

Mathematics Learning Activity Types¹

The purpose of presenting an activity types taxonomy for mathematics is to introduce the full range of student learning activities for teachers to consider when building lessons that strive to effectively integrate technology, pedagogy, and content. In doing so, we attempt to scaffold teachers' thinking about how to best structure their learning activities, best support those activities with educational technologies, and to spark their creativity during instructional planning.

Essentially, these mathematics activity types are designed to be *catalysts* to thoughtful and creative instruction by teachers. We have conceptualized seven genres of activity types for mathematics that are derived from the NCTM's process standards. To encourage active engagement by all students, these activity types are expressed using active words (verbs) to represent the pursuit of a dynamic and student-centered learning environment. Many of these words are drawn directly from the NCTM standards. Each of the seven genres is presented in a separate table that names the activity types for that genre, briefly defines them, and then provides some example technologies that might be selected by a teacher while undertaking each activity.

The "Consider" Activity Types

When learning mathematics, students are often asked to thoughtfully consider new concepts or information. This request is a familiar one for the mathematics student, and is just as familiar to the teacher. Yet, although such learning activities can be very important contributors to student understanding, the "Consider" activity types also often represent some of the lower levels of student engagement, and typically are manifested using a relatively direct presentation of foundational knowledge.

Table 1: The "Consider" Activity Types

Activity Type	Brief Description	Example Technologies
Attend to a Demonstration	The student gains information from a presentation, videoclip, animation, interactive whiteboard or other display media	Powerpoint, iMovie, YouTube, podcasts, videoconferencing, or other display media
Read Text	The student extracts information from textbooks, or other written materials, in either print or digital form	Electronic textbooks, websites (i.e. the Math Forum), informational .pdfs
Discuss	The student discusses a concept or process with a teacher, other students, or an external expert	Ask-an-expert sites (e.g., Ask Dr. Math), online discussion groups, videoconferencing

¹ Grandgenett, N., Harris, J., & Hofer, M. (2009, March). *Operationalizing TPACK for educators: The activity types approach to technology integration in mathematics*. Paper presented at the Society for Information Technology and Teacher Education (SITE) annual conference, Charleston, SC.

Recognize a Pattern	The student examines a pattern presented and attempts to understand the pattern better	Graphing calculators, virtual manipulative sites (e.g., the National Library of Virtual Manipulatives), spreadsheets
Investigate a Concept	The student explores or investigates a concept (such as fractals), perhaps by use of the Internet or other research-related resources	Web searching, informational databases (Wikipedia), virtual worlds (Second Life), simulations
Understand or Define a Problem	The student strives to understand the context of a stated problem or to define the mathematical characteristics of a problem	Web searching, concept mapping software, ill-structured problem media (i.e. Jasper Woodbury)

The "Practice" Activity Types

In the learning of mathematics, it is often very important for a student to be able to practice computational techniques or other algorithm-based strategies, in order to automate these skills for later and higher-level mathematical application. Some educational technologies can provide valuable assistance in helping students to practice and internalize important skills and techniques. This table provides some examples of how technology can assist in these important student practice efforts.

Table 2: The "Practice" Activity Types

Activity Type	Brief Description	Example Technologies
Do Computation	The student undertakes computation-based strategies using numeric or symbolic processing	Scientific calculators, graphing calculators, spreadsheets, Mathematica
Do Drill and Practice	The student rehearses a mathematical strategy or technique, and perhaps uses computer-aided repetition and feedback in the practice process	Mathblaster drill and practice software, online textbook supplements, online homework help websites (WebMath).
Solve a Puzzle	The student carries out a mathematical strategy or technique within the context of solving an engaging puzzle, which may be facilitated or posed by the technology	Virtual manipulatives, Web-based puzzles (magic squares), brainteaser Web sites (CoolMath)

The "Interpret" Activity Types

In the discipline of mathematics, individual concepts and relationships can be quite abstract, and at times can even represent a bit of a mystery to students. Often students need to spend some time deducing and explaining these relationships to internalize them. Educational technologies

can be used to help students investigate concepts and relationships more actively, and assist them in interpreting what they observe. This table displays activity types that can support this thoughtful interpretation process, and gives some examples of the available technologies that can be used to support forming the interpretations.

Table 3: The "Interpret" Activity Types

Activity Type	Brief Description	Example Technologies
Pose a Conjecture	The student poses a conjecture, perhaps using dynamic software to display relationships	Dynamic geometry software (Geometer's Sketchpad), widgets (Explore Learning), e-mail
Develop an Argument	The student develops a mathematical argument related to why they think that something is true. Technology may help to form and to display that argument.	Concept mapping software (Inspiration), presentation software, blogs, specialized word processing software (Theorist), e-mail
Categorize	The student attempts to examine a concept or relationship in order to categorize it into a set of known categories	Database software (Microsoft Access), online databases, concept mapping software, drawing software
Interpret a Representation	The student explains the relationships apparent from a mathematical representation (table, formula, chart, diagram, graph, picture, model, animation, etc.)	Data visualization software (Inspire Data), 2D and 3D animations, video (iMovie), Global Positioning Devices (GPS), engineering visualization software (MathCad)
Estimate	The student attempts to approximate some mathematical value, by further examining relationships using supportive technologies	Scientific calculator, graphing calculator, spreadsheets, student response systems (Clickers)
Interpret a Phenomenon Mathematically	Assisted by technology as needed, the student examines a mathematics related phenomenon (such as velocity, acceleration, the Golden Ratio, gravity, etc.)	Digital cameras, video, computer-aided laboratory equipment, engineering visualization software, specialized word processing, robotics, electronics kits

The "Produce" Activity Types

When students are actively engaged in the study of mathematics, they can become motivated producers of mathematical works, rather than just passive consumers of prepared materials. Educational technologies can serve as excellent "partners" in this production process, aiding in the refinement and formalization of a student product, as well as helping the student to share the

fruits of their mathematical labors. The activity types listed below suggest technology-assisted efforts in which students become “producers” of mathematics-related products.

Table 4: The "Produce" Activity Types

Activity Type	Brief Description	Example Technologies
Do a Demonstration	The student makes a demonstration on some topic to show their understanding of a mathematical idea or process. Technology may assist in the development or presentation of the product.	Interactive whiteboard, video (YouTube), document camera, presentation software, podcasts
Generate Text	The student produces a report, annotation, explanation, journal entry or document, to illustrate their understanding.	Specialized word processing (Math Type), collaborative documents (Google docs), blogs, online discussion groups
Describe an Object or Concept Mathematically	Assisted by the technology in the description or documentation process, the student produces a mathematical explanation of an object or concept	Logo graphics, engineering visualization software, concept mapping software, specialized word processing, Mathematica
Produce a Representation	Using technology for production assistance if appropriate, the student develops a mathematical representation (table, formula, chart, diagram, graph, picture, model, animation, etc.)	Spreadsheet, virtual manipulatives (digital geoboard), spreadsheets, Inspire Data, concept mapping software, graphing calculator
Develop a Problem	The student poses a mathematical problem that is illustrative of some mathematical concept, relationship, or investigative question	Word processing, online discussion groups, Wikipedia, Web searching, e-mail

The "Apply" Activity Types

The utility of mathematics in the world can be found in its authentic application. Educational technologies can be used to help students to apply their mathematics in the real world, and to link mathematical concepts to real world phenomena. The technologies essentially become students' assistants in their mathematical work, helping them to link mathematical concepts to the reality in which they live.

Table 5: The "Apply" Activity Types

Activity Type	Brief Description	Example Technologies
Choose a Strategy	The student reviews or selects a mathematics related strategy for a particular context or application.	Online help sites (WebMath, Math Forum), Inspire Data, dynamic geometry/algebra software (Geometry Expressions), Mathematica, MathCAD
Take a Test	The student applies their mathematical knowledge within the context of a testing environment, such as with computer-assisted testing software.	Test-taking software, Blackboard, survey software, student response systems
Apply a Representation	The student applies a mathematical representation to a real life situation (table, formula, chart, diagram, graph, picture, model, animation, etc.).	Spreadsheet, robotics, graphing calculator, computer-aided laboratories, virtual manipulatives (algebra tiles)

The "Evaluate" Activity Types

When students evaluate the mathematical work of others, or self-evaluate their own mathematical work, they utilize a relatively sophisticated understanding of mathematical concepts and processes. Educational technologies can become valuable allies in this effort, assisting students in the evaluation process by helping them to undertake concept comparisons, test solutions or conjectures, and/or integrate feedback from other individuals into revisions of their work. The following table lists some of these evaluation-related activities.

Table 6: The "Evaluate" Activity Types

Activity Type	Brief Description	Example Technologies
Compare and Contrast	The student compares and contrasts different mathematical strategies or concepts, to see which is more appropriate for a particular situation.	Inspiration, Web searches, Mathematica, MathCad
Test a Solution	The student systematically tests a solution, and examines whether it makes	Scientific calculator, graphing calculator, spreadsheet,

	sense based upon systematic feedback, which might be assisted by technology.	Mathematica, Geometry Expressions
Test a Conjecture	The student poses a specific conjecture and then examines the feedback of any interactive results to potentially refine the conjecture.	Geometer Sketchpad, statistical packages (e.g/, SPSS, Fathom), online calculators, robotics
Evaluate Mathematical Work	The student evaluates a body of mathematical work, through the use of peer or technology- aided feedback.	Online discussion groups, blogs, Mathematica, MathCad, Inspire Data

The "Create" Activity Types

When students are involved in some of the highest levels of mathematics learning activities, they are often engaged in very creative and imaginative thinking processes. Albert Einstein once suggested that “imagination is more important than knowledge.” It is said that this quote represents his strong belief that mathematics is a very inventive, inspired, and imaginative endeavor. Educational technologies can be used to help students to be creative in their mathematical work, and to even help other students to learn the mathematics that they already know. The activity types below represent these creative elements and processes in students’ mathematical learning and interaction.

Table 7: The "Create" Activity Types

Activity Type	Brief Description	Example Technologies
Teach a Lesson	The student develops and delivers a lesson on a particular mathematics concept, strategy, or problem.	Presentation software, interactive video, video, podcasts
Create a Plan	The student develops a systematic plan to address some mathematical problem or task.	Concept mapping software, collaborative writing software, MathCad, Mathematica
Create a Product	The student imaginatively engages in the development of a student project, invention, or artifact, such as a new fractal, tessellation, or other creative product.	Word processor, animation tools, MathCad, Mathematica, Geometer Sketchpad
Create a Process	The student creates a mathematical process that others might use, test or replicate, essentially engaging in mathematical creativity.	Computer programming, robotics, Mathematica, MathCad, Inspire Data, iMovie