussing any global (or local or national) issue or only particular ones? Which ones and why?

e) What does mathematics provide in the development of global citizenship that other subjects might not?

Depending on the time left, the interviewer would skip any of the following questions as needed to ensure that the question in Section 6 is addressed.

4) I would like to ask you a few questions about the general process of including global issues in your lessons as well.
   a) Do you follow any systematic process to incorporate global (or local or national) issues into your mathematics lessons?
   b) Does the inclusion of global issues complement the mathematics objectives of a lesson? If so, in what ways?
   c) Is there any difference in the mathematics of lessons with and without global issues?
   d) How do you or how would you (if at all) assess the students in terms of global citizenship?
   e) How much more time (roughly) does it take to create lessons incorporating global issues and what is that time used for?

5) I also would like to ask you about your thoughts regarding the future of this area for you and in general.
   a) Do you have any future plans or ideas for using global issues in your classroom?
   b) In what ways can (mathematics and/or other) teachers be adequately prepared to include global issues in their classrooms?
   c) Do you envision a future role of global citizenship in mathematics education?

6) Is there anything else that you’d like to add or discuss that we haven’t talked about?
Appendix E

Sample Mathematics and Global Education Tasks

Each task and all information is displayed in the way it was submitted by each teacher.

**Teacher:** Mrs. Paige  
**Grade:** 4th  
**Standards:**  
**Mathematics**  
4.NF.7- Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols >, =, <, and justify the conclusions, e.g. by using a visual model.  
4.NBT.4- Fluently add and subtract multi-digit whole numbers using the standard algorithm.  
**Social Studies**  
Geo 4.3- Explain how culture influences the way people modify and adapt to their environments.  
Geo 4.4- Explain how the cultural and environmental characteristics of places change over time.  
Geo 4.5-Describe how environmental and cultural characteristics influence population distribution in specific places or regions.  
**Reading**  
RL.4.1- Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.  
W.4.1- Write an opinion piece on topics or texts, supporting a point of view with reasons and information.  
**Global Citizenship Education**  
Cognitive – Learners develop skills for critical thinking and analysis.  
Behavioral – Learners act effectively and responsibly at local, national, and global levels for a more peaceful and sustainable world.  
**Mathematical Practices**  
MP2 – Reason abstractly and quantitatively  
MP3 – Construct viable arguments and critique the reasoning of others  
MP8 – Look for and express regularity in repeated reasoning  
**Content Objective:**  
Students will be able to analyze CO₂ emissions data from three countries in order to draw conclusions about their energy usage.  
**Language Objective:**  
Students will be able to defend their conclusions by stating at least one piece of data.
**Background Knowledge:**
During past curriculum maps, students have worked with whole numbers and decimals. Students have fluently added and subtracted multi-digit whole numbers with the standard algorithm. Students have used place value knowledge to compare whole numbers and decimals to the hundredth place value. Students have limited practice using pie charts and bar graphs to interpret data but have covered the topic in 3rd grade. Students also have limited practice taking data and making mathematical models to represent the data. During reading, students are studying global warming and climate change and how it is currently affecting our environment. Students have also learned about different types of energy sources, both renewable and non-renewable, and their correlation with CO₂ emissions.

**Initiation:**
I will introduce objectives for the day and close read the words analyze, draw conclusions, and contrast.
We will review vocabulary and the concept of CO₂ entering our atmosphere through different energy sources.
To begin the lesson I will introduce the roles that the students will be playing. They will pretend that they are on the “International Committee for Climate Change” and will have to review CO₂ emissions for three different countries. I will explain that students will need to interpret the given data in order to draw conclusions and answer the discussion questions.

**Lesson Activity:**
1) I will model a scenario for the students by using an example of CO₂ emissions from Brazil and how I would analyze the data. I will not spend too much time modeling because this is more of a performance task where students need to use multiple skills to draw conclusions.
2) After I model, students will begin to look through the packet of data on the three countries and answer guiding questions. Some of these guiding questions will require them to compare decimals while also finding the difference in the data from one country to the next.
3) Throughout the lesson I will also plan for certain ‘turn and talk’ opportunities for students to think deeper about the material and the connections that they should be making. I will evaluate as the lesson is going to see when adding ‘turn and talks’ would be beneficial to clarify or add a thought.
4) Students will also have the opportunity to discuss their findings within their groups.

**Closure:**
At the end of the lesson I will allow for students to share out for some of their findings and conclusions. I will wrap up the lesson by finding similarities in their conclusions. We will also review our objectives.

**Assessment:**
Students will be able to construct a letter of suggestions.
Students will write a letter to one of the countries suggesting ways that they can improve their CO₂ emissions. They will need to include data that they analyzed as well as conclusions they drew regarding the data. They will also need to include their background knowledge about other energy sources in order to offer suggestions. A rubric will be provided.
Report on the United States of America

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<thead>
<tr>
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<tbody>
<tr>
<td>312,000,000</td>
<td>5490.63</td>
<td>17.62</td>
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</table>

The graph below shows the energy sources used by the United States.

United States Energy Consumption by Source

- Petroleum 36%
- Renewable 10%
- Nuclear 8%
- Coal 19%
- Natural Gas 27%

Data Source: US Energy Information Agency

Major U.S. industries: automotive, agriculture, and energy (natural gas)
Report on Indonesia

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<tr>
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<tbody>
<tr>
<td>238,000,000</td>
<td>426.79</td>
<td>1.73</td>
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</table>

The graph below shows the energy sources used by Indonesia.

Figure 1. Indonesia total primary energy consumption, 2013

Source: Indonesia’s Ministry of Energy and Mineral Resources

**Major industries:** energy (oil), clothes and shoes, tourism
Report on Sweden

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</thead>
<tbody>
<tr>
<td>9,400,000</td>
<td>5.47</td>
<td>4.35</td>
</tr>
</tbody>
</table>

The graph below shows the energy sources used by the Sweden. Use 2008 data.

Sweden's Sources of Electricity

- **2006**
  - 46.3% Nuclear
  - 43.6% Hydro
  - 9.4% Fossil Fuel
  - 0.7% Wind

- **2007**
  - 45.3% Hydro
  - 44.4% Nuclear
  - 9.3% Fossil Fuel
  - 1% Wind

- **2008**
  - 46.9% Hydro
  - 42% Nuclear
  - 9.7% Fossil Fuel
  - 1.4% Wind

*In addition there were net imports adding another 4.3% in 2006*

*In 2007 imports added 0.9% to production*

*In 2008, 1.4% of production was exported*

*Source: World Nuclear Association*

**Major industries:** motor vehicles, telecommunications
Analyzing Data

1) What is the difference in population from the most populous country to the second most populous? From the most to the least?

2) About how many times greater are the CO₂ emissions from the United States compared to Indonesia?

3) What are some conclusions you can make about Sweden’s CO₂ emissions compared to Indonesia and the United States?

4) What conclusion can you make about Indonesia using oil as their major energy source?

5) How much of the United States’ energy is dependent on non-renewable energy? What about Indonesia’s?

6) Why do you think the United States has increased its use of natural gas as an energy source?

7) About how many times greater is Sweden’s use of hydropower compared to Indonesia?

Your task!

Using your knowledge of energy sources, CO₂ emissions and the data from the countries above, write a letter to the United States or Indonesia to offer suggestions on how they can decrease their emissions. Remember to use Sweden as an example and provide data to back up your thoughts!
Teacher: Mr. Hammons
Grade: 3rd

Note: Mr. Hammons modified the following lesson from Junior Achievement Our Nation®. A description of his lesson can be found in Chapter 5 within the third research question.

Session Five
Global Connections

Overview
Students explore how our nation is connected to the global economy.

Objectives
Students will be able to:
- Explain why businesses specialize and trade.
- Define opportunity cost.

Concepts
- Competition
- Globally competitive
- Specialization
- Trade

Skills
- Communication
- Decision making
- Map reading
- Problem solving

Recommended Time
This session typically takes 45 minutes to complete. Ask the teacher to help you keep track of the time.

Materials
1. Junior Achievement Banner
2. Table Tents
3. JA Our Nation Student Fliers (e)
4. Key Term Flash Cards (26-28)
5. STEM Skills Poster
6. Mystery Puzzle Cards Sheets Set (a-f)
7. Certificates of Achievement
   - Pens or pencils (not included)
   - Small bag or container (not included)
   - Optional: highlighters

Global Connections Exercise: Have students open their fliers to the world map inside.

Ask students: “If you could visit anywhere in the world, where would you go? Pause as students answer. Then ask, “What would you buy to bring home?” If answers are slow in coming, you might suggest students could bring home electronics from China, spices or clothes from India, or chocolate from Belgium.

To help students better visualize global connections, read aloud the following statements. Have students find the countries you mention on their maps and draw a line (or shipping route) from the country to the United States.

Presenting Tip
If time allows, extend the activity by having students look for labels on their clothing that say, “Made in ____” and find those countries on the map as well.
Activity

Activity-at-a-Glance
Using the Mystery Puzzle Card Sheets, student groups assemble one of six products. The card sheets illustrate how nations specialize in certain resources and how this exchange results in a product.

Activity Steps:
1. Hold up the front of the six Mystery Puzzle Cards Sheets for students to see. Important! Show only the front of the cards.
2. Tell students that each sheet illustrates a single product that uses resources from six countries.

Presenting Tip
Check with the teacher. If he or she recommends it, emphasize the geography component of the session. Tell the students that the individual puzzle cards are color-coded to indicate continents:
- Green: North America
- Orange: South America
- Blue: Europe
- Yellow: Africa
- Red: Asia
- Purple: Australia and Oceania

Presenting Tip
Have the teacher help you determine the number of puzzle card sheets to use.
For a class of 24 students, use four card sheets; for a class of 30, use five card sheets. For 26 students, you will need to have one or two students pick two cards apiece.

3. Separate the Mystery Puzzle Cards Sheets and drop the cards into a bag or box. Students will pull out one card. (Or simply hand each student a card.) Tell students that on your cue they are to stand and walk around the room and search for other students who have a puzzle card that they think matches their own.
4. When ready, say, ready, set, go! Monitor the activity as students seek out classmates with a piece of their product.
5. Mystery solved! Once students discover their product, have them stay in their group and discuss the many resources and countries needed to produce that product. The mystery products are: chocolate bar, fruit basket, computer tablet, car, toaster, and backpack.
6. Have groups appoint a spokesperson. Have the spokesperson share with the class that group’s product and the resources and countries involved in making it.

Summary and Review
If time permits, review the concepts and key terms introduced in this session. Remind students that many products we buy use resources from around the world and different resources come from different countries. Sometimes, using resources from other countries can lower a business’s cost of making a product and its profits will rise. As a nation, we are all connected globally through the products we purchase and in the production of goods and services.
Teacher: Mr. Reynolds  
Grade: High School Algebra II  
Activism and Mathematics  
Algebra II  
Topic: The Dakota Access Pipeline  
Background:  
The Dakota Access pipeline is a new oil pipeline that would stretch 1172 miles from the rapidly expanding Bakken and Three Forks oil fields in North Dakota to Patoka, Illinois. Below is a map that shows the path the pipeline will take as it passes in between Bismarck, ND and the Standing Rock Sioux reservation.

Question:  
The pipeline is going to be built UNDER the Missouri River, just north of the reservation. The depth of the river is given by the function \( r(x) = 64.63x^2 - 69.16x \), where \( r \) is the depth of the river measured in feet and \( x \) is horizontal distance measured in miles. The depth of the pipeline on that stretch is given by \( p(x) = -46 \), where \( p \) is the depth of the pipeline measured in feet and \( x \) is horizontal distance measured in miles.  
   a.) What is the deepest that the river gets?  
   b.) What is the range of the river depth?  
   c.) What is the range of pipeline depth?  
   d.) How close does the pipeline get to the bottom of the river?  

Want to learn more?  
Research the ‘Dakota Access Pipeline’ and ‘Standing Rock Sioux’. It’s been in the news nearly every day. Here’s a good summary from The Guardian:  
https://www.theguardian.com/us-news/2016/nov/03/north-dakota-access-oil-pipeline-protests-explainer  
What can you do about it?  
There is a protest in [City redacted] on November 15th, but it’s during the school day, and you probably can’t drive to North Dakota right now. Visit https://nodaplsolidarity.org/ to see what you can do to help.
### Appendix F

**Classroom Observation Protocol**

**RTOP (Reformed Teaching Observation Protocol)**

**Background Information**

Name of teacher:
Location of class (district, school, room):
Years teaching:
Teaching certification (K-8 or 7-12):
Grade level and subject:
Date and time of observation:

(Rate 0-4 from “Never Occurred” to “Very Descriptive”)

**Lesson Design and Implementation**

1) The instructional strategies and activities respected students’ prior
   a) mathematical knowledge and the preconceptions inherent therein. 0 1 2 3 4
   b) knowledge of global issues and topics. 0 1 2 3 4

2) The lesson was designed to engage students as members of a
   a) learning community. 0 1 2 3 4
   b) global community. 0 1 2 3 4

3) In this lesson, student exploration preceded formal presentation
   a) in mathematics. 0 1 2 3 4
   b) when discussing local, national, and/or global issues. 0 1 2 3 4

4) This lesson encouraged students to seek and value alternative modes
   a) of investigation or of problem solving in mathematics. 0 1 2 3 4
   b) of investigation into local, national, and/or global issues. 0 1 2 3 4

5) The focus and direction of the lesson was often determined by ideas
   originating with students
   a) in mathematics. 0 1 2 3 4
   b) about local, national, and/or global issues. 0 1 2 3 4
<table>
<thead>
<tr>
<th>Content</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>6) The lesson involved fundamental concepts of</td>
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<tr>
<td>a) mathematics.</td>
<td>0</td>
<td>1</td>
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<tr>
<td>b) global citizenship education.</td>
<td>0</td>
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<tr>
<td>7) The lesson promoted strongly coherent conceptual understanding of</td>
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<tr>
<td>a) mathematics.</td>
<td>0</td>
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<tr>
<td>b) global citizenship education.</td>
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<td>8) The teacher had a solid grasp of the</td>
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<tr>
<td>a) mathematics content inherent in the lesson.</td>
<td>0</td>
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<tr>
<td>b) global citizenship content inherent in the lesson.</td>
<td>0</td>
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<tr>
<td>9) Elements of abstraction were encouraged when it was important</td>
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<tr>
<td>a) in mathematics (i.e. symbolic representations, theory building).</td>
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<td>1</td>
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<tr>
<td>b) in global citizenship education (i.e. social theories).</td>
<td>0</td>
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<tr>
<td>10) Connections with other content disciplines and/or real world</td>
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<tr>
<td>phenomena were explored and valued</td>
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<tr>
<td>a) in mathematics.</td>
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<tr>
<td>b) and related to local, national, and/or global issues.</td>
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<tr>
<td>11) Students used a variety of means (models, drawings, graphs, concrete</td>
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<tr>
<td>materials, manipulatives, etc.) to represent phenomena</td>
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<tr>
<td>a) in mathematics.</td>
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<tr>
<td>b) related to local, national, and/or global issues.</td>
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<tr>
<td>12) Students made predictions, estimations, and/or hypotheses and</td>
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<td>devised means for testing them</td>
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<tr>
<td>a) in mathematics.</td>
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</tr>
<tr>
<td>b) for local, national, and/or global issues.</td>
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<tr>
<td>13) Students were actively engaged in thought-provoking activity that</td>
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<td>often involved the critical assessment of</td>
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<tr>
<td>a) mathematical procedures.</td>
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<td>4</td>
</tr>
<tr>
<td>b) procedures related to local, national, and/or global issues.</td>
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<td>4</td>
</tr>
</tbody>
</table>
14) Students were reflective about their learning
   a) of mathematics.  0 1 2 3 4
   b) of local, national, and/or global issues.  0 1 2 3 4

15) Intellectual rigor, constructive criticism, and the challenging of ideas were valued
   a) in mathematics.  0 1 2 3 4
   b) when investigating local, national, and/or global issues.  0 1 2 3 4

**Classroom Culture**

16) Students were involved in the communication of their ideas to others using a variety of means and media
   a) when discussing mathematics.  0 1 2 3 4
   b) when discussing local, national, and/or global issues.  0 1 2 3 4

17) The teacher’s questions triggered divergent modes of thinking
   a) when asking about mathematics.  0 1 2 3 4
   b) when asking about local, national, and/or global issues.  0 1 2 3 4

18) There was a high proportion of student talk and a significant amount of it occurred between and among students
   a) when discussing mathematics.  0 1 2 3 4
   b) when discussing local, national, and/or global issues.  0 1 2 3 4

19) Student questions and comments often determined the focus and direction of classroom discourse
   a) when discussing mathematics.  0 1 2 3 4
   b) when discussing local, national, and/or global issues.  0 1 2 3 4

20) There was a climate of respect for what others had to say
   a) when discussing mathematics.  0 1 2 3 4
   b) when discussing local, national, and/or global issues.  0 1 2 3 4
## Observation of Classroom Behaviors

### Active Participation
**21) Active participation was encouraged and valued**
- when discussing mathematics.  
- when discussing local, national, and/or global issues.

### Encouraging Conjectures
**22) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence**
- when working on mathematical problems.  
- when investigating local, national, and/or global issues.

### Teacher Patience
**23) In general the teacher was patient with students**
- when discussing mathematics.  
- when discussing local, national, and/or global issues.

### Teacher as Resource Person
**24) The teacher acted as a resource person, working to support and enhance student investigations**
- in mathematics.  
- related to local, national, and/or global issues.

### Teacher as Listener
**25) The phrase "teacher as listener" was characteristic of this classroom**
- when discussing mathematics.  
- when discussing local, national, and/or global issues.
Appendix G

Mathematics Task Protocol

<table>
<thead>
<tr>
<th>Name of Task</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The task involves local issues.</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>2) The task involves national issues.</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>3) The task involves global issues.</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>

**Cognitive (Knowledge)**

| 4) Students learn about governance structures and systems, possibly including politics, history, and economics. | 0 1 2 3 |
| 5) Students learn about the rights and responsibilities of individuals and groups (such as women’s rights and corporate social responsibility). | 0 1 2 3 |
| 6) Interconnections among local, national, and global issues, structures and processes are illuminated. | 0 1 2 3 |
| 7) Students use critical inquiry skills (for example, where to find information and how to analyze and use evidence). | 0 1 2 3 |
| 8) Students learn about the dominance of the English language and how this influences non-English speakers’ access to information. | 0 1 2 3 |

**Socio-Emotional (Attitudes)**

| 9) Students learn about their identities and how they are situated (family, friends, school, local, and national) to understand global citizenship. | 0 1 2 3 |
| 10) Students learn about difference and diversity (for example - culture, language, gender, sexuality, and religion) to understand inequality and discrimination. | 0 1 2 3 |
| 11) Students learn about common factors that transcend difference and develop the ability to respect differences and how to live with others. | 0 1 2 3 |

**Behavioral (Action)**

| 12) Students explore their own beliefs and values as well as those of others and discover challenges for governance of contrasting and conflicting beliefs and values. | 0 1 2 3 |
| 13) Students learn about social justice and ethical issues in local, national, and global contexts. | 0 1 2 3 |
| 14) Students learn about and have the opportunity to develop attitudes of compassion and empathy for others and the environment. | 0 1 2 3 |
| 15) Students learn about opportunities to take individual and collective action at local, national, and global levels as well as examples of these actions taken by others. | 0 1 2 3 |
Use the following scale for the items above:
0 – Does not occur in the task
1 – Occurs once in the task
2 – Occurs more than once in the task, but is not a primary feature
3 – Occurs in the task and is a primary feature

<table>
<thead>
<tr>
<th>Mathematics CDL: (circle one below)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memorization</td>
</tr>
</tbody>
</table>

(Adapted from Stein et. al (2000, p. 16))

**Memorization**
Tasks that are classified as memorization tasks
- Involve either reproducing previously learned facts, rules, formulas, or definitions or committing facts, rules, formulas, or definitions to memory.
- Have no connection to the concepts or meaning that underlies the facts, rules, formulas, or definitions being learned or reproduced.

**Procedures without connections**
Tasks that are classified as procedures without connections tasks
- Are algorithmic. Use of the procedure is either specifically called for or is evident from prior instruction, experience, or placement of the task.
- Require limited cognitive demand for successful completion. Little ambiguity exists about what needs to be done or how to do it.

**Procedures with connections**
Tasks that are classified as procedures with connections tasks
- Focus students’ attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas.
- Suggest, explicitly or implicitly, pathways to follow that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts.

**Doing mathematics**
Tasks that are classified as doing mathematics tasks
- Require complex and nonalgorithmic thinking – a predictable, well-rehearsed approach or pathway is not explicitly suggested by the task, task instructions, or a worked-out example.
- Require students to explore and understand the nature of mathematical concepts, processes, or relationships.