NC COLLABORATIVE FOR MATHEMATICS LEARNING

NC²ML Research-Practice Brief #24

Strategic Use of Tools and Technology

TECHNOLOGY TOOLS SUPPORT STUDENT LEARNING

Technology is an integral part of society. Our students use it every day as they interact with each other and their surrounding world. Technology tools are also integral to the workplace, no matter the field. Despite this, the mathematics classroom has been slow to take full advantage of these tools to support mathematics learning (Dick and Hollebrands, 2011).

Research has shown that strategic use of technological tools can support the learning of procedures and skills, as well as the development of advanced mathematical proficiencies such as problem solving, reasoning, and justifying (e.g., Gadanidis & Geiger, 2010; Nelson, Christopher, & Mims, 2009). Even more importantly, technology tools can provide students access to mathematics they might otherwise not have opportunities to engage with (e.g., McCulloch, 2011).

POSITIONING TECHNOLOGY TOOLS IN INSTRUCTION

There are many different types of technologies available for classroom use. They typically fall into two categories, conveyance technologies and mathematical action technologies (Dick and Hollebrands, 2011). Conveyance technologies are those that are used to convey information. They allow students and teachers to present, communicate, and collaborate with each other. These include presentation software (e.g., PowerPoint), interactive whiteboards, clickers, assessment tools (e.g. Kahoot!), and collaboration tools (e.g. Google Docs). These technologies are not math specific and opportunities for mathematical sensemaking have to come from the users themselves. Yet, when they are used in ways that promote opportunities for students to engage in mathematical sensemaking and reasoning, they have the potential to profoundly impact learning.

In contrast to conveyance technologies, mathematical action technologies can perform mathematical tasks and respond to actions a user takes in mathematically defined ways. These types of technologies have the ability to change the ways that students interact with mathematics. These include graphing technologies, spreadsheets, computer algebra systems, dynamic geometry systems, virtual manipulatives, and computer simulations (Examples provided below.)

The role mathematical action technologies play in task engagement will determine the ways that students interact with the tool, the task, and the mathematics. Two very different roles the technology typically plays are as an amplifier or a reorganizer (Pea, 1987). As an amplifier the technology allows students to do mathematics more efficiently and accurately, often allowing them to move past procedures and focus on reasoning and sensemaking. As a reorganizer, the technology allows students to interact with the mathematics ways they are not able to using only pencil and paper. Such interactions provide students opportunities to explore relationships and patterns in mathematical or statistical behavior. Both roles of technology can be very powerful and how you chose to position any technology tool should depend on your learning goals.

AMPLIFIER VS. REORGANIZER: AN EXAMPLE

Consider a graphing technology tool like Desmos, GeoGebra or graphing calculator. These technologies can be used as either amplifiers or reorganizers, depending on your goals.

- **Amplifier** – Delegating work to the technology like completing a calculation or producing a graph.
- **Reorganizer** – Exploring mathematical relationships like the effects of changing the parameters a, b, and c on the graph $f(x) = a(x-b)2+c$.

MAKING STRATEGIC CHOICES ABOUT TECHNOLOGY USE

In their 2015 position statement on technology use, NCTM stated, "Strategic use of technology in the teaching and learning of mathematics is the use of digital and physical tools by students and teachers in thoughtfully designed ways and at carefully determined times so that the capabilities of the technology enhance how students and educators learn, experience, communicate, and do mathematics.". The emphasis in this statement should not only be on the importance that all students use technology to support their learning, but also that teachers' decisions about when and how to use those technologies should be made strategically. Dick and Hollebrands (2011) suggest that when choosing to use technologies (or not) consider whether or not the technology offers advantages to the student and teacher for: 1) illustrating mathematical ideas, 2) posing mathematical problems, 3) opening opportunities for students to engage in mathematical sensemaking or reasoning, and 4) eliciting evidence of students' mathematical thinking. Using these guidelines to frame your decision making will help you use technologies, especially mathematical action technologies in meaningful ways.

TECH THAT SUPPORTS MATHEMATICAL SENSEMAKING

With an eye toward supporting students' mathematical sensemaking, here we briefly share some great free mathematical action technologies along with suggestions for strategic use. Keep in mind that all of the tools listed below can be used on computers, tablets, and cell phones. Most importantly, they all produce mathematical responses based on user input, allowing students to observe and explore mathematical ideas and make and test conjectures about mathematical relationships.

- **Graphing applications** allow students to observe and explore multiple representations of functions and data by generating linked tables, graphs and symbolic representations (e.g., Desmos, GeoGebra, Core Math Tools). You and/or your students might also have graphing calculators available to use in this way.
- **Spreadsheet applications** quickly display results ofrepeated calculations and can generate tables of valueslinked to a variety of graphical representations. Displaying repeated calculations allows for insights into structure and relationships among variables. (e.g., Excel, Google Sheets, GeoGebra, Core Math Tools).
- **Dynamic geometry software** allows for exploration of geometric relationships in coordinate, transformational and synthetic contexts. Students can make and explore conjectures through dragging of geometric objects and attending to invariances. Such explorations can provide insight into the existence of relationships and why they hold true, an important step to generating formal proofs. (e.g., GeoGebra, Desmos, Core Math Tools)
- **Computer Algebra Systems (CAS)** can operate on algebraic statements. This allows for insight into the structure of algebraic functions and expressions, and is especially powerful for highlighting patterns of equivalence, such as factoring quadratic equations. (e.g., GeoGebra, Core Math Tools, Wolphram Alpha)
- **Data analysis tools** support the visualization of large data sets with linked representations and tools for simulating observable phenomena. These tools provide opportunities to explore "what if" questions that are invaluable to the study of probability and statistics. (e.g.,CODAP, Core Math Tools)

DISCUSS WITH YOUR COLLEAGUES

1. *Discuss instances when it has been helpful to your students' engagement in mathematical sensemaking to use a technology tool as an amplifier and as a reorganizer. Provide specific examples.*
2. *Imagine a geometry lesson in which there is only a teacher computer and projector. How might you use tools like patty paper along with the teacher computer to provide an opportunity for students to use these tools as reorganizers?*
3. *Take the time with your colleagues to explore the tools mentioned above you are not familiar with. In each category note which tools are your favorite and why.*
4. *Identify one lesson in the coming weeks it would be helpful to your students to use a technology tool and try it out!*

References

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NC²ML MATHEMATICS ONLINE

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SUGGESTED CITATION

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