Digital Tools

for Teaching Math and Science

Onslow County Schools

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Program

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Essential Questions

- *What is the purpose of mathematics?*
- *What is the connection between classroom environment and learning?*
- *What is the role of digital tools in 21st century learning?*

In a perfect world…

The Game of NIM

Notes & Observations

Patterns

Analysis

Pieces	Turn?	Take?	Comments

Mathematics | Standards for Mathematical Practice

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections. The second are the strands of mathematical proficiency specified in the National Research Council's report *Adding It Up*: adaptive reasoning, strategic competence, conceptual understanding (comprehension of mathematical concepts, operations and relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently and appropriately), and productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy).

1 Make sense of problems and persevere in solving them.
Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.

2 Reason abstractly and quantitatively.
Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to *decontextualize*—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to *contextualize*, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

3 Construct viable arguments and critique the reasoning of others.
Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions,

communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

4 Model with mathematics.

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

5 Use appropriate tools strategically.

Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

6 Attend to precision.

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.

7 Look for and make use of structure.
Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7 × 8 equals the well remembered 7 × 5 + 7 × 3, in preparation for learning about the distributive property. In the expression $x^2 + 9x + 14$, older students can see the 14 as 2 × 7 and the 9 as 2 + 7. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 - 3(x - y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.

8 Look for and express regularity in repeated reasoning.
Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation $(y - 2)/(x - 1) = 3$. Noticing the regularity in the way terms cancel when expanding $(x - 1)(x + 1)$, $(x - 1)(x^2 + x + 1)$, and $(x - 1)(x^3 + x^2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

Connecting the Standards for Mathematical Practice to the Standards for Mathematical Content
The Standards for Mathematical Practice describe ways in which developing student practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle and high school years. Designers of curricula, assessments, and professional development should all attend to the need to connect the mathematical practices to mathematical content in mathematics instruction.

The Standards for Mathematical Content are a balanced combination of procedure and understanding. Expectations that begin with the word “understand” are often especially good opportunities to connect the practices to the content. Students who lack understanding of a topic may rely on procedures too heavily. Without a flexible base from which to work, they may be less likely to consider analogous problems, represent problems coherently, justify conclusions, apply the mathematics to practical situations, use technology mindfully to work with the mathematics, explain the mathematics accurately to other students, step back for an overview, or deviate from a known procedure to find a shortcut. In short, a lack of understanding effectively prevents a student from engaging in the mathematical practices.

In this respect, those content standards which set an expectation of understanding are potential “points of intersection” between the Standards for Mathematical Content and the Standards for Mathematical Practice. These points of intersection are intended to be weighted toward central and generative concepts in the school mathematics curriculum that most merit the time, resources, innovative energies, and focus necessary to qualitatively improve the curriculum, instruction, assessment, professional development, and student achievement in mathematics.

Making Mathematicians: The Standards for Mathematical Practice

Six-Word Summary:

Dan Meyer: Math Class Needs a Makeover
http://new.ted.com/talks/dan_meyer_math_curriculum_makeover

Agree	Question	Surprise / Aha!

Resource Curation

1. Visit my curated list of digital tools at http://aungst.me/digital-math.
2. Browse for a few minutes, then select 3-4 that intrigue you.
3. Below, list possible criteria to use for evaluating these sites.
4. Share and discuss with your group.
5. Refine your collective list until you have some consensus.
6. Share out to the whole room.

Infographics

1. Create an account at **http://infogr.am**.
2. As a group, develop a rating system for evaluating digital resources
3. Use your rating system to evaluate at least 3 of the sites you visited on the previous page.
4. Begin building an infographic to present your findings and evaluations

Think Different: http://aungst.me/3-questions

1. ____

____

2. ____

____

3. ____

____

Culture of Problem Solving

A Puzzling Pandemic

Reflect on the puzzle activity. How did you feel? What was the learning environment like?

The Cure

Elementitis	Aboutitis

Clock Angles

As the bell rang for the start of school at 9:00 one day, Daniel noticed that the hands of the clock made an angle of exactly 90°. He quickly realized that this would happen again at dismissal at 3:00. "I wonder," he thought, "what other times during the day the clock hands will make a 90° angle?"

Spreading Out

1. Take a handful of small objects (coins, paper clips, etc.) and drop them from a foot or two above a large sheet of paper. Mark the locations where they land.
2. Do this again on a second sheet of paper, marking the locations of the objects.
3. Now, work with a partner or group and examine both sets of marks. Which one is more spread out? Support your argument mathematically.

6 Classroom Cultural Practices

First and Foremost Communicate

Understand that math is not primarily about computation or a checklist of content and skills. It is about solving problems (and I don't mean computation exercises written in word form; they are not the same thing), and problems are solved through communication.

Therefore, a math classroom should first and foremost be a communication classroom, and should be filled mostly with talking and writing. Most of the math learning that happens takes place when students are talking to each other, writing (in English, not just math symbols) about their thinking, explaining, arguing, defending, critiquing, and discussing ideas. Students should talk frequently, write daily (and write longer math pieces weekly), and share their writing with multiple audiences.

Teach the symbolics of math as its own language for communicating mathematical ideas in short, simple ways. Talk about how you are really translating between two languages when you discuss something in English and then show it in mathematical symbols.

Think the Avengers, Not the Lone Ranger

Math has always been treated as primarily a solo activity, but in the real world, problems are rarely solved by individuals acting alone. So instead of encouraging your students to be Lone Rangers, think the Avengers instead. (Yes, I know I'm mixing my literary references!) Students should most often tackle problems in pairs or small groups. Solo solving should be a rare event in the classroom. Pair/group work encourages dialogue and debate.

Set an expectation that student pairs or groups may not consider a problem "solved" until everyone in the group is satisfied with the result and is comfortable explaining it to someone else. In practice, there will be times when this is not always possible, but groups should always strive for this ideal.

It's Gonna Be Messy

There is a misconception about math that because it demands precision it is also neat and clean. While we want the "final draft" to be neat and clean, just as we do for writing work, math, like writing, is more about the process than the product. And the process of solving problems is messy.

We tend to want students to proceed in strict linear fashion from the start of a problem or exercise through to its solution. But real world problem don't work that way, and math class problems shouldn't either. There will be false starts, reversals, and abandoned trails when students start to really solve problems.

Don't be in too much of a hurry to bail them out, either. Let them get lost in the muck for a while. It's OK. By struggling through and working it out on their own, they will better understand the territory in which the problem lives.

Never End With the Answer

As teachers, we are accustomed to asking questions that we already know the answers to, and we keep calling on students until we get the answer we're expecting. At that point we are "done" and we move on to the next question.

To create a culture of inquiry and the habits of mind required by the Common Core, don't ever end with the answer. Instead, when a student responds to a question--even a fairly straightforward factual one--keep on going. Ask another student their thoughts on it. Ask the responder or another student to tell how they know that's correct. Ask students to restate the answer in other terms or explain it differently. Do something that will keep students thinking and encourage reasoning instead of guessing.

Validate Effort, Not Answers

Carol Dweck's research points out how we can affect a student's mindset about learning simply by the kinds of language we use to reinforce their work. When we praise a student for how smart they are and how good their answers are, they develop a fixed mindset that believes intelligence is an inherent quality that they either have or don't, and that learning is something that they either "get" or "don't get".

When we validate effort instead, then students can develop a growth mindset, focusing on steady improvement, and believing that everyone can learn, it just takes work to get there.

It is easy during math instruction, though, to focus on "getting right answers," and to primarily validate student accuracy. Focus instead on recognizing and rewarding the effort that students put into working through a problem solution. Any effort that is productive, even if it doesn't ultimately result in an answer, should be praised. Effort that is not productive should be honored and redirected. For example, if you have a group which has worked hard but is going down an apparently dead end route, try something like this: "I really appreciate the work you have done on this. You did great work in finding the information you needed to solve the problem, and you are really challenging each other to think deeply about the problem. Do you think you are closer to a solution than you were ten minutes ago? Where do you think you went wrong? Let's back up to this point and try a different tack."

Celebrate Small Victories

Since we are shifting our mindset away from only complete and correct answers to questions, it's important that we also honor student efforts towards solving a problem.

So celebrate little victories: if a group is working on a tough problem and they have a realization that takes them in a new direction, don't just tell them to keep going, have them share their "aha" with the class, put it on the wall, or post it on the class blog.

In the real world, complex problems are solved when we share the little victories with each other, then the next person can stand on their shoulders and find the next little victory. Give your students a taste of this in the classroom.

Insider's Guide to ~~Your Classroom~~

Their Learning Environment

Physical Space	**Culture**
Technology	**Materials/Resources**
Instruction	**Assessment**

The Technology Integration Matrix
Table of Teacher Descriptors

This table contains teacher descriptors for each cell of the Technology Integration Matrix (TIM). Other available resources include a tables detailing student activity, instructional settings, and a table of summary indicators for each TIM cell.

Levels of Technology Integration into the Curriculum

Characteristics of the Learning Environment

	Entry	Adoption	Adaptation	Infusion	Transformation
Active	The teacher may be the only one actively using technology. This may include using presentation software to support delivery of a lecture. The teacher may also have the students complete "drill and practice" activities on computers to practice basic skills, such as typing.	The teacher controls the type of technology and how it is used. The teacher may be pacing the students through a project, making sure that they each complete each step in the same sequence with the same tool. Although the students are more active than students at the Entry level in their use of technology, the teacher still strongly regulates activities.	The teacher chooses which technology tools to use and when to use them. Because the students are developing a conceptual and procedural knowledge of the technology tools, the teacher does not need to guide students step by step through activities. Instead, the teacher acts as a facilitator toward learning, allowing for greater student engagement with technology tools.	The teacher guides, informs, and contextualizes student choices of technology tools and is flexible and open to student ideas. Lessons are structured so that student use of technology is self-directed.	The teacher serves as a guide, mentor, and model in the use of technology. The teacher encourages and supports the active engagement of students with technology resources. The teacher facilitates lessons in which students are engaged in higher order learning activities that may not have been possible without the use of technology tools. The teacher helps students locate appropriate resources to support student choices.
Collaborative	The teacher directs students to work alone on tasks involving technology.	The teacher directs students in the conventional use of technology tools for working with others.	The teacher provides opportunities for students to use technology to work with others. The teacher selects and provides technology tools for students to use in collaborative ways, and encourages students to begin exploring the use of these tools.	Teacher encourages students to use technology tools collaboratively.	The teacher seeks partnerships outside of the setting to allow students to access experts and peers in other locations, and encourages students to extend the use of collaborative technology tools in higher order learning activities that may not have been possible without the use of technology tools.

Levels of Technology Integration into the Curriculum

	Entry	Adoption	Adaptation	Infusion	Transformation
Constructive	The teacher uses technology to deliver information to students.	The teacher provides some opportunities for students to use technology in conventional ways to build knowledge and experience. The students are constructing meaning about the relationships between prior knowledge and new learning, but the teacher is making the choices regarding technology use.	The teacher has designed a lesson in which students' use of technology tools is integral to building an understanding of a concept. The teacher gives the students access to technology tools and guides them to appropriate resources.	The teacher consistently allows students to select technology tools to use in building an understanding of a concept. The teacher provides a context in which technology tools are seamlessly integrated into a lesson, and is supportive of student autonomy in choosing the tools and when they can best be used to accomplish the desired outcomes.	The teacher facilitates higher order learning opportunities in which students regularly engage in activities that may have been impossible to achieve without the use of technology tools. The teacher encourages students to explore the use of technology tools in unconventional ways and to use the full capacity of multiple tools in order to build knowledge.
Authentic	The teacher assigns work based on a predetermined curriculum unrelated to the students or issues beyond the instructional setting.	The teacher directs students in the conventional use of technology tools for learning activities that are sometimes related to the students or issues beyond the instructional setting.	The teacher creates instruction that purposefully integrates technology tools and provides access to information on community and world problems. The teacher directs the choice of technology tools but students use the tools on their own, and may begin to explore other capabilities of the tools.	The teacher encourages students to use technology tools to make connections to the world outside of the instructional setting and to their lives and interests. The teacher provides a learning context in which students regularly use technology tools and have the freedom to choose the tools that, for each student, best match the task.	The teacher encourages innovative use of technology tools in higher order learning activities that support connections to the lives of the students and the world beyond the instructional setting.
Goal-Directed	The teacher uses technology to give students directions and monitor step-by-step completion of tasks. The teacher monitors the students' progress and sets goals for each student.	The teacher directs students step by step in the conventional use of technology tools to either plan, monitor, or evaluate an activity. For example, the teacher may lead the class step by step through the creation of a KWL chart using concept mapping software.	The teacher selects the technology tools and clearly integrates them into the lesson. The teacher facilitates students independent use of the technology tools to set goals, plan, monitor progress, and evaluate outcomes. For example, in a given project, the teacher may select a spreadsheet program that students use independently to plan and monitor progress. The teacher may provide guidance in breaking down tasks.	The teacher creates a learning context in which students regularly use technology tools for planning, monitoring, and evaluating learning activities. The teacher facilitates students' selection of technology tools.	The teacher creates a rich learning environment in which students regularly engage in higher order planning activities that may have been impossible to achieve without technology. The teacher sets a context in which students are encouraged to use technology tools in unconventional ways that best enable them to monitor their own learning.

The Technology Integration Matrix was developed by the Florida Center for Instructional Technology at the University of South Florida College of Education and funded with grants from the Florida Department of Education. For more information, visit http://mytechmatrix.org.

What is User-Generated Learning?
by Kristen Swanson

Available at http://www.usergeneratedlearning.com/what-is-ugl/. Used by permission.

User-generated learning is learning that is acquired through active curation, reflection, and contribution to a self-selected collaborative space. This basically means that user-generated learning is something you do, not something you get. You have to actively participate in the process through searching, evaluating, and sharing. In user-generated learning, everyone has something to contribute. We are all experts in our own way. This doesn't negate the importance of educational research or vetted practices. Instead, user-generated learning reflects that all adults recognize their personal applications of ideas and strategies, and this synthesis and community are a valuable part of the learning process.

Let's break down each part of the definition provided above. First, user-generated learning requires curation. Curation is defined as the careful collection of relevant resources. Just like a museum employee, teachers must find and aggregate content that is relevant to the problems they are facing in their profession. Need resources for a new unit you are teaching? Interested in trying guided reading during your reading block? Need fun sites for students to use to practice mitosis and meiosis? Curation can help! Instead of relying on a content area expert or textbook, you are responsible for finding meaningful information. Curation can occur in many forms, such as file folders, saving pages from professional journals, or copying article excerpts to share with colleagues. However, the Internet provides fantastic new tools that allow you to find, organize, and share content in ways that were previously not possible. Further, using online tools such as Twitter, Google Reader, Pearltrees, iTunes U, and Paper.li fosters sharing. You benefit greatly from what the community selects and shares. The community essentially serves as a functional filter to help you find the best content. By using the Internet to learn from lots of teachers, not just the teachers where you work, you will find better solutions that meet your students' needs. For example, maybe you are having difficulty engaging your students with a very traditional poetry unit that you have always taught. Curation can help you skim and search lots of different educational blogs each day for ideas.

Reflection is the second component of user-generated learning. As you curate and consume information from a variety of sources, you must take the time to assimilate the new information with your existing background knowledge. Sometimes the information you've curated will match what you already know. Other times, it will challenge previously held beliefs. (A good curator always includes a variety of viewpoints when aggregating content.) As you wrestle with the information relative to your beliefs, your reflection will be critical. Just as there are many ways to curate, there are also many ways to reflect. You could simply write your thoughts in a small journal or word-processing document. However, you could also start your own online blog, allowing others in your learning community to comment on your reflections. Blogs are a dynamic space for transactional, or interactive, reflection. Personally, the feedback, questions, and comments I've received on my blog (www.kristenswanson.org) have both affirmed my beliefs and challenged me as a learner.

Thirdly, user-generated learning requires a contribution to the learning community that you serve. You can select a community from physical or virtual places. At the local level, you could connect with your grade-level team, department, school, or district. At the virtual level, you could join an online forum, create a list of followers on Twitter, or identify and follow your favorite blog writers.

User-generated learning is thus a three-part process: curation, reflection, and contribution. Each phase can be distinct or they can overlap. Certainly, user-generated learning is not linear or clean. It's messy. The more you become engaged with it, the harder it is to see clear distinctions between the phases. Welcome to the world of connected, informed, educators!

Additional Notes

Additional Notes

Resources and Recommended Reading

Workshop handouts and links to related resources are available at:
http://www.geraldaungst.com/onslow

Below is a recommended reading list. Many of these were referenced today, or are good follow up resources for additional information.

Bunday, Karl. (2013). Problems vs. Exercises. http://epsiloncamp.org/ParentResources/PResource.1.php

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Richardson, Will. (2012). *Why School?: How Education Must Change When Learning and Information Are Everywhere*. TED Conferences.

Swanson, Kristin. (2013). *Professional Learning in the Digital Age.* Eye On Education.

Image Credits and References from today's slides:

Apple Computer ad: http://youtu.be/tjgtLSHhTPg

Baby names: http://www.babycenter.com/0_unusual-baby-names-of-2013_10388919.bc

Comics by Mark Anderson: http://www.andertoons.com

European Vacation: Roundabout: http://youtu.be/iAgX6qlJEMc

How not to answer exam questions: http://www.magicalmaths.org/funny-how-not-to-answer-exam-questions/

Most popular passwords: http://mashable.com/2013/11/05/20-most-popular-passwords-adobe/

Nuclear Launch Codes: http://www.huffingtonpost.com/2013/12/05/nuclear-missile-code-00000000-cold-war_n_4386784.html

Spaceballs movie clip: http://youtu.be/a6iW-8xPw3k

Upscale Hoarder: http://youtu.be/M_6Wm4tbWRc