Maine Educators Describe Innovative Technology Uses in K-12 Education

Prepared by:

Abigail Garthwait, Ph.D.
Associate Professor

Janet Fairman, Ph.D.
Associate Research Professor

March 2014

Maine Education Policy Research Institute
College of Education & Human Development
University of Maine
Orono, Maine

Maine Educators Describe Innovative Technology Uses in K-12 Education

March 2014

Abigail Garthwait, Ph.D.
Associate Professor

Maine Education Policy Research Institute
A nonpartisan research institute funded by the Maine State Legislature, the University of Maine, and the University of Southern Maine.

Center for Research and Evaluation
College of Education and Human Development
University of Maine, 5766 Shibles Hall, Orono, Maine 04469-5766
(207) 581-2475

A Member of the University of Maine System

EXECUTIVE SUMMARY

At the request of the Maine State Legislature, the Maine Education Policy Research Institute (MEPRI) sponsored a study to describe the current use of non-MLTI technology in K-12 education in Maine. This report describes a broad range of technology use occurring in Maine classrooms and educators' perceptions about the impacts of the technology for teaching and learning.

The author, Abigail Garthwait, collected "vignettes" from Maine educators regarding various technological tools they are using and how these are being applied in and out of the classroom. While a wide range of different technologies were discussed, they were broadly being used to address the following teaching and learning goals: *Differentiated Instruction, Aspirations and Motivation to Learn*, *Problem Solving, Communication and Community*, *Leveraging the Power of Technology, and Using Data to Inform Instruction*.

Technology can allow teachers to shape classroom assignments or projects in a way that different students can benefit from multiple modalities for both learning and demonstrating their knowledge. As reflected in *The Fire of 1947* project, teachers are using technology to design classroom projects that provide students with a high degree of flexibility in how different students can approach the same goal. Through technology, students have an array of resources available to them so that each student can focus on learning and communicating in ways that best accommodate their personal learning style. In addition, technology provides tools for individual students who may be experiencing specific challenges are able to participate and work at a higher level of performance and engagement than would be possible using traditional methods. For example, as reflected in *Playaways*, audio technology allows struggling readers to stay engaged in more inclusive learning environments while also promoting interest and skill in reading.

Technology is also seen by many educators as a valuable tool to inspire and motivate students to explore new directions or skills. One area some schools are targeting is computer programming,

with initiatives such as "*Hour of Code*" or introductory programming opportunities using *Scratch*. However, projects such as *Aspirnauts* are also seeking to introduce students to new fields, but using technology to expand the classroom setting by linking with researchers nationwide. Robotics and robotic competitions such as *FIRST LEGO League* or *FIRST Robotics* are another sophisticated way that schools are seeking to engage students in disciplines such as engineering and programming. Educators also see these as valuable tools for teaching students problem solving skills and logical thinking.

Teachers in Maine also use technology as a way for students to communicate and work with other students and educators locally, nationally, and internationally. The important of using technology for connecting students with the wider-world is reflected in a variety of national initiatives, such as Common Core and the International Society for Technology in Education standards. Such linkages can be challenging for rural schools; however, teachers are using technology in order to introduce their students to international settings. For example, the report highlights a project in a first grade Maine classroom where a carefully monitored class blog served as the basis for students to establish friendships with a class in Slovenia—learning about each other's countries, sharing stories, songs, and classroom videos.

Technology is also widely used by educators as a tool for leveraging classroom resources, providing teaching and learning experiences that exceed what is possible using traditional tools. This can involve providing students with access to video lectures that cover material a student may have missed when absent, or videos that provide addition review or material that students can watch outside of class. Some teachers have expanded this to students creating electronic portfolios of their own videos and other digital work across multiple years. As described in the full report, students in one school create digital portfolios across their four years of high school. These can provide valuable material that students can use for college or job applications, and also provide a rich and in-depth resource for teachers and administrators to use when examining student growth.

In addition, perhaps the most high profile use of technology as a tool for leveraging the classroom experience is the use of formal online education resources and tools, such as Khan Academy, and a variety of services available from many textbook publishers. This report

profiles one product, The Madcap Learning Adventure, which illustrates how such tools provide opportunities for expanded, individualized student-guided learning that are impossible using traditional tools. For example, within Madcap, both students and teachers were extremely positive regarding an interactive map of the Battle of Gettysburg. Using the map, students could trace action and movements on the field, zooming in on key figures or locations, exploring what was happening at different locations at the same time, or following different figures (e.g. Joshua Chamberlain) throughout the three day battle. This type of interactive, individualized learning resource is only possible through technology-based resources.

Finally, technology makes it possible for students and teachers to receive timely, valuable information regarding how a student is doing, and what needs to be done in order to address potential learning issues. Schools in Maine use technology in this way through programs such as Hungry Guppy, adaptive software that provides young students with immediate feedback regarding whether they answers correctly or incorrectly, while also presenting more difficult questions as the student improves and reviewing less challenging material when a student is having difficulty on a concept. Similarly, ASSISTments is a free, online intelligent math tutoring system. In addition to providing students with feedback regarding whether their answer is correct, ASSISTments can also recognize mistakes and offer hints or scaffolding material to help the students learn. The program also provides teachers with instant summaries of students' progress on homework problems, informing teachers' selection of concepts and skills to target in the next lesson.

This study highlights a wide range of technology uses in Maine schools today. The report illustrates the potential of technology for supporting student learning: increasing student motivation and excitement about learning; promoting active learning; deepening and extending students' learning, engaging students in real-world problem solving and critical thinking; developing computer literacy and coding skills; learning at one's own pace; keeping schoolwork organized, fostering independent learning; demonstrating knowledge and learning in many different ways; and building collaborative work skills within and beyond the classroom. The report also describes positive benefits for teachers: engaging students in active learning; providing feedback to students through the computer programs; providing instant summaries of student data to inform teaching decisions; differentiating instruction to support students' individual learning needs and varied interests; providing ways for students to integrate knowledge across disciplines, the arts and music; data to inform instruction; and providing authentic and informal ways to assess students' learning.

Implications from the study include the need for policymakers, teacher education programs, and school systems to consider ways to support technology literacy and continued professional development for educators to use technology in effective ways. The state, higher education, and school districts all have an important role to play in developing and providing high quality training for educators that connects technology with content and pedagogical knowledge. Other implications relate to the important role of instructional leadership in schools and districts. Administrators, curriculum coordinators, technology integration specialists provide critical support and resources to support teachers' professional learning and use of technology.

Finally, teachers' own desire to improve their professional knowledge and skill to support student learning provides the kind of catalyst that allows for innovative technology use. A commitment to life-long learning and a willingness to experiment with new instructional strategies shines through all the examples described in this report.

Contents

INTRODUCTION

Whether one stands in awe of the talents of "digital natives" or shakes their heads in distress at contemporary "devices of mass distraction" it is important to understand the educational value technology being used in Maine schools. With expanding options and increasing calls by parents, educators, and policy makers for greater use and training in technology, information regarding how technology is being used to meet various educational goals and pedagogical needs can help inform practitioners and policy makers regarding strengths and gaps in educational training and practice in Maine. Therefore, at the request of the Maine State Legislature, the Maine Education Policy Research Institute (MEPRI) sponsored a study to describe the current use of non-MLTI technology in K-12 education in Maine. This report describes a broad range of technology uses occurring in Maine classrooms, and educators' perceptions about the impacts of the technology for teaching and learning.

One question often asked by non-educators is, "What does effective educational technology actually look like?" This report provides examples collected from Maine classroom teachers, technology integrators, and library media specialists, as well as results from a limited state-wide survey of schools regarding their use of technology.

Rather than simply create a listing of technology projects and initiatives occurring throughout the state, this report is designed to illustrate **how educators in Maine are using technology in different ways in order to support learning and address various educational outcomes**. Narrative, "real-life" examples are provided in order to give readers the larger context and impact of example. These examples and vignettes are then categorized according to the broad purpose or intended outcomes of the technology—instead of grade level or type of technology. Technology is being used broadly in classrooms across Maine, both within STEM disciplines, but also in language arts, social sciences, and other areas. By structuring the report around the intended educational or pedagogical goal, we sought to focus broadly on the use of technology in schools across all disciplines, rather than narrowly focus on the training of technological skills.

Examples are organized around the following headings:

- ***Differentiated Instruction***: Using technology to provide varied and individualized instruction to students.
- ***Aspirations and Motivation to Learn***: Using technology to inspire and motivate students to explore new directions or skills. These are often targeting STEM fields, but not necessarily.
- ***Problem Solving:*** Using technology to help students learn skills related to developing hypotheses, critical thinking and decision making.
- ***Communication and Community***: Using technology, often digital media, to communicate with others and to develop a global (and local) awareness.
- ***Leveraging Power of Technology***: Using technology to expand teaching and learning opportunities, and enhance educational practice in engaging and innovative ways.
- ***Using Data to Inform Instruction***: Using technology to readily compile data for students and teachers so that it can inform instructional decisions and help students learn.

Finally, it should be noted that while the term "technology" is often used synonymously with computers, this report is interested in technology in the broadest sense, including other contemporary devices, resources, or tools.

METHODS

In the fall of 2013, MEPRI solicited requests for examples of how technology is being used in schools from non-MLTI schools via three state listservs:

- *MeLibs*, sponsored by the Maine Association of School Libraries and Maine Library Association
- Two listserves from *the Association of Computer Technology Educators in Maine*
    - The general ACTEM list has a broad audience of technology coordinators.
    - ACTEM Technology Integrators, a smaller list targeting instructional technology.

Follow-up emails provided additional information. Examples were also collected from current and past students in the Master's of Education, Instructional Technology program at the University of Maine. Others were collected from educators collaborating with UMaine and MEPRI researchers in studies of specific technology tools (i.e., Aspirnauts, ASSISTments, and Madcap). Each vignette is told in the educator's own words (with only minor editing). While permission was obtained to share these quotations, we have used only the first name and general job description of these participants in order to maintain privacy. While we cannot generalize from a few informally collected cases, they do illustrate diverse ways in which educators in Maine are using technology to promote student learning and growth.

FINDINGS

DIFFERENTIATED INSTRUCTION

Education is a complex process; teachers must balance curricular standards with students' developmental levels, behavior, cognitive abilities, and interests to best meet student learning needs. The goal is to deliver differentiated instruction, where students receive instruction that specifically addresses their own learning styles or requirements. Dr. Puentedura, a consultant to Maine Department of Education, outlines levels of technology use that can facilitate this process. The least innovative type of use is "Substitution" – a simple replacement of one tool for another, such as a computer supplanting a typewriter. The highest level of technology use is "Redefinition" which "allows for the creation of new tasks, previously inconceivable," and this level has a transformative impact on learning (2014).

While technology seems poised to provide a means of instruction that can individualize or differentiate learning, merely placing the technology in schools doesn't ensure that learning goals are met, or even that the tools are used in goal-oriented ways. The following three examples illustrate specific ways that technology provides flexibility and differentiation in learning at both the classroom-level and for specific students.

Individualized Group Activities: Fire of 1947 Project

When done well, technology can allow teachers to shape classroom assignments or projects in a way that different students can benefit from multiple modalities for both learning and demonstrating their knowledge.

> In a third grade class, students created a newscast about the *Fire of 1947* [Bar Harbor, Maine]. Before writing a script, students learned how to use *Photo Booth*. To practice recording, students were prompted to tell everything they knew about the fire. This allowed the teacher to check in with students: she could watch the recordings to see what they knew, or what misconceptions they had. Then students worked with partners to write a script and do a final recording. This was a great alternative to the traditional presentation. It took away the pressure of speaking in front of the class and allowed the teacher to re-watch the recordings. In this case, students wrote out a script before the final recording. However, I think that recording is a valuable classroom tool with or without a script. I have noticed that if students don't like to write or struggle with writing, they may not include everything they know on paper. In addition students use only the vocabulary

> they know how to spell. Recording and dictation allow students to show what they know without a pencil and paper. (Iris, Technology Integrator)

The Fire of 1947 project illustrates two valuable ways that teachers can innovatively use technology to support differentiated instruction. Although researchers have identified a complex relationship between speaking and writing, children typically express themselves orally before they are able to do so in writing (Teale & Sulzby, 1986). As Iris points out, students can demonstrate their knowledge about this event in Maine's history in a way that supports their strengths. While the ultimate goal is for students to communicate effectively in written form as well as before an audience or in a recording (Common Core State Standards), as seen here, technology can be used as a stepping-stone. It allows less proficient students to formulate ideas before writing a script, while providing expanded opportunities for those students who are already more proficient. In particular, for many students this project serves to stimulate thinking and help to eliminate the stress of facing a blank page.

Secondly, as this assignment unfolds, all children have the potential of *actively* learning, in contrast to passively listening to a series of one-at-a-time student presentations. The teacher can circulate around the room, prompting deeper thinking, and ensuring that students remain focused on the task. An added benefit comes from recording the ephemeral processes of students' learning, such as found in the developmental stages of learning to write well. The teacher can use these recordings to monitor students' thinking and writing progress outside of class, allowing her to use the limited class time as needed without losing important information on how all students are doing. Furthermore, with such recordings teachers can juxtapose a child's initial attempt at organizing and communicating ideas to those of a later date in order to evaluate growth in fluency.

Audio Books and Technology: "Playaways"

While the 1947 Fire Project illustrates how technology can enhance an entire classroom-wide project, the same benefits of differentiated instruction and learning can be applied to specific individual children—some students need to work with alternative forms or styles of material.

> [For our library] I bought *Playaways* (audio books playable on mp3 players or other devices) to expand the range of materials available to the students and to use in the classrooms. Some teachers jumped right in and tried them out. One of the special

> education teachers could see the potential. She has used them with several of her students, and now they are asking for more and more. Some of the students have made large jumps in fluency, others have increased their vocabulary, and some are willing to try new books. The latter is interesting because some of these students were very hesitant to look at anything they did not already know. I know this may not be considered "deep" learning, but it is significant learning for these students. Some are able to access the same books the rest of their grade level is using, participate in discussions and interact with classmates on a level never possible before. More of the students are choosing *Playaways* for their library books, too. (Barbara, elementary school)

Library Media Specialists can provide crucial support for differentiated instruction that impacts students throughout an entire school. Barbara ordered audio books in a popular and commonly used format (mp3) and was impressed with the variety of ways teachers used them to enhance learning and reading. Often, teachers would pair an audio file with a paper copy of the book and encourage students to follow along in the text. At other times, students would be encouraged to hone listening skills by using audio only, while drawing or mapping components of the plot or character attributes. For aural learners who may experience attention or distractibility issues, an additional benefit of digital books is the ease of backing up to hear again confusing or complex passages.

Most children understand more words they hear than they are able to read (Graves, 1986). Thus the same audio book can be used to challenge and extend the reading ability of Barbara's youngest students, as well as to provide auditory support for older, but less able readers. For many struggling students, audio access to quality literature allows them to extend their range of reading materials because they *hear* excellent writing without stumbling through lengthy sentences. For example, Barbara reported that special education students in her school benefited from knowing and discussing the same books as their peers. This helps to create a more inclusive and positive classroom experience for these students. Similarly, for any struggling reader, audio books may tap the motivational aspects of quality writing, helping the student to discover the joy of reading.

Digital Texts: Bookshare.org

Beyond audio-books, technology provides other formats for traditional paper books that can help many students who need alternative, differentiated learning support. Hillary, an assistive

technology specialist, saw major benefits from digital texts as a tool for differentiating instruction for special needs high school students:

> Students in grades 9-12 access technology in various forms (i.e. laptop, iPad) to access instructional text that has been downloaded from Bookshare.org (a service available for students who have a qualifying print disability). This affords these students access to grade level text in a modality that allows students to take notes, highlight words, and have the text read to them. (Hillary, assistive technology specialist)

Because of their inherent flexibility, digital texts often allow students and teachers to manipulate the format and style of written material so that it can be more accessible to students with disabilities. This is not possible with paper text books, where at best, a limited set of alternative texts may be available on request. Furthermore, this example illuminates an additional benefit digital books provide all students: the ability to interact with the text in a way that does not damage the actual text. With a simple click of the mouse, a student can hear or read the definition of an unfamiliar word. The highlighting and note taking features of digital textbooks allow readers to identify key concepts and questions, and change or remove this highlighting and notation as students understanding grows.

Tools for Individualized Instruction: English Language Learners

Not surprising, this same technology and tools that help those students who may struggle with reading or vocabulary, can also benefit English Language Learners (ELL).

> This year I have 23 students - eight students are ELL - in my classroom. I have been using iPads in my kindergarten classroom since the spring of 2013. I got the idea to use iPads in my classroom when I read about the kindergarten teacher in Auburn using iPads in her classroom. I use iPads as both an intervention and enrichment tool. I have seen good growth in students who are struggling with number or letter identification, etc., when it comes to using various number and letter apps. My ELLs, whose first language is Spanish, have really done well when it comes to learning phonemic awareness by using apps that promote sound/letter connection. . . .
>
> I have been telling my principal and fellow teachers that the days of using flash cards and worksheets to help students learn numbers, the alphabet, spelling, and other academic content needs to die. Today's young students are hooked into using technology. My students are more engaged in their learning when they are doing an interactive intervention activity on an iPad than if I were sitting in front of them holding up a flash card saying, "This is the letter Bb. Now this is the letter Ff." Using sound, educationally appropriate apps have really benefited my young students in their learning. (Suzen, kindergarten teacher)

Suzen explains the effectiveness of the iPad technology for teaching early literacy skills in terms of the immediacy of feedback and the enticement of using mobile computing. She highlights the fact that students are learning independently and not relying on her to be present in every instructional situation.

Tools for Individualized Instruction: Assistive Technology

As these examples illustrate, technology offers great potential for helping many children with communication challenges. The *Autism Spectrum Disorder Foundation* promotes iPads because they offer amazing benefits for autistic children. iPads do not need an input device (mouse or keyboard); they use a touch screen. They are portable and they provide customization that support communication needs for autistic children.

> A student with Autism uses an iPad to communicate wants and needs during the school day, and participates in the regular education classroom using an iPad to "talk" with peers, as well as for academic tasks (i.e. spelling, math). Special Education staff use iPads as video modeling exercises for students with disabilities in completing tasks, behavioral compliance, and participation in the regular education setting. They also use videos as a way of demonstrating student progress in reading fluency and oral comprehension. (Hillary, assistive technology specialist)

Aspirations and Motivation to Learn

One of the major promises that many educators have held out in regards to technology, is that it can be a valuable tool to inspire and motivate students to explore new directions or skills. Efforts in this regard often target STEM fields, but not necessarily.

Computer Programming

Computer programming is one obvious area in which technology can inspire and motivate students to explore new fields, while learning valuable skills such as problem solving, planning, and logical reasoning. Even young students are capable of grasping the fundamentals of writing computer code as Cathy notes:

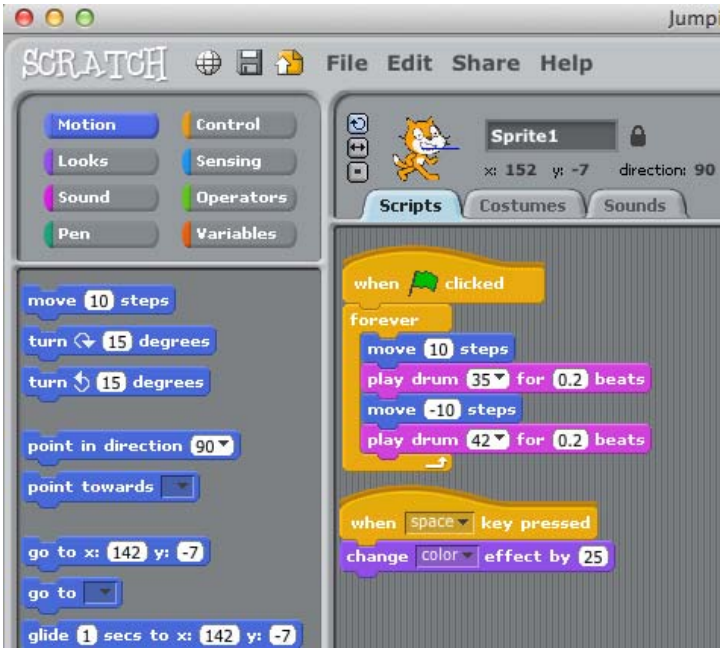
Recently, all students in grades 1-12 participated in the *Computer Science Week "Hour of Code"* to learn about sequencing, repetition and logical thinking. At the middle school, community members came in to math classes and talked about using programming and code in their workplaces and students accessed the http://csedweek.org/learn videos and tutorials using various programming tools. At the high school, all math classes participated and, even at elementary level, second, third and fourth graders spent a class building code to solve maze challenges. First graders used the app *Kodable* on iPads.
(Cathy, technology integrator, elementary school)

Hour of Code

Nineteen percent of 37 Maine schools that responded to a school technology-use survey, reported participating in *Hour of Code*.

For some students, programming involves what Seymour Papert calls "hard fun": The internally motivated human desire for challenge and personal satisfaction. Pondering the types of activities that engage youngsters, Dr. Papert created *Logo*, a child-friendly programming language. He wrote a simple computer program combined with a robotic turtle that students could manipulate using commands such as "forward 10 [steps], left 90 [degrees]." This *Logo* language was subsequently made accessible to even younger students with *Scratch*, free software developed at MIT. *Scratch* uses a virtual or digital turtle or cat instead of a 3-dimensional one. Clare describes her students' experience with *Scratch*:

Figure 1: Example of coding blocks in *Scratch*, programming software created at MIT



I introduce *Scratch* to my fourth graders each year so they have a chance to try their hand at a bit of programming, after a brief intro to binary code to show all the progress we've made in programming over the years. *Scratch* allows them to create animations, which involves many skills and decisions. Students are collaborating, speaking, listening, planning, thinking, deciding, creating, testing, fixing, troubleshooting, rethinking, and

> sequencing. (I recently asked students to come up with their own list of verbs and my favorites were "realizing" and "being smart.") We discuss how learning can happen, even if their animation isn't yet doing what they want it to do. . . .
>
> While I design many other projects that could or should result in deep thinking and learning, I have to admit that when using *Scratch* this sort of thing seems to happen more naturally and effortlessly and with far more self-motivation, for a vastly higher percentage of students. This year I introduced *Scratch* earlier, so my fourth graders would have it as a "free choice when other work's done" activity for more of the year. (Clare, technology teacher, elementary school)

Clare and many other educators around the state of Maine have identified *Scratch* as a free resource providing multiple benefits. Not only are students introduced to valuable skills at an early age, they also are provided a setting in which to practice logical thinking. The fact that children are sufficiently motivated to work in *Scratch* during their own "free choice" time illustrates its power for engaging students in learning.

Minecraft is another student- and teacher-friendly tool with which some educators are introducing programming concepts to youth. MinecraftEDU is a "sandbox" computer program that allows novice students and teachers to create "virtual" worlds in a controlled environment. In doing so, students naturally learn basic programming, computer science, and problem-solving skills in an inherently engaging and interactive format. Minecraft is being used by a number of schools around Maine, both in class, but often as an after-school club.

Expanding Minecraft in Maine

MEPRI is currently partnering with Computer Science and Education researchers at the University of Maine on a $1.5 million NSF grant proposal to support and expand MinecraftEDU opportunities to schools across Maine.

Technology-Facilitated Engagement: Aspirnauts

While programming is one way some have found to engage and motivate youth to explore new areas and disciplines, technology provides other ways to increase student engagement and aspirations. As the name implies, Aspirnauts is designed to introduce children to STEM research, and encourage them to "aspire" to studying and ultimately seeking jobs in STEM fields. Last year, as part of the work conducted for MEPRI, we reported on the use of video-

conferencing in elementary schools in Maine, to help teachers and students connect with research scientists (Fairman & Jorgensen, 2013).

In classrooms participating in the "Aspirnauts" program, teachers used their laptops and a smartboard/ projector and large screen to connect the classroom to scientists at Vanderbilt University. The scientists facilitated students' hands-on science investigations in the classroom, engaged students in discussions about what they were learning, and provided clear and content rich answers to students' questions. Depending on the topic of the lab, different scientists were involved to share their expertise in geology, biology, chemistry, engineering, medicine, and other fields. Teachers and students praised the program for not only the strong science content, but also for the opportunity it provided to motivate students to aspire to further study and careers in STEM disciplines. Students proudly donned their white lab coats while "doing real science" in their classroom laboratories, and talked about different ways they could pursue their interests in STEM careers.

Programming Options Available in Maine Schools

Based on a limited survey of Maine schools, it appears that formal training in computer programming may be limited. Of 37 schools that responded to a technology-use survey, *Scratch* was taught at 14%, followed by Java, which was taught at 11% of these schools. Only 14% of responding schools offered any programming instruction beyond *Scratch*—with only one of these schools offering C/C++ and two offering Basic/Visual Basic.

Robotics

While programming is one way to engage and motivate youth to explore new areas and disciplines, technology provides other ways to increase student engagement and STEM disciplines. Nationally, robotics is another relatively popular approach for introducing students of all ages to programming and engineering. Schools in Maine have participated in a number of robotics programs. For example, in 2013, 76 teams and over 600 students from across Maine participated in FIRST LEGO League Team robotics competition. FIRST LEGO League covers a wide age-span, including elementary school age students, and can involve in-school, after-school, or school-affiliated teams. Another robotics program seen in Maine schools is the FIRST Robotics competition. FIRST robotics specifically targets high school students, with 14 teams currently from across Maine. This involves sophisticated design and programming work,

requiring many of the "21st Century"-type skills currently receiving attention, including problem solving, ability to work in teams, and creative thinking. The 2014 competition is titled "Aerial Assist" and involves two teams of three robots earning points through various elaborate strategies that require teams to work together to get large balls into their goal area. A video of the 2014 assignment is available at: http://www.youtube.com/watch?v=f5zWzICG5to&list=PLZT9pIgNOV6ZXH3WmbXEK4bwDuPZcMFF3

PROBLEM SOLVING

Teaching Problem Solving: Debugging

From a pedagogical perspective, many of these "hands on" uses of technology—particularly areas such as programming and robotics— share an underlying theme of promoting problem solving skills in children. The goal of strengthening problem solving abilities in students is woven through nearly all recent educational initiatives, including Common Core and the Next Generation Science Standards, it is seen as a fundamental 21st century skills that students will need in the workplace. In part, this is what helps to draw many teachers – even those who would not have previously thought of themselves as "geeks" – to programming and robotics. As Clare went on to describe, "debugging" is a vital component of any programming application such as *Logo* or *Scratch*. Students decide what they want the avatar (a figure that represents the user) to do, describe the needed steps to attaining their goals, and test their directions. Feedback is instant; the avatar does what is wanted or it doesn't. Students must figure out what went wrong, fix the directions, and retest the programming. Debugging becomes a life skill that can translate into "what is the problem?" and "how can I solve it?"

Teaching Problem Solving: Popplet

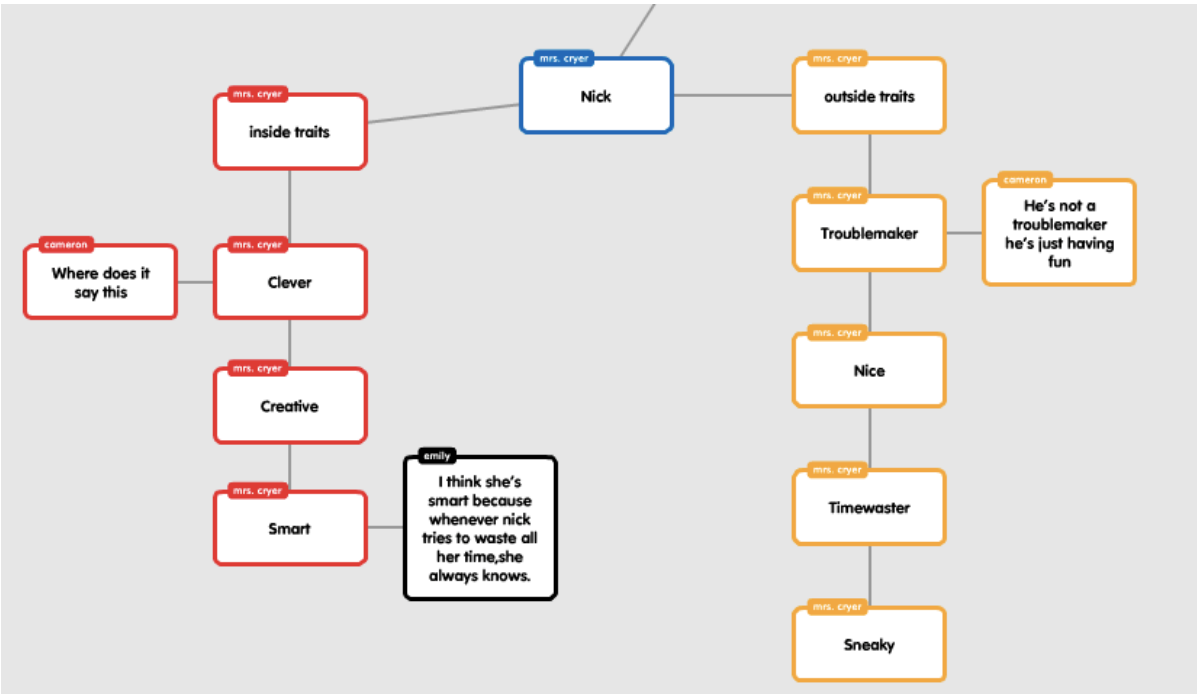
Beyond programming, technology provides other tools for teaching problem solving skills to students in more depth and complexity than is possible with more traditional means. Consider the following classroom project using concept maps, also called webs.

> I had been wanting one of my reading groups to create a digital story map, but *Bubbl.us* [an online webbing app] does not allow synchronous access [multiple users working at the same time]. The students had started a concept map on paper, but their thinking was

not as deep or connected to the book as I was looking for. And they were not truly engaged. So, I took the beginning of their story map and recreated it on *Popplet*. . . .

Today I gave them their log-in information, planning to show them how it is different from *Bubbl.us* and how they can add comments and such. Once they were in, I never had the chance to say a thing! Within a minute they began writing in new vocabulary words, their thoughts about what words meant, their agreements and disagreements about events and characters, and so on. They worked side by side on their own laptops in our [private and secure] chat room. It made my day! (Marty, third grade teacher)

Figure 2. A small section of the concept map by Marty's third graders ("*Popplet*")



Marty noted how quickly her third graders engaged with a new tool (*Popplet),* one that had some similarities to the concept mapping tool with which they were familiar, but contained the added feature of real time collaboration. As a teacher, Marty noted that she was initially surprised that their normally bustling room was unusually quiet during the exercise. Upon investigation she found that children were actually having great discussions -- in writing. "It was an incredible display of how comfortable they feel with technology with the right resource," Marty explained.

While teaching practices such as concept maps and webs can be created with pencil and paper, there are important differences when technology is involved. For example, some teachers will introduce a new unit by projecting a concept map. The students then offer statements about what

they already know (or think they know), with the teacher color-coding these concepts as they are generated. As questions emerge, these also go on the concept map in a different color. This web is digitally saved and mid-way through the unit, the teacher presents it again to the class. Students revisit what they thought they knew and can correct misconceptions. Answers to questions may be added; questions no longer relevant may be deleted. Items can be colored differently. This updating is part of the learning process and the teachers use this time to "think aloud" about ways that an experienced learner contemplates new information.

COMMUNICATION AND COMMUNITY

Teachers in Maine also use technology as a way for communicating and working with others—both near and afar. The important of using technology for this purpose is officially recognized by the International Society for Technology in Education (ISTE), and is reflected in the Common Core State Standards.

One teacher, Nadene, created a blog for her first grade students[1] with the result that her students made friends with a classroom in Eastern Europe, exchanging ideas, insights, and songs. The Maine children learned to sing a song in a different language, which was video recorded and posted with a blog entry. Nadene reported that learning the words was difficult, but the children loved it and sang it endlessly for the rest of the year. That year happened to be an Olympics year and so the children cheered for "the country of their new friends." This type of international collaboration and community building is particularly valuable for many rural schools where such opportunities may be limited or impossible without technological aides.

International Society for Technology in Education (ISTE) Standards

2. Communication and Collaboration (NETS-S): *Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.*

It's worth noting that these first graders not only built friendships with a classroom in Slovenia, they also interacted with high school students in their own district.

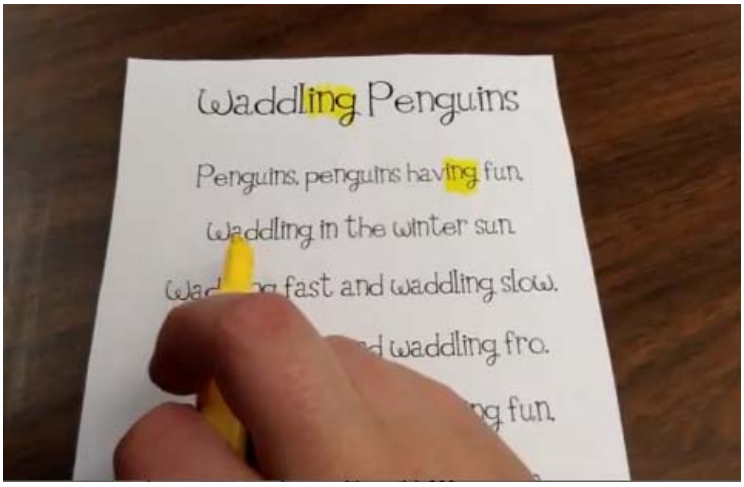
[1] Done in alignment with her school's Acceptable Use Policy and in a way that students could not be identified.

> My class wrote dragon stories, and then we partnered with a high school French class. They read the stories and translated a word or two from the stories into French in the comment section. Each author picked the French words they wanted to learn, we made an audio file on QuickTime and sent it to the high schoolers. (Nadene, first-grade teacher)

In this manner, the young children realized that high school students they knew were studying French. They understood the application of the abstract concept "modern language" as applying to words they wrote in their dragon stories. This broadened their horizons, fostered collaboration, and promoted a foundational understanding of global citizenship.

A different type of collaboration was demonstrated in Marty's report of her third grade students' use of *Popplet*. Her students discovered and instinctively used a private and secure "chat" area to the benefit of the entire classroom. Via the technology, students assisted others with vocabulary definitions and negotiated the meaning and themes of a piece of literature.

Figure 3. Screen shot from a video in which the teacher extends the in-class lesson for students who were out sick or for those who need additional practice.



Leveraging the Power of Technology

Another benefit that many see in technology is that it provides teaching and learning experiences that exceed the capabilities of traditional tools.

"Multiplying the Teacher"

> One such valuable way that teachers have learned to apply technology is to use it to expand the teacher's presence, providing more opportunity to teach and learn. I am currently working with teachers in grades K-2 who are implementing five iPads in each classroom. They are doing things such as recording lessons to "multiply" the teacher, and developing their own e-books that address the topics we are working on. Other teachers are using the technology to record their whole group lessons to allow for students to revisit the content or to share with students who missed the lesson for various reasons. (Audrey, literacy specialist, elementary school)

As education seeks to provide more differentiated teaching targeting individual student learning needs, teachers are faced with the fundamental challenge that one can't be providing individual attention to everyone all the time. Audrey explained what it meant to "multiply the teacher" through simple video technology now readily available on most devices. For example, as the teacher prepares a lesson on the suffix *-ing*, she records herself reading text and highlighting the targeted syllable. What extends the video beyond a one-way communication from teacher-to-student, is the invitation for the listener to mentally participate. For example, in the video she then queries, "There are two *–ing brothers* on this line. Can you find them?" She pauses and then reads the line and highlights the appropriate suffixes. By asking probing questions, the teacher is stimulating deep thinking and by recording it in advance, she is able to work more intensively with some students, while other students continue to learn. Furthermore, some teachers place instructional videos on their class website thereby providing parents with an understanding of class instruction as well as providing more opportunities for students to learn or practice at home.

Figure 4: Screen shot from a video of students reading to each other.

Other teachers have adapted this use of technology strategy to "multiply" reading and literacy time by recording students reading to each other. For example, one teacher, Stephanie, uses these recordings to support additional practice reading aloud time for students. She then evaluates student reading in order to plan for short-term instruction and individual intervention strategies.

> I have kiddos practice reading to each other and record it. Then I can check it that night and see what their independent reading skills are like when I'm not around. Then I can plan lessons to address strengths and needs. (Stephanie, kindergarten teacher)

Videos of students' reading provide visual and auditory evidence of learning that teachers can store over time and use to assess and demonstrate student growth.

Electronic Portfolios for Measuring Growth

In that regard, using video or other types of digital information can be used to assess student growth in many areas. For example, another teacher, Kim, has her art students create digital portfolios.

> All of the students in studio art courses at [Kim's High School] are expected to create digital portfolios that document their growth in the course over the year. These are added to each year, creating a visual to easily document evidence of learning and improvement. Students use Google sites to create their digital portfolios. They are required to scan/photograph their artwork in a "professional" manner, write reflections, and create videos in which they display and discuss their process. These have been amazing for the students (and teachers) to easily see how a student has improved over the years (especially for students taking art all four years of their high school careers). These portfolio sites are often included in their college resumes and applications. (Kimberly, visual arts teacher, high school)

Enhanced Online Learning Resources: Madcap Learning Adventure

While all of these examples have shown ways in which technology is being used to provide teaching and learning experiences that exceed the capabilities of traditional tools, perhaps the most high profile such use of technology is with formal online education resources and tools. These include commercial products available from many textbook publishers that either expand or enhance material available in the texts, to free products (e.g., Khan Academy, ASSISTments) that serve as stand-alone complements to other resources a school may be using.

Recognizing Technology Resources in Maine Schools

The Madcap Learning Adventure is being developed by a Canadian educational software group that chose Maine as a test-bed for piloting their system due to the technological infrastructure available in Maine schools—particularly laptop access and internet connectivity.

The Madcap Learning Adventure is an online, interactive learning system that allows students to work at their own pace and engage with a variety of multi-media tools to support and integrate critical thinking and learning of reading, writing, and content knowledge. Modules include a number of components that were designed to engage students in student-led exploration and learning—goals emphasized in the Common Core State Standards. For example, students were able to explore a map of the Battle of Gettysburg, tracing the action and movements on the field

from before the battle started, through the end of the fight. At any point, students could zoom in on key figures or locations and explore what was happening at different locations at the same time, or follow different figures (e.g. Joshua Chamberlain) throughout the three day battle. This type of interactive, individualized learning resource is only possible through technology-based resources.

Two Maine middle schools piloted a social studies unit on the Civil War, with the results showing improvement in writing skills and persuasive argument (a similar project was piloted for math skills in Canada, also with positive results). Teachers and students reported that students were more engaged using the program and that the high quality of content on the interactive videos, maps, and timelines enriched their learning. ". . . you were learning about the Civil War, but at the same time, you were learning how to write persuasive arguments and stuff. And I kind of like how they sort of snuck that in . . ." (8th grade student). Students uniformly reported that many of the features, such as the Battle of Gettysburg component, were highly engaging and led them to want to learn more.

Khan Academy

Of 37 schools that responded to a technology-use survey, 59% reported having teachers that used Khan Academy as a free, web-based resource.

USING DATA TO INFORM INSTRUCTION AND STUDENT LEARNING

Finally, technology – particularly computer technology—creates the opportunity for both students and teachers to receive more information regarding the learning process, and to receive this information in a more timely manner and in more usable formats.

Adaptive Assignments: Hungry Guppy

Research shows that providing students with immediate feedback regarding their learning – is their understanding correct or incorrect, is their answer right or wrong—enhances long-term learning and academic performance. Simply knowing that one has answered a question incorrectly can help a student avoid future mistakes that might come from basing new ideas on errors. A variety of software exists that provide this type of immediate feedback to students.

> Our Kindergarten and first grade students do centers at least twice a week. One of the centers consists of iPads where an adult instructs students how to use a specific app and supports them when necessary. Some of the apps we use are *Counting Caterpillar,*

> *Hungry Guppy, Number Bonds: Addition & Subtraction, Jungle Coins, Letter School,* and *Lexia Core 5*. These apps are used to reinforce concepts and skills in Math and ELA [English language arts]. For example, *Hungry Guppy* requires students to combine dots within bubbles to make a specified number – the exact number that the guppy needs to eat. (Iris, technology integrator)

Iris explains that this type of app provides a deep learning experience because it is not merely skill-based practice, requiring math fact memorization, but rather visualization of deeper mathematical concepts of number. The *Hungry Guppy* app (by Motion Math) functions as a math manipulative that provides interactive support for the abstract relationship between quantity, addition, and subtraction. Apps of this nature work well for very young or developmentally delayed children; they are able to understand what it means to put "two and two together." When the guppy isn't fed the correct number of dots, it shrinks a little, thereby providing a non-verbal response to the user's actions.

Furthermore, *Hungry Guppy* is "adaptive," which means easier problems are presented if the child is having difficulty. If the user's speed and accuracy demonstrate mastery, harder problems appear on the screen. The power of computer technology is leveraged because feedback to the learner is immediate. In a matter of a split second, children know if they performed the operation successfully or not.

Immediate Student Feedback: Schoology

Beyond "Hungry Guppy", there exist a variety of resources that Maine teachers use that can provide more immediate student feedback than traditional tools across a range of topics.

> In Chemistry, learning to name chemical compounds and write chemical formulas is one of the most challenging topics for students. Normally, a step in the process is taught, worksheets reinforce the process and are also given for homework to be checked for correctness during the next class period.
>
> I've used *Schoology* to build a huge database of chemical names and chemical formulas. I then created 20 problem quizzes for each step in the process of naming compounds or writing formulas. I give a brief mini-lecture, have students try the problems on paper (so I can help if needed), and then turn them loose to work on a 20 question eWorksheet. They are also able to practice on their own on the days they don't have my class. The eWorksheets are scored automatically when a student is done. This gives them instant feedback about how they have done and shows them corrected mistakes. I can easily monitor progress online seeing if students have completed the eWorksheet and

how they have done. By allowing students to assess themselves daily, I've increased the ability of students to be successful in this challenging unit. (Jeff, high school chemistry)

ASSISTments

Finally, computer technology allows for large amounts of complex data to be assembled in databases and for simple interfaces with users and access the data whenever, wherever needed. Middle school math teachers in over 50 schools in Maine are using an online program called "ASSISTments" to support students' homework online using their laptop computers or iPads. The program provides teachers with instant summaries of students' progress on homework problems, informing teachers' selection of concepts and skills to target in the next lesson. Cathy describes the benefits this way: "I like the fact that students get immediate feedback, but more importantly, I get analyzed feedback about the students. I can address needs as they arise. Looking at the results before class leads my class review." (Cathy, middle school math teacher)

ASSISTments Evaluation Study

MEPRI researchers are currently partnering with Worcester Polytechnic Institute and SRI International on a $3.5 million U.S. Department of Education grant examining the efficacy of ASSISTments. This has brought free resources, training, and professional development to mathematics teachers in 48 Maine middle schools.

In addition to providing useful data to teachers to guide instruction, the ASSISTments program is also an example of how technology can motivate and engage students in their learning, and so could fit under that category of technology use as well. Rather than completing and turning in homework that may have persistent errors in thinking, and waiting for the homework paper to be graded and returned, students get immediate feedback from the software program to learn if their answers are correct or not. If not, they are encouraged to rethink their solutions to gain understanding. The following example describes how the software tool works with students at any ability level and continues learning beyond the school day when students do homework.

ASSISTments Evaluation Study

MEPRI researchers are currently submitting a $7.5 million NSF grant to expand ASSISTments to include Engineering Education targeting 30 middle schools across Maine. This is in collaboration with Worcester Polytechnic Institute, the University of Virginia, and the University of Colorado-Colorado Springs.

ASSISTments has truly benefited the entire spectrum of our student population. It's a great tool for our already engaged learners and also helps some of our struggling students meet with successes they might not have seen in the past. Our students' world is a technological one, and ASSISTments is a great fit for those kids. Our students are "plugged in" and ASSISTments is a great bridge from school to home. (Jerry, middle school principal)

CONCLUSION

While technology use could be categorized in various ways, and can sometimes fall into overlapping categories as we described in this report, the conceptual categories are useful for demonstrating the power of thoughtfully integrated technology. We identified technology use that facilitated: *Differentiated Instruction, Aspirations and Motivation to Learn*, *Problem Solving, Communication and Community*, *Leveraging the Power of Technology, and Using Data to Inform Instruction*. Regardless of the specific purpose for technology use, we can draw some broad observations about its potential:

- Technology has the potential to provide varied and multiple learning experiences tailored to the interests, needs, and developmental level of all students. Technology facilitates differentiated learning and individualized assignments for students.
- Today's students use digital tools in their free time; with support, educators can wisely build on these skills for instructional purposes. For example, learning time can be extended into the weekend, during in-service or snow days, and over the summer vacation, reducing the loss of learning that takes place during extended school breaks.
- Under Seymour Papert's influence, instructional technology use in Maine was geared to the concept that 1-to-1 technology provided a powerful "tool with which to think." In other words, computers properly used can be influential in promoting problem solving, critical thinking, and independent learning.
- Access to the Internet can facilitate collaboration and communication. However, digital citizenship must be fostered and taught. Class and school websites have the potential for better connections with parents and the community. Technology can also be used to develop connections with students in other states or countries, or with scientists, authors, and other professionals beyond the classroom.

- The inherent power of computing can be leveraged in numerous ways. For example, teachers and students can get immediate, delayed, or longitudinal feedback through adaptive and intelligent software programs.

We believe that this sample, albeit small, is representative of the uncelebrated achievements happening daily in Maine classrooms. Our call for vignettes garnered both laptop and mobile device examples. However, we know this is only a portion of technology use. We are aware of educators who are developing ways that interactive whiteboards can move from a presentation-only mode to more individualized learning center. Moreover, with the advent of better weather in spring, we anticipate that mobile technology will be brought outside on field trips in order to collect and organize data.

A concluding note is an essential addendum to this eclectic collection of vignettes. There are several words used in this document that were carefully selected-- phrases such as "*can," "has the potential,"* or *" is possible."* Placing computer technology in the classroom is not the panacea claimed by some. The benefits of such expensive investments are only as good as the knowledge, understandings, and beliefs of educators and administrators, parents and the community. Professional development is the key that has the potential to bring valuable returns on these investments.

Maine policymakers and education leaders need to consider several factors that impact the effective use of technology. One important factor is the level of technology literacy for educators. As the rate of teacher retirements in Maine begins to accelerate, younger teachers will assume these positions. While younger teachers may be more comfortable using technology, they do not necessarily know how to integrate technology into instructional activities in thoughtful, effective ways. Pre-service teachers need explicit, discipline-oriented and hands-on instruction on technology integration. To use an analogy, even though our college students know how to read, colleges of education offer courses on how to teach reading. For our current teachers, professional development is a must. The state, higher education, and school districts all have an important role to play in developing and providing high quality training for educators that connects technology with content and pedagogical knowledge.

Another important factor facilitating innovative technology use in schools is the administrative support and encouragement that superintendents, curriculum coordinators, technology integration specialists, and principals provide to teachers. It is important that administrators provide technology goals and expectations, resources, and opportunities for professional learning and experimentation.

Finally, teachers themselves are perhaps the most critical factor. Their desire to improve their professional knowledge and skill in the interest of stimulating deeper engagement and student learning is the catalyst for the kinds of innovative technology use we saw in the vignettes shared in this report. A commitment to life-long learning and a willingness to experiment with new instructional strategies shines through all the examples.

In the 1800s slates and chalk were used by students in schools. This is the 21st century. It is now time for education to understand that technology has an important place in our classrooms. (Suzen, kindergarten teacher)

REFERENCES AND RESOURCES

Auburn School Department. (2014). *Advantage 2014: Auburn's literacy and math initiative with iPads. Retrieved from:* http://www.auburnschl.edu/pages/Auburn_School_Department/Programs/Advantage_2014

Autism Spectrum Disorder Foundation. (2012). *Why the iPad is such a helpful learning tool for children with autism.* Retrieved from http://www.myasdf.org/

Common Sense Media (2014). *Digital literacy and citizenship.* Retrieved from http://www.commonsensemedia.org/educators/curriculum

Computer Science Education Week. (2014). Available from http://csedweek.org/learn

Donis-Keller, C., Bartlett, C., Gerrish, S., & Silvernail. D. L. (2011). *The condition of K-12 public education in Maine 2011.* Center for Education Policy, Applied Research and Evaluation. University of Southern Maine.

Fairman, J. & Jorgensen, B. (2013). *Evaluation of the Aspirnaut Program in a Rural Maine School*. Orono, ME: MEPRI and the Center for Research and Evaluation, University of Maine.

Prensky, M. (2001). Digital natives, digital immigrants. *On the horizon*, *9* (5). Retrieved from http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Edutopia. (2014). Retrieved from http://www.edutopia.org/

Graves, M. (1986). Vocabulary learning and instruction. *Review of Research in Education, 13,* pp. 49-89.

International Society for Technology in Education (2009). *NETS-A national educational technology standards for administrators.* Retrieved from http://www.iste.org

International Society for Technology in Education (2007). *NETS-S national educational technology standards for students*. Retrieved from http://www.iste.org

International Society for Technology in Education (2008). *NETS-S national educational technology standards for teachers.* Retrieved from http://www.iste.org

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Author. Retrieved from http://www.corestandards.org

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: Basic Books.

Puentedura, R.R. (2014). *SAMR: An applied introduction.* Retrieved from http://www.hippasus.com/rrpweblog/

Teale, W., & Sulzby, E. (Eds.). (1986). *Emergent literacy: Writing and reading*. Norwood, NJ: Ablex Corp.

AUTHOR'S BIOGRAPHICAL INFORMATION

Abigail Garthwait began in the field of educational technology over 40 years ago when she graduated from Rutgers University with a Master's in library service. One of the highlights of the degree work was a field trip to the school's computer (note the singular noun), which occupied an entire room. Her first career took place in an elementary school where the library media specialist was in charge of instructional equipment. Thus it was no surprise that the first computer in the school was purchased by the library. A few student computers were available soon after; each had an amazing 128 K memory capacity and all programs had to be loaded each time via 5.25 floppies. Abigail taught research skills and critical evaluation to the older elementary students when the school used dial up Internet. Years later, after earning a doctorate in literacy, specializing in technology-related issues, she was hired by the University of Maine to teach in the fledging Master's of Education, Instructional Technology program. Her interests and focus have remained on thoughtful and effective use of computer technology.