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**RESEARCH ARTICLE**

# Technology as an equity lever: Applying the EqT-tech framework to center equitable integration of technology in the math classroom

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## Abstract

In this paper, we describe a framework developed by synthesizing and combining scholarship from the fields of equity in mathematics education and effective integration of technology in the classroom. This framework allows researchers, educators, and teachers to examine the potential of technology-enhanced mathematics lessons to advance equity along six identified dimensions. We share a case study of a research lesson that applied this framework and implemented technology as an equity lever by allowing students to explore social justice issues using a suite of technology tools. Implications for mathematics teacher educators and researchers are discussed as ways the framework can be used to promote the equitable integration of technology.

**Keywords:** equity, technology, positioning, social justice, technology-enhanced mathematics tasks

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# I. INTRODUCTION

As technology becomes ubiquitous to our everyday life, the complexity of digital equity is of importance for educators. Digital equity is not only having access to digital devices and the internet (Reich, 2019) but includes the need for professional development for pre-service and in-service teachers on effectively integrating technology to expand educational opportunities for all students (AMTE, 2022). Wiburg (2003) shared four essential components related to educational equity in terms of technology. Students need (a) access to up-to-date hardware, software, and connectivity; (b) access to meaningful (digital) content; (c) access to educators who know how to use digital tools and resources; (d) access to systems sustained by leaders with vision. These components still feel relevant and unresolved in our educational community after two decades. Educators still question how to ensure technology-rich learning experiences are not restricted to the most privileged students (Reich, 2019). Attewell (2001) coined the phrase, “usage divide,” stating

> Even when access gaps are closed, white and affluent students are more likely to use technology for creativity and problem-solving with greater levels of mentorship from adults, while students from minority groups and low-income neighborhoods use technology more commonly for routine drills with lower levels of adult support (Reich, 2019, p. 31).

To disrupt this usage divide in mathematics, we must consider using technology for inquiry and discovery of mathematics (NCTM, 2023).

Gutiérrez’s (2009) dominant and critical axes of equity, highlight the need to evaluate the role technology has on the dominant axis in promoting and increasing the mathematics achievement and participation of each and every student. Additionally, the role technology has on the critical axis in promoting identity and power. This critical axis of equity suggests educators should consider ways technology might support students in analyzing and critiquing knowledge, issues, and events in our world. These efforts towards digital equity require educators to learn more deeply about equitable teaching practices and how they can apply to technology integration (AMTE, 2022; NCTM, 2020).

Two recent position statements highlight the importance of considering how equity should be the center of technology integration. AMTE’s (2022) statement, Position of the Association of Mathematics Teacher Educators on Technology, states that mathematics teacher educators must support their students in purposefully evaluating and selecting technology that advances equitable practice. NCTM’s (2023) Equitable Integration of Technology for Mathematics Learning, focuses on ways mathematics teachers in the classroom can use technology strategically to ensure equitable access and opportunities for all students.

This paper illuminates the foundational and current literature around the equitable integration of technology in mathematics and how the scholarship led to the creation of a lesson analysis tool. Additionally, we will highlight a lesson that integrates all six dimensions of the lesson analysis tool, along with the teacher’s reflections on her purposeful use of technology and how the tools provided students with the ability to generalize and make sense of data and provide insight on social justice issues.

## II. RELATED LITERATURE

Technology tools have the potential to amplify mathematics and provide space for students to dive deeply into, explore, and generate conjectures about mathematics content (NCTM, 2023). This study focuses on the Equity-centered Transformative Technology Lesson Analysis Tool (Suh et al., 2022; Suh & Roscioli, 2023a; EqT-tech LAT), which integrates research across mathematics, equity, and technology into a lesson analysis tool for educators. Many frameworks currently exist to evaluate technology tools (Kolb, 2020), but tools specific to mathematics that also consider equity-centered practices are limited (McCulloch et al., 2021). NCTM's (2020) key recommendations for catalyzing change in mathematics include implementing equitable instruction, which requires educators to build strong mathematicians with strong mathematical identities and has the potential to be fostered through equity-centered technology. The research-based dimensions curated in the Equity-centered Transformative Technology Lesson Analysis Tool (EqT-tech LAT) support educators in evaluating the technology they plan to integrate into their classrooms (Suh et al., 2022; Suh & Roscioli, 2023a). The following sections outline the development of the EqT-tech LAT and the research used to develop the six dimensions within and across the areas of equity, mathematics, and technology.

### Technology as an Equity Lever: Development of the EqT-tech Framework

After working with pre-service teachers in a mathematics methods course on a technology integration assignment during virtual learning, it was made clear that they needed additional support in analyzing and evaluating technologies that support effective and equitable mathematics teaching practices. Our work focused on the need to design a technology analysis tool that focused on equity, forefronting how technology transforms our instruction as we center equitable mathematics in our methods course. We examined widely used equity frameworks in mathematics education, which build on one another and share several common fundamental tenets that support equitable teaching practices (Aguirre et al., 2013; Gutiérrez, 2009). Ultimately, we used Aguirre et al. (2013) framework with attention to equity to go deep with the mathematics, affirming student identity by leveraging multiple competencies and knowledge bases to elevate diverse students.

In developing our analysis tool, we leaned on the term 'transformative' from Jemal's (2017) work on "transformative potential," which is defined as levels of consciousness and action that produce the potential to transform contextual factors and relationships perpetuating inequitable conditions and that are necessary for change.

We see technology being a lever for equity. With that in mind, as we designed this framework, we examined the affordances of technology and the potential it has to transform contextual factors and relationships in the classroom that might perpetuate inequitable conditions. Next, we considered the potential technology has to bring necessary changes for a more equity-centered classroom including ways technology provides insight into social issues for students to think critically using mathematics and technology. To focus on this transformative potential, we developed the first five dimensions (Suh et al., 2022; Suh

& Roscioli, 2023a) focused on the equity-centered classroom, then later added the sixth dimension (www.eqttech.org) that focused on the role technology plays in providing insights into issues of social justice.

When developing the framework, we conducted a research synthesis to find the intersection of equity, mathematics education, and technology. We included recent technology-based research and practitioner articles to ensure that we were up to date not only on the emerging technology but also on how teachers as practitioners used them in mathematics classrooms.

The EqT-tech LAT considered research from within and across the areas of equity, mathematics, and technology to identify important qualities of transformational technology use specific to mathematics that epitomize equity-centered practices. This section highlights research across and within these fields to explore the purpose of each key dimension featured in the EqT-tech LAT.

The first dimension highlighted in the EqT-tech LAT focuses on providing access to inquiry-based learning. As part of equitable instruction, students should be able to craft their understanding through exploration, inquiry and problem solving (NCTM, 2020). One of NCTM's (2014) effective mathematics teaching practices highlights the importance of educators implementing tasks that promote reasoning and problem-solving. Additionally, Aguirre et al. (2013) share that one equity-centered teaching practice in mathematics includes providing space for students to dive deeply into mathematics content. McCulloch and Lovett (2023) describe how technology has the capability to be used in ways that position students as explorers with technology enhanced mathematics tasks that "foster their curiosity and provide ways for them to interact with and act on mathematical objects to test their ideas" (p. 7). According to McCulloch and Lovett (2023), the centerpiece of well-designed technologically-enhanced tasks that can transform learning is offering student-centered learning experiences that allow for exploration, discovery, collaboration, and discourse. Some of the digital tools with differing potential include dynamic and graphical tools that amplify mathematics by supporting students' reasoning and problem-solving, as well as conveyance tools that facilitate communication, assessment, presentation, and collaboration (Dick & Hollebrands, 2011). Pulling together literature from across these areas shows the importance of inquiry learning in the fields of equity, technology and mathematics education, which is why it serves as the first dimension of the tool.

The second dimension highlighted in the EqT-tech LAT focuses on students having opportunities to develop their mathematical identities through authorship and agency. Mathematics education research highlights the importance of developing identities and how one way to promote this is by providing opportunities for authorship and agency promotes (Aguirre et al., 2013; Berry, 2003; Kobett & Karp, 2020; Martin, 2009; Schoenfeld & the Teaching for Robust Understanding Project, 2016). Research on positioning theory focuses on promoting equitable structures and assigning competence of individual contributions to affirm mathematical identity (Cohen & Lotan, 2014; Featherstone et al., 2011; Horn, 2012; Jilk, 2016; Wager, 2014). Wills (2021) detailed how conveyance technology has afforded opportunities for authorship and agency using Google

Slides, where each and every student can have a voice. Technology evaluation frameworks called PICRAT where PIC stands for (passive, interactive, creative) referring to the student's relationship to a technology in a particular educational scenario and RAT stands for (replacement, amplification, transformation) describing the impact of the technology on a teacher's previous practice. (PICRAT; Kimmons et al., 2020) promote the benefit of technology to provide opportunities for students to author ideas through various platforms (Borthwick et al., 2020). Technology-supported mathematics lessons have the potential to affect not only their achievement but also their identity and self-efficacy which is centered in this dimension (Freeman, 2012).

The third dimension highlighted in the EqT-tech LAT emphasized the importance of collecting formative assessment data throughout a lesson to provide differentiation. Formative assessment has been shown to impact student achievement by providing educators with knowledge about what their students know and understand (Black et al., 2004). There are many ways to collect formative assessment data to know and understand student thinking beyond traditional paper-pencil activities (Fennell et al., 2017). One way to dive deeply into student thinking is through conferring (Munson, 2018). By constantly evaluating where students are and where they should go next, educators are valuing students' knowledge and providing the opportunity to have rigorous instruction that meets their needs and draws on their funds of knowledge (Aguirre et al., 2013; Seda & Brown, 2021). Effective teaching and learning cycle involves providing immediate feedback and differentiated learning activities (Hackenberg et al., 2020). More recently, technology using teacher dashboards and/or ease of scanning student work has facilitated in providing in the moment scaffolds for students (Knoop-van Campen & Molenaar, 2020). Many technology tools have the ability to monitor students' answers, and personalized learning systems automatically differentiate tasks based on student responses (Shirley & Irving, 2015). Technology tools can amplify the formative assessment process as students can use multiple modalities to explain their thinking, including orally, by drawing, using virtual manipulatives, and taking a picture of a physical manipulative (Wills et al., 2021). Providing space for students to think about what they have learned, show it in a way that makes sense to them, and receive feedback from an educator allows both students and educators to see where students are and where they need to go next while considering each specific child's needs which make this an essential element of the LAT.

The fourth dimension highlights how technology-enhanced mathematical tasks can empower students through collective thinking. Student achievement increases when they are able to work together on group-worthy tasks (Cohen & Lotan, 1995, 2014), sharing ideas and collaborating through problem-solving (Liljedahl et al., 2021). Providing opportunities for students to work together through difficulties provides the space for students to lean on multiple resources of knowledge and leverage multiple mathematical competencies (Aguirre et al., 2013). Conveyance technology tools can support collaboration, communication, and connection through social interaction and distribution of authority by honoring all student ideas, which can disrupt status and inequities in the classroom (Aguirre et al., 2013; Cohen & Lotan, 1995, 2014; Gresalfi et al., 2009). Cavey et al. (2022) reported on the potential of online tools to support mathematical modeling and community building. Specifically, they highlighted that tools that integrate mathematical objects and free-hand drawings allow students to share ideas and work collaboratively. Similar to Wills (2021), Cavey et al. (2022) used online learning platforms Desmos and Google Slides strategically to "amplify student voice by simply giving students several days to ponder a challenging problem, post their ideas and questions, and consider the ideas of their peers before engaging in a real time conversation" (p. 15). Students working collaboratively, even while using technology, is essential in fostering a mathematics community where students have a high sense of self-efficacy and all voices are honored.

The fifth dimension highlights the features of technology tools that amplify mathematical and cognitive processes. The importance of rigor present in the content and going deep with the mathematics is part of many equity frameworks (Aguirre et al., 2013; Schoenfeld & the Teaching for Robust Understanding Project, 2016) and technology-mediated features can amplify the mathematics process with fidelity (Zbiek et al., 2007). Students should be presented with mathematical tasks that allow them the opportunity to generalize, problem-solve, and make connections (NCTM, 2014). Using mathematical tasks that amplify mathematics provides space for students to explore and dive deeply into the mathematics (Aguirre et al., 2013). Educational technology tools have the potential to give students the outlet to play and explore concepts that generate their own ideas and theories about why things work (Fingal, 2018). Technology in mathematics can allow students to manipulate and iterate in ways that are tedious to do on paper and amplify the content (Zbiek et al., 2007). More specifically, technology in mathematics can be viewed as either a mathematics action technology (MAT) or a conveyance technology. MATs have the potential to provide opportunities for inquiry as students generalize mathematics topics (Dick & Hollebrands, 2011). Through the use of MATs, students can dive deeply and develop conjectures about mathematics (Cullen et al., 2020). Together, the research suggests the importance of students in having access to technology tools that provide them with the opportunity to explore through MATs as they use the tools to go beyond what can be done with paper-and-pencil.

The sixth dimension was added more recently to highlight how technology can be used to support students in developing insights into social justice issues (www.eqttech.org). Technology tools can provide insights into inequities and social justice issues (Rubel & Nicol, 2020). Witt (2022) explored the implementation of the technology-based critical literacy lesson with prospective elementary and secondary mathematics teachers. Social justice mathematics lessons allow students to see and write their world using mathematics (Gutstein & Peterson, 2013). Students need to experience mathematics in ways that can position them to identify inequities and take action to improve their world (Zavala & Aguirre, 2023). Technology tools have the ability to organize and represent data quickly and in ways that support students in understanding what a large amount of data can tell them (Byun et al., 2023). In mathematics, computer-based spreadsheet tools allow students to manipulate data into multiple representations and use the data to take action on social justice issues (Suh et al., 2023b). Integrating technology into social justice lessons allows students to gather data effectively, and efficiently so they can focus on how to find patterns and use mathematics to highlight the social justice issue at hand and identify points of action.

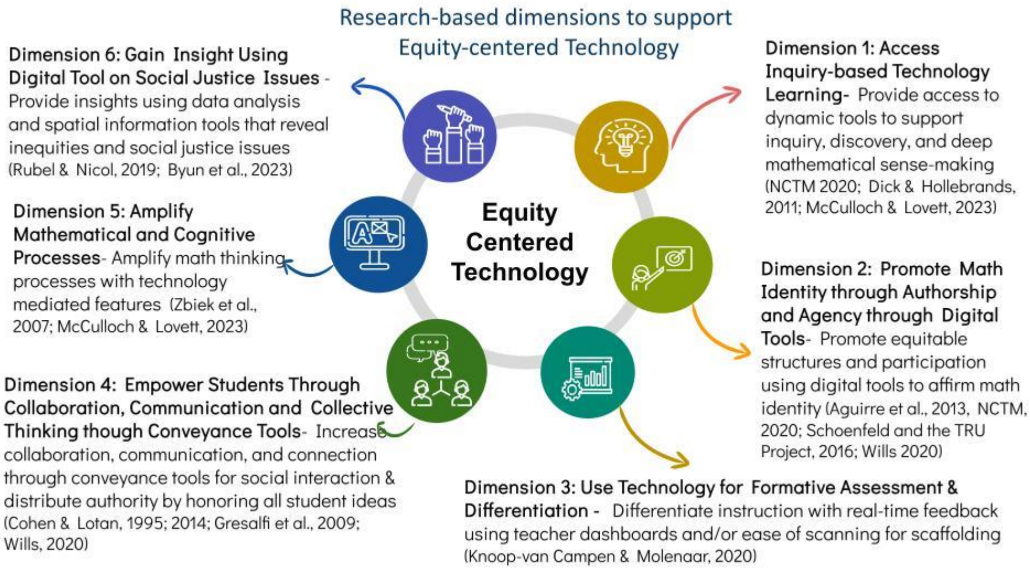


**Figure 1.** EqT-tech LAT framework (eqttech.org)

## Supporting Teachers use Technology with Equity at the Forefront

A central part of our framework is identifying the affordances of *technology that serves as an equity lever*. However, we acknowledge that the tool itself cannot advance without *attending to equitable instruction and the pedagogical moves*. In other words, these technology tools with transformative potential must work in tandem with equitable teaching practices. To ensure equity is centered in every aspect of teaching mathematics with technology, we need to preface each of these important components outlined in McCulloch et al.'s Framework (2021, See Figure 2) details how to prepare teachers to teach math with technology with equity at the forefront. In terms of *how students learn with technology*, McCulloch et al. (2021) places importance on considering virtual cultural theory, that technology "[has] innovative ways of sharing new forms of mathematical experiences, mathematical representations, and mathematical understanding" and describe the role of technology as an amplifier/reorganizer. This knowledge of how students learn mathematics with technology can inform the design of students' opportunities to learn through the use of technology. When we forefront this with equity in mind, we must recognize that not all students have opportunities to have these rich experiences as described by the usage divide.

In terms of the *design and evaluation of mathematics technology tools and tasks*, McCulloch et al., (2021) describe design principles for Pre-Constructed Dynamic Geometry Sketches where teachers must attend to questions to prompt students thinking that invites exploration and experimentation with the technology tool. When we forefront this with equity in mind, we must design and select activities that have multiple pathways for success and that require reasoning, problem-solving, and modeling, thus enhancing each student's mathematical identity and sense of agency (NCTM, 2020).

In terms of *how teachers use technology to teach mathematics,* McCulloch et al., (2021) describe many frameworks at play, but one that can help advance equity is the didactic tetrahedron (Hollebrands, 2017) which considers the ways in which the use of technology mediates the interactions among the teacher, students, and mathematics task. In this framework, Hollenbrand (2017) describes the pedagogical activities related to 1) the selection and implementation of mathematical tasks, 2) questions teachers pose to push student thinking or probe their understandings, 3) strategies teachers use to facilitate mathematical discussions, and 4) methods teachers use to assess what students are thinking and learning. When we forefront equity this with equity in mind, we can appreciate the unique affordances of technology that provide ease of differentiation, and assessment so that we might highlight the interaction among peers and highlight and "elicit students' ideas and strategies and create space for students to interact with peers to value multiple contributions and diminish hierarchical status among students (i.e., perceptions of differences in smartness and ability to participate" (NCTM, 2020, p. 59).

Finally, in terms of *how teachers learn to use technology to teach mathematics*, McCulloch et al., (2021) describe the specialized knowledge that teachers need for teaching mathematics with technology, Technological Pedagogical, and Content Knowledge (TPACK; Koehler & Mishra, 2009). Using the EqT-tech LAT, we aim at focusing this specialized knowledge that teachers need for teaching mathematics with technology.

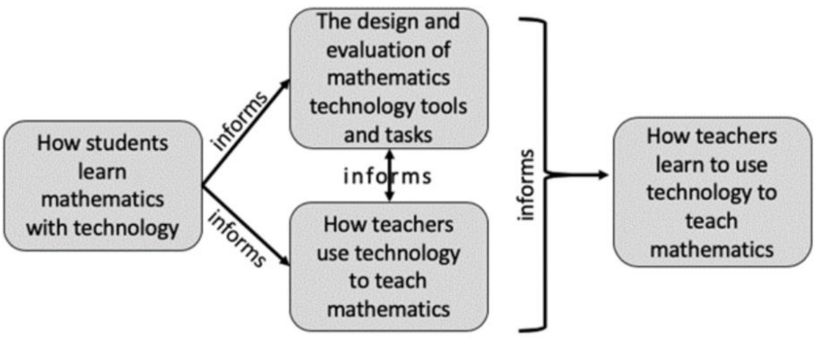


**Figure 2.** Preparing teachers to teach mathematics with technology (McCulloch et al., 2021)

To support teachers' equitable integration of technologies, we share a case study to examine how technology can serve as a lever to bring equity to the forefront when intentionally designed and implemented. We focused on two research questions:

1) How does integrating technology into justice-oriented modeling tasks support students' understanding of mathematics and reveal inequities in our community?
2) How does the EqT-tech LAT support teacher's reflection around the transformative potential of equitable integration of technology?

## III. METHOD

### Data Collection

We chose a case study approach with interviews, video recordings, and student work samples, to provide a detailed and nuanced understanding of the teaching and learning using specific technologies that have transformative potential for equity in the math classroom. We showcase this lesson to see how all six dimensions were highlighted in the planning and enactment process.

Data for this study include video-recorded classroom observations, audio-recorded semi-structured interviews before and after observed lessons, student work, and analytic memos from planning meetings. During our final debrief, we used the EqT-tech LAT to support teacher reflection on how the technology used in the lesson afforded opportunities for equity-centered practices.

The collected data were entered into Atlas.Ti and underwent a rigorous analysis process. Using the six dimensions as *a priori* codes, we analyze the teachers' lesson enactment, artifacts and reflection from the technology-focused math lesson and evaluation of the digital tool using the EqT-tech LAT. We used qualitative data analysis methods, including thematic coding and content analysis, to identify recurring patterns, themes, and key findings.

### Participants and Context

This study took place in Ms. M's advanced 6th-grade mathematics class. The school has a diverse ethnic population of culturally and linguistically diverse students: Latinx (71 percent), Asian (11 percent), White (14 percent), and Black (2 percent), with 2 percent of the families identifying themselves as "other". Seventy-two percent of the elementary school students identify as economically disadvantaged.

This case study was part of a larger collaborative project across four institutions and four districts in four very different regions of the US (mid-Atlantic, Pacific Northwest, Southwest, and Mountain regions) that focused on teaching through mathematical modeling in the elementary grades. The project engaged teachers in designing mathematics modeling tasks and using Culturally Responsive Mathematics Teaching (CRMT, Zavala & Aguirre, 2023) to advance equity. The CRMT framework for culturally responsive mathematics teaching consisted of three main strands: *Knowledges and Identities*; *Rigor and Support*; and *Power and Participation*. The modules and lessons drew out the *Knowledges and Identities* strand by elevating student cultural and community knowledge and experiences, affirms positive mathematical identities, and honoring student thinking and ideas (Aguirre et al., 2013; Carpenter et al, 2014; Civil, 2007). CBMM task presented opportunities for the *Rigor and Support* strand by focusing on students engaging with high cognitive demand mathematics tasks (Smith & Stein, 1998), scaffolding instruction and supporting multilingual learners (Chval et al., 2021). Finally, the CBMM tasks emphasized the *Power and Participation* strand by engaging critical consciousness through mathematical analysis and taking action (Featherstone et al, 201l; Gutstein, 2006).

As we led the PD and lesson planning process, we first brainstormed tasks that students could relate to in their community that connected to issues of fairness, access and representation; then in our planning phase, we prepared data folder with background information and data on social justice topics and connected relevant mathematics concepts to make the lesson appropriate for the grade levels; finally, we supported teachers enact Culturally Responsive Math Teaching practices focused on taking action in the community during the teach phase, and supported them in reflecting on collective work.

## IV. FINDINGS

### Connecting the Data Cycle and Technology to Implement a Community-Based Mathematics Modeling Task

In planning this task, Ms. M discussed that her motivation for this topic was seeing how a lack of access or exposure to some sports could limit her students' options for playing sports in high school. She shared how the region where they live is competitive with sports, with many young children starting "travel" sports in elementary grades. She wanted to see how the students in her community might expand their opportunities if exposed to a variety of sports at a younger age. With this motivation in mind, the team planned on taking students through the data cycle where they would formulate questions, collect or acquire data, organize and represent data, analyze data, communicate results, and take action. The data cycle moves through four phases: a) formulating questions that can be answered with data, b) collecting and acquiring data, c) organizing and representing data, and d) analyzing and communicating results. The lesson featured in this case used technology tools to enhance the data cycle as students explored resources, collected, organized, represented, and shared their data on a topic focused on a community-based mathematics modeling context. This section highlights the case through the phases of the data cycle.

### Exploring Data and Formulating Questions

To launch the lesson, Ms. M. 's class read an article entitled *Kids Aren't Playing Enough Sports. The Culprit? Cost* (Cohen, 2019). The report highlights the socio-demographic data illustrating the racial and economic disparity. More specifically, that parents of families spent $30-40 billion on their children's sports activities, a number that differs by race as white families spend more on sports for their children than black families. In addition to cost, transportation to practice and access to fields and sports facilities were mentioned as barriers.

To further explore the issue of access to fields, Ms. M. used Google Maps, a Geographic Information System (GIS) tool to highlight two areas the students would be familiar with (see Figure 3) and ask them to notice and wonder about the differences between the two areas. Google Maps allows Ms. M. to search for the school area and identify sports fields easily. Ms. M. 's goal for this activity was to have students analyze access to fields and sports facilities in different communities and how that might impact opportunities to play sports.

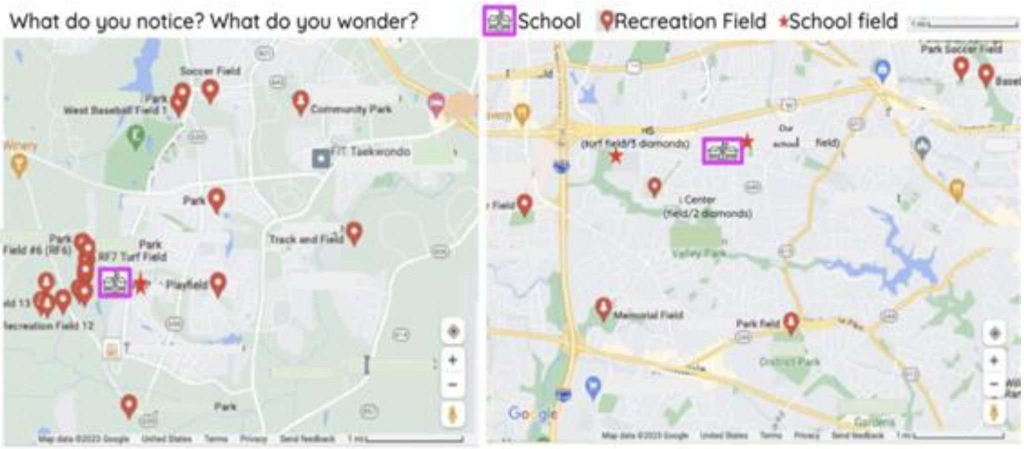


**Figure 3.** Using spatial representation to analyze issues of inequities by local facilities

Students noticed that the right side was their school community and had red markers that represented sports facilities and fields, most of which were not within walking distance. The other community had more green space and sports facilities less than a mile away. One student said, “I see major highways on our map, so it would be too dangerous even if we wanted to walk to the fields.” This helped them understand how transportation and access to green space are some underlying systemic issues to this problem. The discussions came up about how some areas have planned communities with amenities like golf courses, pools, and multiple parks that are well maintained and other areas have less available areas or may have major barriers to access due to highways and distances.

Through exploring the article and the maps, students started to wonder what they could do to address the issue of the lack of access to sports fields in their neighborhood. Some of the ideas that they brainstormed were getting second hand equipment from sports centers and physical education programs, getting siblings who play the sport to come as guests to share about the sport and demonstrate, and offering a Sports Clinic after school.

### Collecting Data using Technology Tools

After determining that the students wanted to hold a sports clinic to provide exposure to different sports for the students in their school, the class decided to create a survey to determine what sports they should offer. Since the students are familiar with the Google Suite, they determined they would create the poll using Google Forms and disseminate it to students in grades three through six. To answer their questions about what sports to include and the primary barriers to playing sports, they created three questions. 1) What sports do you play right now? 2) What sports do you want to play in high school? and, 3) What are the reasons you are not playing a sport? Students felt that knowing this data would help them display and interpret their findings to make decisions about what sports they wanted to offer in the after-school Sports Clinic. Google Forms allowed for easy dissemination to the students in their school and allowed students to convert results into a Google Sheet, which provided ease to organize and represent the data in the next step of the data cycle.

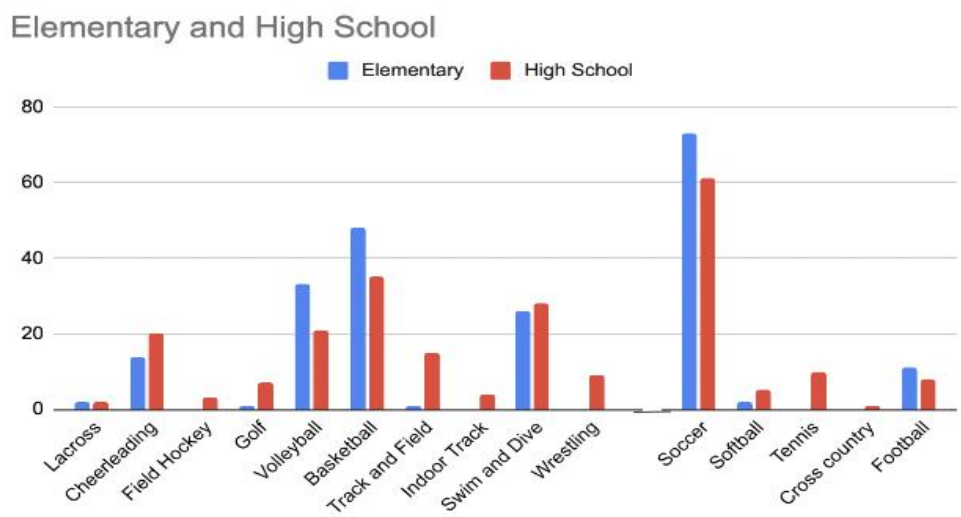


**Figure 4.** Example of student-generated graph based on data collected from survey

## Affordances of Technology to Organize and Represent Data

The biggest affordance of collecting data in a Google Form is the connection and ease of creating a spreadsheet of the data in Google Sheets. After students collected and converted the data, they were left with 158 different pieces of data that they needed to organize and find ways to represent. After students were shown how to create visualizations within Google Sheets, they set off in groups to explore and create different representations. As they played, they had to think about what graph made the most sense to represent their data, which built on their data literacy skills when applied to reading charts and graphs (Figure 4). Google Sheets allowed the students to create many different representations at once and play with the variables they chose to include in each representation (See Figure 5). However, since they had ease to create the representations, they needed to be critical about which representation would best tell their story and give them the information they needed to determine which sports to include in their clinic and what barrier to sports students in their school see as an issue.

## Analyzing Data

An important discussion was around the graphs students created around barriers to sports. Much like how the article emphasized the cost of joining teams and equipment was a large barrier, it also rated high in their poll. However, an interesting outcome in their poll was how students rated time commitment and schedule as being the biggest barriers to joining a sport. In discussing the survey results, one student shared, “I cannot participate in team sports because I am the oldest, and I have 6 younger siblings that I have to take care of after school.” Others shared other family responsibilities and weekend activities. They noticed that the data showed that it was not because children were not interested in team sports but was related to the conflicts in their schedule, the cost of joining a sport, the cost of equipment, and transportation.

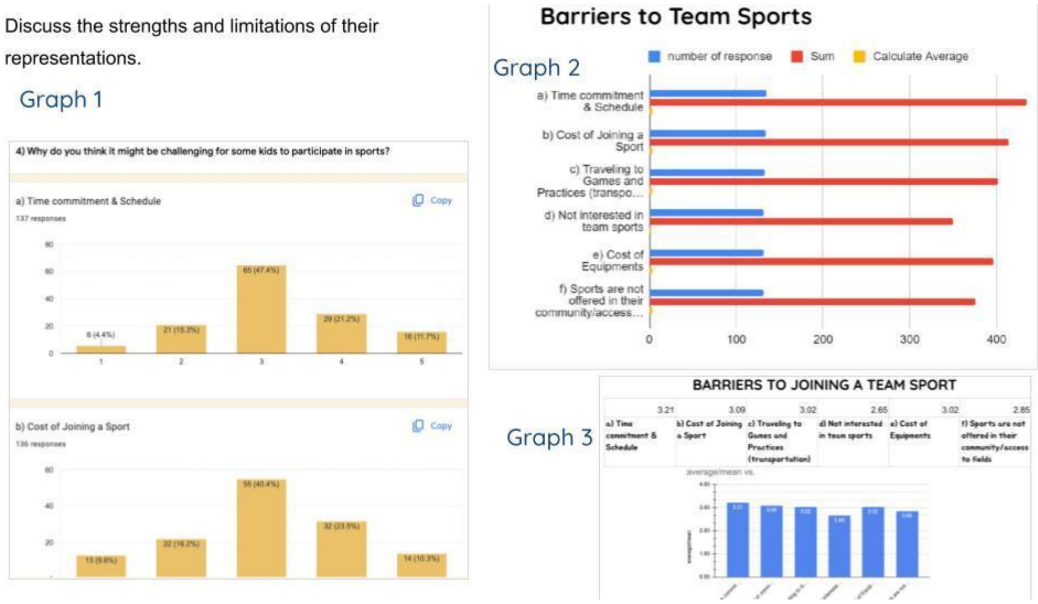


**Figure 5.** Student-created graphs based on survey results related barriers to participating in sports

In addition to making choices and analyzing their representations, Ms. M. wanted students to see others' representations. She decided to structure this as a data talk by showing multiple representations and having the students discuss how each data representation tells different stories.

| Sports | Points from **survey data** | Fun factor | Access at our school | Coaches | Total |
|---|---|---|---|---|---|
| *Soccer* | 5 | 4 | 5 | 5 | 19 |
| Basketball | 4 | 4 | 5 | 5 | 18 |
| Volleyball | 4 | 4 | 5 | 5 | 18 |
| Dance/ Cheer/ gymnastics | 3 | 3 | 5 | 5 | 16 |
| Tennis | 3 | 3 | 5 | 5 | 16 |
| Track | 4 | 3 | 4 | 4 | 15 |

**Figure 6.** Class decision matrix and planning

The next step in the analysis was to determine which sports to include in their sports clinic. To do this, Ms. M. introduced a decision matrix to support students in deciding the sports they chose. Decision matrix techniques are used to define attributes, weigh them, and appropriately sum the weighted attributes to give a relative ranking among choices. Mrs. M. asked each group to use the decision matrix, come up with a plan for the Sports Clinic based on their analysis of the data, and present their plan to the class. The class brainstormed the criteria that would be important to consider and arrived at four criteria (see Figure 6) to rank. Soccer, basketball, volleyball, dance/cheer/gymnastics, and tennis all rated highly based on the matrix. However, only soccer, volleyball, dance/cheer/gymnastics, and tennis were included in the sports clinic because they had a volunteer coach for these sports and space to play. Soccer included a way to draw in students since they loved this sport, and the other three were the ones that they wanted more students to get exposure to as part of their Sports Clinic.

### Sharing Results and Taking Action

To share the results and justification of this group-worthy task (Cohen & Lotan, 1995), Mrs. M. had students create Google Slides to map the layout of the clinic and the timing for the rotations. She provided a Google Earth image of the school grounds where students were able to map out the location for each sport, as well as work out the timing for each station, including transitions. Because all student groups were working in the same Google Slide deck, they could collaborate between groups by scrolling through others' ideas and commenting in real-time right on the slide.

The after-school Sports Clinic was successful, bringing 60 students to explore 4 different sports stations. High School athletes and school physical education staff came to teach students how to play the different games and hook them with some exciting skills they could practice on their own

After the Sports Clinic, the class interviewed a sports education professor and learned more about how to increase access to youth sports. He shared how transportation was one of the biggest issues and how his work focuses on offering sports closer to the community by using fields and gyms in schools, the YMCA, and local churches, removing many of the barriers of transportation and scheduling challenges. He also suggested ways to advocate for better access could be to write a letter to their School Board representative. Students were inspired to write a letter to their school board to explain what they had learned about access to sports and bring attention to a problem of access and representation of students exposed to various sports.

### Using EqT-tech LAT to Evaluate and reflect on the Planning and Enactment of the Technology-enhanced Mathematics Lesson

In reflecting on this lesson with Ms. M using the EqT-tech LAT, she thought through how the Google Suite (Google Classroom, Slides, Sheets, Docs, and Maps) was used differently to support equitable teaching and learning. Using these EqT-tech dimensions allowed Ms. M to attend to and interpret specific math and supportive features to consider how the technology can promote equitable participation, engagement, and agency.

**Table 2.** EQT-tech lesson analysis prompts

| **Equity-centered Transformative Technology Lesson Analysis Prompts** |
| --- |
| **Dimension 1: Access to Inquiry-based Learning Technology Learning-** In what ways does the choice of technology give students equitable access to mathematical inquiry, discovery, conjectures, and foster sense-making? |
| **Dimension 2: Promote Math Identity through Authorship and Agency Through Digital Tools-** In what ways does the technology allow student ownership and authorship to create, represent, and share their mathematical thinking to build positive mathematical identities? |
| **Dimension 3: Use Technology for Formative Assessment & Differentiation-** In what ways does the technology used in the lesson allow for formative assessment and differentiation to meet learners' needs? |
| **Dimension 4: Empower Students Through Collaboration and Collective Thinking through Conveyance Tools** In what ways does the use of the technology allow for students to collaborate, communicate, and build collective knowledge among their peers and provide opportunities to affirm multiple ideas and empower students' ideas? |
| **Dimension 5: Amplification of Mathematical and Cognitive Processes-**In what ways do the features of the technology make mathematics concepts visible and amplify cognitive processes? |
| **Dimension 6: Gain Insight Using Technology Tools on Social Justice Issues-**In what ways does the technology provide insight into inequities and issues affecting their communities empower marginalized groups to challenge the status quo? |

When discussing Dimension 1: Access to inquiry-based learning, based learning through technology, Ms. M. reflected on how technology provides access to dynamic tools that support inquiry, discovery, and access to deep mathematical sense-making. She mentioned that the ease of the feature of "insert chart" allowed for experimentation. As students made sense of the data, the ability to create multiple graphs and manipulate the data included in the representation led to richer discussions about which display provided more insights into the issues, "the ability to instantly create graphs allowed for students to focus more on the critical conversation about which graph should we use to talk to important school board members." instead of taking all the time to create multiple charts manually.

When discussing Dimension 2: Promote math identity through authorship and agency through digital tools, Ms. M frequently mentioned the words "choice," "ownership," and "creating." Ms. M. provided openness to the task of creating graphs, which in turn gave ownership in the student's learning and sense-making. Ms. M pointed out that the students had a choice in creating different graphical representations, how they represented their findings, and using different ways to record and explain their thinking. In this way, students had a sense of agency in expressing their thinking by creating and authoring their ideas. She stated, "they were able to create their own graphs, and write letters, and have agency in what mattered.”

When discussing Dimension 3: Using technology for formative assessment and differentiation, Ms. M. asked each team to work in Google Classroom so she could simultaneously access all group work at once**.** Ms. M mentioned the features of working in real-time with the Google suite allowed her to see what students were doing in their Google Slides deck and allowed for differentiation and scaffolding the level of difficulty. She shared that having access to student work allowed her to give students timely feedback and know which student groups needed additional support or check-ins. She shared, “I was able to flip through their Google Slides and ask them questions and leave comments as they are making sense of the math in real-time.”

When discussing Dimension 4: Empower students through collaboration, communication, and collective thinking through conveyance tools, , Ms. M allowed her students to share their workspace with other peers and the teacher. This feature allowed her to select and sequence a variety of student representations, provide an opportunity to position students as being mathematically competent and build students' mathematical identities. Ms. M. mentioned that the technology provided access to students' work, which made it easy to select, sequence, and show student work in ways that all students could see and make connections. Additionally, students were able to collaborate in their creation because all students could access the appropriate documents from their devices and communicate through different representations and reasoning.

When discussing Dimension 5: Amplify mathematical and cognitive processes, Ms. M. commented on how students learned about the measure of central tendencies in grade 5, but applying that concept with 160 data points was new and cognitively demanding. Ms. M. attended to features that dynamically represented the data into means and graphs. She interpreted this feature as amplifying and supporting their mathematical thinking. Additionally, she reflected on the power of data and how students pulled up their representations to make decisions when they were using the decision matrix. She added that the goal of the lesson was not how to construct graphs but a higher-level thinking activity,

> It wasn't about learning how to draw graphs; it was about which graph represented your data better. And that's a real-world tool and useful skill. We don't draw our own graphs, nobody does that. And so being able to have them be like mini professionals, and think ‘Here's the data I need to present to somebody important on the school board.’ And then having them use it to create graphs in two seconds and compare and contrast which graph shows the data better. That's a better use of time and math skills, frankly. They start to realize that this is a skill that they can take into the world as far as questioning ‘Why is the y-axis different on this graph than this graph?’ They can notice things when someone's trying to pull the wool over their eyes. So, I think they can just build on those skills over the years.

This important goal that went beyond the content and into problem solving and reasoning, allowed Ms. M to respond by allowing students to share the different graphs they created and justify their choice.

When discussing Dimension 6: Gain insight using digital tools on social justice issues, she shared that this was the focus of this 6th-grade lesson. Starting with the notice and wonder activities with the images from Google Maps provided the class with an opportunity to unpack this issue to give students some insight into a local problem that they could relate to. Ms. M attended to the features of Google Maps and how students' reactions showed their discovery of inequities that exist among communities,

> The comparison of maps was eye-opening for students to understand the issue at hand. With the Google Maps and their understanding of scale and distance allowed for them to compare their community with another and quantify the disparity in the number of fields and green space that would not be possible without the Google Map.

To unpack the issues of access to sports, students had a chance to analyze what their school identified as the biggest barriers within their school community. By collecting data and analyzing the barriers to sports, students were able to find that the biggest barrier that the students at this school encountered was time and schedule as the primary barrier and then cost as a secondary. As they discussed this outcome, students shared how their day was packed with other responsibilities, such as caring for siblings, going to church, and engaging in family events. In this way, technology helped students unpack issues of inequitable access to sports facilities and fields and better understand their school communities' barriers to accessing sports.

## V. DISCUSSION AND IMPLICATION

This case study provides an example of how a design team of a teacher and mathematics educators planned for a justice oriented task. In our discussion we highlight a) the importance of centering the task around social justice issues b) how this justice focused task developed student awareness and taking action which were key to building criticality for both teacher and students and c) provide implication and future directions for research.

First, the Sports Clinic task could have been focused on the aim of offering more sports without being focused on a social justice issue. However, it was important to the team to codesign this task to be more “transformative”. The technology used in this lesson had a major transformative role in supporting students in developing insight, analysis, elevating collective voice, and taking action on this social issue that they cared about and was relevant to their life. Google Maps has the transformative potential to reveal and analyze inequities to gain insights by visualizing the access to green space and fields and barriers to access. Leveraging maps and the results of analyses has the potential to empower communities to create actionable plans and model impacts of positive change. This rigorous task guided students through the different elements of the data cycle as they developed and administered a survey, processed the data, and chose the most appropriate representation to visualize the data. As a class, they communicated their graphical representation and offered feedback about the appropriateness of each visualization (see Figure 7). The way the teacher and students utilized the suite of Google tools, had the transformative potential to reveal and bring insight into a problem of access and representation of students exposed to various sports but also a way to increase participation in rigorous mathematics.

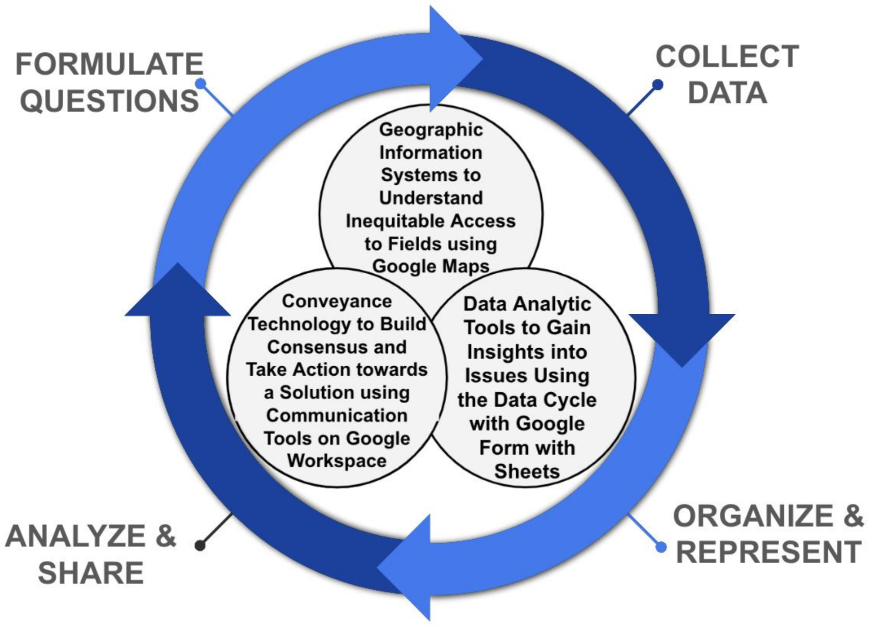


**Figure 7.** Integrating technology and the data cycle on a justice-oriented task

The use of the EqT-Tech LAT allowed Ms. M to reflect on the ways she learned to use technology to teach mathematics with a focus on social justice as well as equitable teaching practices in mind. She knew that students would enjoy tinkering with technology and would easily grasp how to create multiple graphs using the ‘insert chart’ function. Her belief that students were capable of learning how to use Google Sheets and her knowledge of how students learn with technology informed the way she would design the lesson to be inquiry-based. She had experience using technology dashboards to formatively assess and support student learning and used the Google Suite of technology to encourage collaboration and build ownership and collective thinking, which builds student agency and autonomy, a hallmark of equitable teaching. The final debrief using the EqT-Tech LAT helped us inventory some of the ways Ms. M used technology to amplify issues of social justice and enhance the learning experience.

Second, this task emphasized the dimensions of power and participation in the CRMT framework (Zavala & Aguirre, 2023). In other words, the justice focused task developed student awareness and taking action which were key to building criticality for both teacher and students

Finally, this case study provides mathematics teacher educators and researchers an example of what is possible through the use of technology in the mathematics classroom with intentional design thinking around equity and social justice. We hope that the Eqt-Tech LAT may be useful to educators and researchers in harnessing technology as an effective equity lever in the math classroom.

## REFERENCES

Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). *The impact of identity in K-8 mathematics learning and teaching: Rethinking equity-based practices*. The National Council of Teachers of Mathematics.

AMTE. (2022). *Position of the Association of Mathematics Teacher Educators on Technology* [Position Statement]. https://amte.net/news/2022/06/press-release-amte-statement-technology

Attewell, P. (2001). The first and second digital divides. *Sociology of Education*, *74*(3), 252-259. https://doi.org/10.2307/2673277

Berry, R. Q. (2003). *Voices of African-American male students: A Portrait of successful middle school mathematics students*. The University of North Carolina at Chapel Hill.

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2004). Working inside the black box: Assessment for learning in the classroom *Phi Delta Kappan*, *86*(1), 8-21. https://doi.org/10.1177/003172170408600105

Borthwick, A., Foulger, T., & Graziano, K. J. (Eds.). (2020). *Championing technology infusion in teacher preparation: A framework for supporting future educators* (First edition). International Society for Technology in Education.

Byun, S., Weiland, T., Cannon, S., Fernandes, A., Nti-Asante, E., Peterson, F., Smucker, K., & Engledowl, C. (2023). Teaching and learning with data investigation: Working group report from 2022. In T. Lamberg & D. Moss (Eds.), *Proceedings of the forty-fifth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 674-678). University of Nevada Reno.

Carpenter, T., Fennema, E., Franke, M., Levi, L. & Empson, S. (2014). *Children's mathematics: Cognitively guided instruction*, 2nd Edition. Heinemann.

Cavey, L., Lee, H., Hernandez, M., & Yokley, K. (2022). Online tools to support mathematical modeling and community building. *The Centroid*, *47*(2), 11-17.

Chval, K., Smith, E.M., Trigos-Carrillos, L., Pinnow, R.J. (2021). Teaching math to multilingual students, grades K-8: Positioning english learners for success. Corwin.

Civil, M. (2007). Building on community knowledge: An avenue to equity in mathematics education. In N. Nassir & P. Cobb (Eds.), *Improving access to mathematics: Diversity and equity in the classroom* (pp. 105-117). Teachers College Press.

Cohen, E. G., & Lotan, R. A. (1995). Producing equal-status interaction in the heterogeneous classroom. *American Educational Research Journal*, *32*(1), 99–120. https://doi.org/10.2307/1163215

Cohen, E. G., & Lotan, R. A. (2014). *Designing groupwork: Strategies for the heterogeneous classroom* (Third edition). Teachers College Press.

Cohen, K. (2019, August 11). *Kids aren't playing enough sports. The culprit? Cost*. ESPN News. https://www.espn.com/espn/story/_/id/27356477/kids-playing-enough-sports-culprit-cost

Cullen, C. J., Hertel, J. T., & Nickels, M. (2020). The roles of technology in mathematics education. *The Educational Forum (West Lafayette, Ind.)*, *84*(2), 166-178. https://doi.org/10.1080/00131725.2020.1698683

Dick, T. P., & Hollebrands, K. F. (2011). *Focus in high school mathematics: Technology to support reasoning and sense making.* National Council of Teachers of Mathematics.

Featherstone, H., Crespo, S., Jilk, L., Parks, A. N., & Wood, M. B. (2011). *Smarter together! Collaboration and equity in elementary mathematics*. National Council of Teachers of Mathematics.

Fennell, F. M., Kobett, B. M., & Wray, J. A. (2017). *The formative 5: Everyday assessment techniques for every math classroom*. Corwin Mathematics/National Council of Teachers of Mathematics.

Fingal, D., & ISTE (Eds.). (2018). *Edtech for the K-12 classroom: ISTE readings on how, when and why to use technology*. International Society for Technology in Education.

Freeman, B. (2012). Using digital technologies to redress inequities for English language learners in the English speaking mathematics classroom. *Computers & Education*, *59*(1), 50-62. https://doi.org/10.1016/j.compedu.2011.11.003

Gresalfi, M., Martin, T., Hand, V., & Greeno, J. (2009). Constructing competence: An analysis of student participation in the activity systems of mathematics classrooms. *Educational Studies in Mathematics*, *70*(1), 49-70. https://doi.org/10.1007/s10649-008-9141-5

Gutiérrez, R. (2009). Framing equity: Helping students "play the game" and "change the game." *Teaching for Excellence and Equity in Mathematics*, *1*(1), 4-8.

Gutstein, E., & Peterson, B. (Eds.). (2013). *Rethinking mathematics: Teaching social justice by the numbers* (Second edition). Rethinking Schools.

Gutstein, E. (2006). Reading and writing the world with mathematics: Toward a pedagogy for social justice. Routledge. https://doi.org/10.4324/9780203112946

Hackenberg, A. J., Jones, R., & Borowski, R. (2020). Tiering instruction for seventh-grade students. *Mathematics Teacher: Learning and Teaching PK-12*, *113*(2), 124-131. https://doi.org/10.5951/MTLT.2018.0048

Hollebrands, K. (2017). A framework to guide the development of a teaching mathematics with technology massive open online course for educators (mooc-ed). In Galindo, E., & Newton, J., (Eds.). *Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, (pp. 80-89). Hoosier Association of Mathematics Teacher Educators.

Horn, I. S. (2012). *Strength in numbers: Collaborative learning in secondary mathematics*. National Council of Teachers of Mathematics.

Jemal, A. (2017). Critical consciousness: A critique and critical analysis of the literature. *The Urban Review*, *49*(4), 602-626. https://doi.org/10.1007/s11256-017-0411-3

Jilk, L. M. (2016). Supporting teacher noticing of students' mathematical strengths. *Mathematics Teacher Educator*, *4*(2), 188-199. https://doi.org/10.5951/

mathteaceduc.4.2.0188

Kimmons, R., Graham, C. R., & West, R. E. (2020). The PICRAT model for technology integration in teacher preparation. *Contemporary Issues in Technology & Teacher Education*, *20*(1), 176-198.

Knoop-van Campen, C., & Molenaar, I. (2020). How teachers integrate dashboards into their feedback practices. *Frontline Learning Research, 8*(4), 37-51. https://doi.org/10.14786/flr.v8i4.641

Kobett, B. M., & Karp, K. S. (2020). *Strengths-based teaching and learning in mathematics: Five teaching turnarounds for grades K-6*. Corwin Press.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Kolb, L. (2020). Frameworks that scaffold learning to teach with technology. In Borthwick, A. C., Foulger, T. S., & Graziano, K. J. (Eds.), *Championing technology infusion in teacher preparation: A framework for supporting future educators* (pp. 69-94). International Society for Technology in Education.

Liljedahl, P., Clarke, A., & Morrison, N. (2021). Building thinking classrooms: A conversation with Dr. Peter Liljedahl. *Journal of Mathematics Education at Teachers College*, *12*(1), 1-7.

Martin, D. B. (2009). *Mathematics teaching, learning, and liberation in the lives of Black children*. Routledge New York.

McCulloch, A. W., Leatham, K., & Bailey, N. (2021). Theoretically framing the pedagogy of learning to teach mathematics with technology. *Contemporary Issues in Technology & Teacher Education*, *21*(2), 325-359.

McCulloch, A. W., & Lovett, J. N. (2023). *Exploring math with technology: Practices for secondary math teachers*. Routledge.

Munson, J. (2018). *In the moment: Conferring in the elementary math classroom*. Heinemann.

NCTM (Ed.). (2014). *Principles to actions: Ensuring mathematical success for all*. National Council of Teachers of Mathematics.

NCTM. (2020). *Catalyzing change in early childhood and elementary mathematics: Initiating critical conversations*. National Council of Teachers of Mathematics.

NCTM. (2023). *Equitable integration of technology for mathematics learning: A position of the National Council of Teachers of Mathematics*. https://www.nctm.org/Standards-and-Positions/Position-Statements/Equitable-Integration-of-Technology-for-Mathematics-Learning-2146929161/

Reich, J. (2019). Teaching our way to digital equity. *Educational Leadership*, *76*(5), 30-35.

Rubel, L. H., & Nicol, C. (2020). The power of place: Spatializing critical mathematics education. *Mathematical Thinking and Learning*, *22*(3), 173-194. https://doi.org/10.1080/10986065.2020.1709938

Schoenfeld, A. H., & the Teaching for Robust Understanding Project. (2016). *An introduction to teaching for robust understanding (TRU) framework.* http://truframework.org

Seda, P., & Brown, K. (2021). *Choosing to see: A framework for equity in the math* *classroom*. Dave Burgess Consulting Incorporated.

Shirley, M., & Irving, K. (2015). Connected classroom technology facilitates multiple components of formative assessment practice. *Journal of Science Education & Technology*, *24*(1), 56–68. https://doi.org/10.1007/s10956-014-9520-x

Smith, M. S. & Stein, M. K. (1998). Selecting and creating mathematical tasks: From research to practice. *Mathematics Teaching in the Middle School,* 3, 344–50.

Suh, J., & Roscioli, K. (2023a). Learning trajectory-based formative assessment & sequenced digital learning activities in math class. In C. L. Webb & A. L. Lindner (Eds.), *Preparing pre-service teachers to integrate technology in K-12 classrooms: Standards and best practices*. IGI Global.

Suh, J., Maxwell, G., Roscioli, K., Tate, H., Seshaiyer, P., & Marttinen, R. (2023b). Young mathematicians take action through sport clinics. *Mathematics Teacher: Learning and Teaching PK-12, 116*(11), 845-855. https://doi.org/10.5951/MTLT.2023.0105

Suh, J., Roscioli, K., Morrow-Leong, K., Tate, H. (2022). Transformative technology for equity-centered instruction. In E. Langran (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1559-1567). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/220920

Wager, A. A. (2014). Noticing children's participation: Insights into teacher positionality toward equitable mathematics pedagogy. *Journal for Research in Mathematics Education*, *45*(3), 312-350. https://doi.org/10.5951/jresematheduc.45.3.0312

Wiburg, K. M. (2003). Technology and the new meaning of educational equity. *Computers in the Schools*, *20*(1–2), 113-128. https://doi.org/10.1300/J025v20n01_09

Wills, T. (2021). *Teaching math at a distance, grades K-12: A practical guide to rich remote instruction*. Corwin, a Sage Company.

Wills, T., Crawford, D., Roscioli, K., & Sanghavi, S. (2021). Mathematical representations in a synchronous online mathematics specialist preparation program. *Journal of Mathematics and Science: Collaborative Explorations. 17*(1), Article 9. https://doi.org/10.25891/XZY1-8Q44

Witt, N. E. (2022). Leveraging technology to support sociopolitical dispositions. In A. E. Lischka, E. B. Dyer, R. S. Jones, J. Lovett, J. Strayer, & S. Drown (Eds.), *Proceedings of the forty-fourth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* (pp. 2084-2092). https://www.pmena.org/pmenaproceedings/PMENA%2044%202022%20Proceedings.pdf

Zavala, M. del R., & Aguirre, J. (2023). *Cultivating mathematical hearts: Culturally responsive mathematics teaching in elementary classrooms* (First). Corwin Press.

Zbiek, R. M., Heid, M. K., Blume, G. W., & Dick, T. P. (2007). Research on technology in mathematics education: A perspective of constructs. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (2nd ed., pp. 1169–1207). Information Age Publishing, Incorporated.