2019 TIMSS Overview. The 2019 Trends in International Mathematics and Science Study (TIMSS) is the 7th cycle of assessment administered by the International Association for the Evaluation of Educational Achievement (IEA) and conducted in the United States by the National Center for Education Statistics (NCES). Fourth and eight graders from sixty-four countries participated and the U.S. participated since 1995. TIMSS is conducted every four years with the latest one scheduled for 2023. In 2019, *eTIMSS*, a computerized version of TIMSS was introduced and half of the participating countries took the computer version while the rest completed the paper version. Moving forward, eTIMSS will be promoted more but countries who can not fully transition online will be provided with paper versions of the tests.

TIMSS assesses students' knowledge, application, and reasoning skills in *mathematics*: fourth grade (number, measurement and geometry, data) and eighth grade (number, algebra, geometry, and data and probability) and *science*: fourth grade (life, physical, earth) and eight grade (biology, chemistry, physics, and earth science). A *stratified two-stage cluster sampling design* is employed to draw samples of students per grade level from each participating country. For 28 years, TIMSS mathematics and science data have been used by governments around the world in making evidence-based decisions to reform their mathematics and science education. US presidents and politicians over the years reference the latest trends from TIMSS and the Programme for International Students Assessment (PISA) data when they pitch policy reform agenda related to our K-20 STEM education. For the purpose of this digital humanities project, we are using the 2019 mathematics and science data for 4th and 8th graders.

Previous 1999 TIMSS Research Work: In 2002, I quantitatively analyzed data from 6601 Filipino 7th graders and published a research article investigating the relationship between language and mathematics achievement. I compared the mathematics achievement of students who took the English version and the Filipino version of the test. Results showed that students who took the English version test performed significantly better than those who took the Filipino version test in five content areas. It is important to note that Filipino students during this time period generally learned mathematics in English, which is their second or third language. I sought answers to the questions: *Do English and Filipino test takers significantly differ in overall mathematics achievement? Do they differ in achievement in specific mathematics content areas? Do students' self-concept of language and mathematics proficiency relate to their mathematics achievement?* I found that there was a statistically significant but weak relationship between students' self-concept of language and mathematics proficiency and their achievement. I stressed the importance of investigating the teaching and assessment practices in a bilingual classroom to identify language-related practices that contributed to students' mathematics achievement.

Current 2019 TIMSS Research Work: This year, I'm extending my previous work on the relationship between language and achievement to include science and data from both 4th and 8th graders. This time, I want to focus on the top ten (i.e., Singapore, Chinese Taipei, South Korea, Japan, Hong Kong, Russia, Northern Ireland, England, Ireland, Latvia) and bottom ten (i.e., Iran, Chile, Oman, Saudi Arabia, Morocco, Kuwait, South Africa, Pakistan, and Philippines) performing countries. Any country in the list which only administers one language for testing will be eliminated and be replaced by the next country in the ranking order. It is interesting to know if there is a pattern emerging among top and low performing countries consistent or not with my previous research finding. *Do students' whose first language is the language of the test perform better than those who are not? How does language of instruction relate to students' achievement? What are socio-cultural and environmental factors affecting the teaching and learning of mathematics and science in these countries?*

The first part of the research is quantitative in nature and driven by statistical analysis of the 2019 TIMSS dataset. This part will be the focus of my summer work. The second part is mixed-methods in nature and will focus on the socio-cultural and environmental aspects of teaching and learning of mathematics and science in these selected countries. This second part will be the focus of your summer group project. It is important for you to know the home, school, and classroom contexts of these countries to understand how they affect language skills, learning, and teaching of mathematics and science. This part of the research is where you can integrate digital humanities tools and methodologies to answer some relevant questions.

Research Questions to Explore (Mixed Methods). TIMSS include complete questionnaires related to students' home, school, classroom contexts and a subset of their science questions that focus on students' environmental awareness. To answer the question of socio-cultural and environmental factors affecting the teaching and learning of mathematics and science, you can start exploring data from context questionnaires including highlights from these varied contexts. Some relevant follow up research questions to explore are grouped in the following categories.

Home and School Contexts: What learning resources students have at home? What are forms of early childhood learning (literacy and numeracy) in each country? What accommodations are provided to students who sometimes or never speak the language of the test at home? How are mathematics taught in their native languages? How are strategies different if taught in English? How different are mathematics and science taught in affluent and disadvantaged schools? What is the scope of parents' involvement in school and how does their involvement affect students' achievement? What are bullying experiences students encounter in these countries? How do these bullying experiences affect their achievement? What are the characteristics of safe and orderly schools in these countries?

Classroom Contexts: How is mathematics or science taught in these countries? How is problem-solving or science investigation taught? How do schools and communities provide students access to technology? How do these countries address the issues on digital divide? How do teachers integrate technology into instruction? How is technology used to teach mathematics and science content? What are ways teachers engage students' critical thinking skills? How do schools and communities address issues with absenteeism, hunger among school children, and at risk students? What school and social factors contribute to teachers' job satisfaction? How do students value mathematics and science and do they relate school achievement to future success in life?

Environmental Awareness: How environmentally aware are the 4th and 8th graders from these countries? How does environmental awareness differ by gender and socioeconomic status? How is the level of students' environmental awareness achievement related to the prevalence of environmental issues in these countries? How do environmental problems affect students' cognitive achievement?

Digital Humanities and Research Questions. Through your 5-week DH summer camp and workshops with Prof. Abby Mann and other guests, you will learn about digital humanities and the different tools and methodologies (e.g., data scraping, text analysis, data visualization, maps and timelines, visual storytelling, GIS) that can be used to answer some of the research questions listed above. As you learn and explore these tools and methodologies, continue to brainstorm and explore specific research questions that would be appropriate to answer given a specific tool or methodology. I listed some ideas here to get you started thinking about possible group projects. Your final group project is your choice as a group. It could be a combination of ideas shared here or other ideas that emerge from your workshops that are still related to the educational topics covered here.

Data for You to Explore: This is a subset of the 2019 TIMSS data focusing on top 5 performing and bottom 5 performing countries (10 countries only to reduce file size). Math and science data are included in each grade level. You can use data from (1) summary results/highlights and (2) curriculum questionnaire to explore and familiarize yourself with the mathematics and science achievement data. Other contexts data from TIMSS 2019 results are summarized online: home and school, classroom, and environmental awareness. Take note that these questionnaire data are measured based on a 3-scale scoring to summarize results quantitatively. Any related data tied to digital humanities tools that you choose to use can be used as well. It is expected that you will do additional research to find relevant qualitative or quantitative data pertaining to these suggested topics. Find reputable and up to date data and sources.

Textual Analysis: Find out how problem-solving tasks or science investigations are embedded in textbooks. For example, compare through textual analysis by topic South Africa's Siyavula Open Textbooks with any available online mathematics or science textbooks from top performing countries. *Problem-solving* or *strategic competence* refers to students' "ability to formulate, represent, and solve mathematical problems" (National Research Council, 2001, p. 116). It's important to know how etextbooks provision may provide access to free or affordable curriculum but countries like South Africa continue to face challenges that need immediate attention (Dlodlo & Foko, n, d).

Timelines (With Audio and/or Video):

- Show historical timeline of girls participation in education across different countries. Highlight milestones. Examine trends and patterns across time, cultures, and geography. Combine multimedia and statistical data for emphasis.
- Construct an interactive virtual tour of schools in participating countries (top and lowest performing). Focus on socio-cultural and environmental differences of students' learning spaces. See if you can embed videos of students talking about their learning experiences.
- Create a timeline of major educational policy across the world and relate that to the timeline of achievements in mathematics and science. This will require longitudinal data from at most three countries and covers the past 7 TIMSS results for those countries. Challenge yourself if you can include video data showcasing policy highlights and accomplishments.

Spatial Visualizations: Create a digital story of school lunch provided by public schools in the top ten and bottom ten performing schools. Provide a nutritional breakdown of each lunch menu. Explore any relationships with school attendance/drop out, behavior issues, and graduation rates.

Network Analysis: Create a collection of online posts or updates associated with lived experiences of public school teachers across the world. Analyze any patterns based on geography, job satisfaction, and students' achievement level.

GIS:

- Show relationship between environmental problems (e.g., air and water pollution, ozone layer depletion, deforestation, biodiversity loss, land degradation, desertification, nuclear power/waste, urban sprawl) and students' cognitive achievement.
- Demonstrate patterns of migration due to environmental changes (i.e., sea level rise, tornado or hurricane frequency and intensity, forest fires, ocean acidification, temperature rise, etc). Relate these patterns to students' achievement data in mathematics and science.
- Explore relationship between food wastes and recycling efforts of each participating country and cases of hunger and malnutrition among school children.
- Compare data on lack of access to clean drinking water due to scarcity. long term drought, or depleting watersheds, landfill contamination, lead poisoning, and sanitation problems that cause health issues with data on school children's academic achievement and schooling completion.
- Map participating countries with historic public health epidemics and pandemics (e.g., flu, COVID, AIDS, polio, swine flu, zika, ebola). Relate data in terms of children and schooling.

- Construct a neighborhood map of some of low performing countries, locating schools, communities with varying soci-economic status, and green spaces. Add population and demographic information to showcase current problems involving environmental justice and equity (e.g., redlining, deteriorating housing and infrastructure, industrial pollution, concentrated poverty and unemployment).
- Create a web map of how the level of students' environmental awareness achievement relates to environmental issues prevalent in these countries.
- Show relationship between literacy rates and graduation rates of children in conflict stricken countries due to gun/school violence, religious intolerance, racism, ethnic wars, etc.
- Model human migration pattern due to refugee crises around the world. Relate that with students' graduation rate or achievement level.
- Using multiple data layers, create an interactive map of locations of public learning spaces (e.g., library, museum, park/zoo, theater, community garden, free wifi hub or computer cafe, cooperatives, community-based organizations, health/community centers) that provide services to students and their families. Focus on participating countries that are low performing. Reference major public and private schools in those areas to geographically see how accessible or inaccessible these learning spaces are to students.

Your Group Task. During the 2nd week of the summer camp, you will start brainstorming about your group project. Send me clarification questions about this position paper or ideas about your group project at **lnillas@iwu.edu**. I'll be able to respond by the end of the day after attending mathematics education conference events throughout that week. Our goal is for you to learn and apply skills in digital humanities methodologies and create a project that demonstrates the skills that you learned. With your experience going through the DH camp this summer, I will also invite you this fall to present your final work to my IS 373/Educ 373 (Education and International Development) students and discuss with them the analysis of the data and the model you created. These students will also create digital humanities projects during the fall semester. Your final group work will be a model for them to see how digital humanities tools and methodologies can be applied for research.

I hope you enjoy this exciting summer experience. I'm looking forward to working with you this summer.

Engage and Collaborate!

Leah Nillas, Associate Professor (Mathematics Education)