

MONTESSORI PRACTICES: OPTIONS FOR A DIGITAL AGE

by Mark Powell

Mark Powell's plea for an open-minded view on the full scope of technology that is compatible with Montessori education enriches Maria Montessori's clear modernism of welcoming science into her educational vision. Growing up digital can be intelligently managed so that "technology may offer an effective, adaptable, and easily available means ... to gain independence ... that may otherwise have intimidated them." Mark's enthusiasm for the right use of technology in history, writing, touch typing, information access and sharing, photography, place-based learning, and citizen science upholds technology as a supportive and educational tool for today's Montessori student. Mark offers a laundry list of technology resources to choose with commentary as to positive learning tendencies met by digital natives, millennials, and succeeding generations of young people who look to adapt to the onslaught of technological tools in carrying out life missions.

In recent years a great number of discoveries have been made to fully exploit almost all the energies that exist in this world. Whatever material wealth there is in our surroundings is being made use of. Man has explored and made use of not only the things that are on the surface of the earth, but has dug into the bowels of the earth to derive from it gold, silver, coal and all other minerals. Man has

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gone and knocked on the doors of the rocks in order to call forth from it precious metals. Man has gone down to the greatest depths of the ocean in order to see what sort of life exists there. I need not say that, with the discoveries of these energies and with their harnessing, man has worked the miracles that we enjoy in our times. Man indeed has acquired faculties and powers that in olden times were considered to be inherent only to the gods. He can speak from one continent to another. He can fly through the air. He has arrived at powers which are no longer natural, but supranatural. (Montessori, "Inaugural Lecture").¹

Maria Tecla Artemisia Montessori was the child of an era of explosive technological and social change throughout the world. Her life choices as much as her own words portray a revolutionary thinker who not only challenged the social conventions of her day but who also embraced innovation and understood the importance of technological progress in the evolution of humankind. Most famously, in the 1890s she defied intense public and professional antipathy (including that of her own father) to become one of only about twenty-four women in Italy to graduate in medicine by the turn of the twentieth century (Povell 31). But even as a teen she revealed herself as a young woman not easily intimidated either by technology or traditional Italian views on her place in society by enrolling in the Leonardo Da Vinci Technical School with the intention of becoming an engineer (Povell 29).²

Among those who first welcomed the famous Dottressa to the United States were Alexander Graham Bell and Thomas Edison, both leaders in technological innovation at the time. Several of her method's most famous graduates a century later are again transforming society through the use of information technology. Even while it was still an emerging technology, Montessori had produced a "moving picture" about her method, and much of S. S. McClure's motivation in sponsoring her visit here was in the profits he would realize from gaining exclusive rights to her film (Povell 98-100).

1. By "supranatural" Montessori is referring to the nineteenth century positivist idea that part of human evolution was to create a technological overlay on nature that would allow the continued development of the human spirit. This tradition saw science and technology as the salvation of humanity, having the ability to ultimately end human suffering.

2. See also Montessori Australia, *A Biography of Dr. Maria Montessori*, <<http://montessori.org.au/montessori/biography.htm>>.

Especially while in India, Dr. Montessori was fascinated by 16mm films that showed news, cities, natural phenomena, mechanical or scientific apparatus, or attempted to portray history. She supposedly imagined a day when elementary children could load and view film themselves from a library of images and sound.³ All in all it's a fairly safe bet that if Maria Montessori were alive today she would own—and know how to use—a smartphone and probably also a tablet.⁴

If Dr. Montessori were a young mother now, would she allow little Mario to spend any time manipulating apps on her iPad? Would she view this as giving more to his mind than to his hands? Now more than ever, this question demands careful consideration from Montessorians. The popularization of touch-screen technology has lowered the age of entry into the digital realm as children no longer require a working knowledge of the alphabet to access a smartphone or tablet. Although Dr. Montessori understood the importance of technological innovation to human progress and was not frightened by it, she saw the undiscovered power of the human mind as an even more important source for the peaceful progress of human society and frequently warned against educational methods that bypassed the senses and overwhelmed children with information that has not been filtered to match their developmental characteristics:

How are the discovery and full use of whatever is available made possible? It is made possible by the great powers of the conscience and intelligence of man. Then I ask...Why is it that a little piece of land or some source of energy, are

3. This anecdote was related by Tim Seldin, president of the *Montessori Foundation* and later corroborated by Elena Dompè of the *Opera Nazionale Montessori* in Rome. According to her, the importance of educational films was dealt with in the July-August 1932 issue of the *Montessori: Rivista bimestrale dell'Opera Montessori* (235-238), a bimonthly magazine of which Dr. Montessori was director. The magazine even suggested that teachers themselves should make these kinds of films for their students.

4. A 2010 AMI position paper on digital technology concurs, at least in principle, that "It would be safe to say that Maria Montessori would view the iPad as a tool for tomorrow's mind. She said, "Give the world to the young child," and this new technology has the potential to do this." ("Virtual vs. Reality: Montessori Education and Today's Technology" in *AMI/USA News* 23.4, 2010.) Perhaps a more interesting question is whether she would prefer the centralized quality control of the *Apple* ecosystem, or the more open invitation to uninhibited, innovation-allowed *Android* developers. If she were to act privately with the same scientific mind that she exhibited publicly, she would surely have tried out both to see which platform best suited her needs.

of greater attraction to governments and the best minds of science? Whereas the immense energy that belongs to the human mind, that has created out of nothing the whole of our modern civilization and has made all these new discoveries possible, is overlooked. ...While just a little bit of land left uncultivated is pounced upon, yet thousands and millions of human beings are abandoned and left uncultivated....The study of the child itself has been very modest in comparison to the studies in other fields....A movement is necessary to uplift this sleeping humanity and to make it conscious of its power and of its hidden wealth.... Today education (what is called education), is still largely the passing on of information. It is static and stagnant. It fails its purpose if it remains on the same old level, if it does not move with the needs of the time. Mere information imparted is nothing. It is the cultivation of the values that are hidden in the human personality that is of importance and urgently needed today. The mere transmission of a greater amount of information cannot help much. It is the cultivation of the personality itself, of man himself, that is necessary. (Montessori, "Inaugural Lecture")

Dr. Montessori was an innovator who embraced technological change and encouraged us to "Give the world to the young child." When used in ways that are in harmony with the developmental needs of the child, technology can help deliver the world to the child. She saw threats to humanity not necessarily in technology itself but in our compulsive idolization of technology and the transmission of information at the expense of the cultivation of the personality of the child. For many Montessorians, separating the threat from the potential has, in recent decades, become a challenging puzzle as technological changes and the concomitant transformation in Western societies have raised the possibility of innovations to the Montessori curriculum.

Both AMI and AMS offer cautious statements of support for the introduction of digital technology into Montessori classrooms while reminding us that digital experiences should not take the place of hands-on, real-time activities, especially for younger children. The AMS statement focuses on digital technology as a communications tool, suggesting that at the elementary level and beyond "Technology may enhance student research through the ability to access and

exchange information in global learning communities.”⁵ Apart from their use as a reference tool, computers are seen here as a means of enhancing skills: “As we move into the twenty-first century, our children will be expected to have digital-age literacy, inventive thinking skills, effective communication skills, and high productivity skills. Efficient use of technology as well as basic Montessori practice can aid in achieving these objectives.” The only principles it offers that might be used to select from among the various forms digital technology can take in Montessori classrooms are that, like any other material, it must nurture the development of the child and complement, rather than replace, the Montessori curriculum. There is no suggestion that digital technology might also serve as a medium for creative expression.

The question of how digital experiences differ from other two-dimensional, primarily visual, activities common in Montessori classrooms (such as three-part cards) is not explored. Without offering any examples of ways that digital technologies might be used in classrooms or credible research on its negative effects, this statement warns that “this new technology bypasses many of the developmental needs of the child and, at times, speeds them up.... The iPad could provide a useful learning tool to supplement Montessori education, but at the same time, is no substitute for the immeasurable amounts of knowledge gained from real-life encounters and hands-on, three-dimensional learning experiences.” The AMI statement suggests that Montessori education must not be technophobic and children should be prepared for the digital world despite the absence of computers from their classrooms.

THE DIGITAL BIG BANG

Wherever possible mechanical contrivances are introduced for every detail of practical life, so that our children may be fitted to take part in a civilization which is entirely based on machines. (*To Educate the Human Potential* 8)

Like most young boys of the 1960s, the technology that most often infused my play involved transportation. My first free-form Lego creations were cars, trucks, and planes. My daughter, born in 2009,

5. “AMS Position Statement on Information Technology” 2010.

has had very little access to screens and yet she has gleaned from observing adults around her that the valuable technology in this era is digital. Her first spontaneous Lego object was an iPhone, with colorful knobs for calling grandma and a flat surface for viewing family photos and *YouTube* videos about sharks or flamenco dancing!

Whatever form it takes, this digital appliance has become an indispensable “memory box” capable of sustaining an exhaustive record of our day-to-day existence. Depending on how many of the more than 1.5 million apps now available for either iPhone or Android we use, our digital devices have become an amalgam of the family album, home video library, scrapbook, educational portal, file cabinet of work-related documents and media, telephone, television, scanner, alarm clock, remote control for an increasing array of Internet-connected appliances, camera (still and video), juke box and tool of creative expression all wrapped into one. Since for most of us it’s always within reach, we can handily record anything at any time at high resolution and instantly access almost the entire extent of human knowledge and culture in a variety of multimedia formats (Lambert 5).

As these devices have captured more of our lives over the past decade or so, the Internet has exploded exponentially, like a digital Big Bang. By the end of 2006, Facebook had about 12 million users; by its tenth anniversary in 2014, the leading social networking site had 1.23 billion monthly active users, one quarter of whom were reportedly under the age of ten.⁶ By the first quarter of 2016, Facebook’s user base had grown to over 1.65 billion—if it were a country it would now be the largest in the world, followed by China then India! Started in early 2005, YouTube was hosting 6 million videos by 2006. Eight years later there were 6 billion hours of video being watched on YouTube every month, with 100 hours of video being uploaded every minute! YouTube now reaches more 18 to 34 and 18 to 49-year-olds than any cable channel, and 80% of its traffic comes from outside the US. Growth in watch time has increased by at least 50% year over year for three straight years, and the number of people

6. Most of the statistics in this section are from Wikipedia and a few other Web sources. The numbers can vary widely depending on the source. For the purposes of this article their accuracy is less important than the impression that they’re always big and continue to grow exponentially!

watching YouTube daily has risen 40% year over year since 2014! The social photo sharing site Flickr was started around the same time, and by 2006 was hosting 3.5 million photos. Currently about 2 million photos are uploaded daily to the site, with a total of 728 million new photos posted in 2015. We live in exponential times!

With this rapid expansion of the Internet, information has become increasingly ubiquitous and easily accessible. Google was started in 1998 as the result of a research project by Stanford University Ph.D. students (and former Montessori children) Larry Page and Sergey Brin. Search traffic has grown from 9,800 searches per day that year to almost 6 billion searches per day in 2013 when Google was the largest search engine and most visited site on the Web. As Thomas Friedman has argued, the world is becoming “flat,” blurring the age-old distinction between an aristocratic class of information producers (“experts”) and consumers of information.

The process of digitizing anything and everything worth knowing and then uploading it to the Web is accelerating at an astronomical pace. By 2011 Amazon was selling more e-books than print books. Although by some estimates, the growth in popularity of e-books has slowed in recent years, sales of self-published e-books have continued to grow rapidly (Ingram). In 2004 the Google Books project was launched with the aim of creating a freely accessible online knowledge base by scanning all of the approximately 130 million distinct books in existence. Although the project has been plagued by copyright lawsuits and uncorrected scanner errors, so far over 25 million titles have been completed, with those in the public domain being viewable in full.

The Internet is organized very differently to book information, so many of the assumptions and skills of traditional education about how to ask questions and evaluate answers no longer hold in the Information Age... There's no hierarchical organization that might slow down random exploration and no gatekeeper judging additions to the Web for quality or organization.

In 2010, Google CEO Eric Schmidt claimed that every two days humans are generating as much new information as had been

created from the dawn of civilization up until 2003! According to Worldometers, there may be debate about specifics, but his point stands: There's a *lot* of information out there and it's easier than ever before to access. More than 6,000 new books are published around the world each day. While the average small-town child of the boomer generation had access to three television stations, a small-town library, one newspaper and maybe a few magazines of interest, today's youth in the US have more than 200 cable television networks, 5,500 magazines, 10,500 radio stations, and at least 15 billion Web pages available (Tapscott 30). It is estimated that a week's worth of *New York Times* alone contains more information than a person was likely to come across in a lifetime in the 18th century (Fisch). Our children are living in a world that is awash with information. Learning how to gain access to information on a particular topic is no longer the main challenge of becoming educated.

THE NEW LITERACY

In the Information Age, information will compete for attention in much the same way that products on a store shelf competed for attention during the Industrial Age. (Warlick 102)

Literacy is the ability to use information to accomplish goals. In this new "flattened" and increasingly globalized world swimming in easily accessible digitized information, creative workers are valued above all on their people skills and their information literacy skills: Their abilities to collaborate well, to ask the right questions and to know how to discern which answers out of the many that present themselves are the most legitimate and credible (International Society for Technology in Education). Information is increasingly digital as computers have become the prevailing tool for using information and as more and more of it is stored in the "Cloud." However the Internet is organized very differently to book information, so many of the assumptions and skills of traditional education about how to ask questions and evaluate answers no longer hold in the Information Age.

The World Wide Web is based on the idea of hypertext: "http:" stands for "HyperText Transfer Protocol," which is a nonlinear information retrieval system where "hot links" are created between

sets of information that take the user from one page to another that may be seemingly unrelated to the original page. There's no hierarchical organization that might slow down random exploration and no gatekeeper judging additions to the Web for quality or organization. In effect the Web is like a huge neighborhood garage sale where everyone brings their junk and puts it on a table: text, graphics, sound, animation, video, or databases. Although there are tools for searching out particular pages, there is no master index of everything.

Unlike analog text, digital text can be indexed because behind it are ones and zeros. The potential for working digital text as a raw material can be breathtaking. Most of us have experienced this while searching the Web for an image or a product without knowing exactly what we're looking for. Figure 1 presents a less obvious

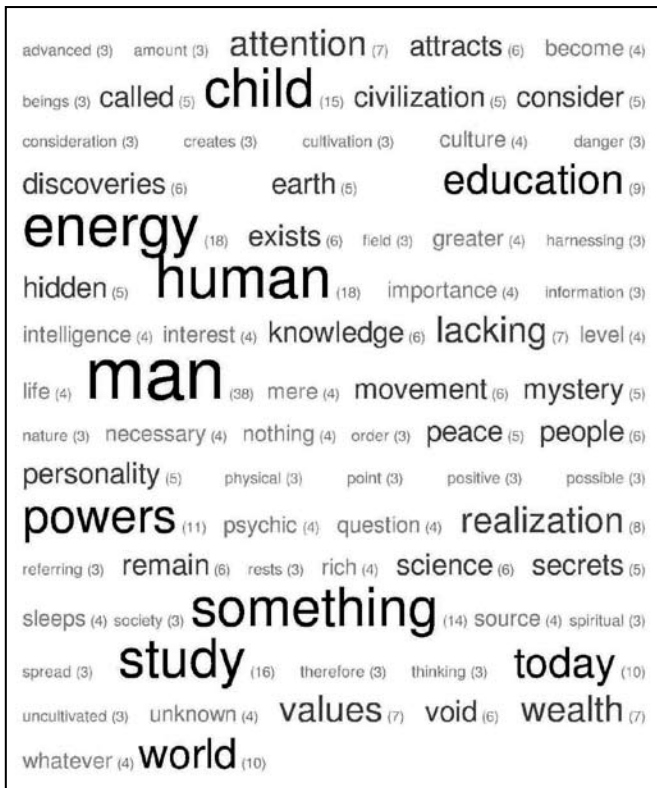


Figure 1. Montessori's Inaugural Lecture, Poona, India 1948 as a tag cloud image. Conversion done at <http://www.tagcrowd.com>.

example of how useful this attribute can be. This image shows all significant words, which occur at least three times, from Dr. Montessori's 1948 inaugural lecture. Words are shown in alphabetical order and in a font size and color density that make clear how prominent those words are in her speech, giving us an immediate visual sense of what her speech is about. There are many other ways in which digital text can be rendered visible so it can tell a story. Finding value in digital text by rendering it meaningful with the right algorithms can be a profitable business; it is one that brings in \$60 billion a year to *Google* alone!

Digital devices themselves have characteristics that invite new assumptions about learning and working with information. Unlike conventional learning tools, laptops, tablets, and smartphones⁷ are inherently appealing because, rather than delivering information in just one direction, they are *interactive* as they invite response and promote dialogue and community. This aspect, along with the *democratizing* access to the sum total of human knowledge on the Web, has blurred the line between producers and users of information. They are *insensitive* to time and distance, which has made global communications cheap and immediate. They are also *customizable*, being easily configured to meet the needs of individuals of various ages in different situations. (Consider the different experience digital seat-back entertainment systems have made in airline travel so travelers do not have to watch the same movie at the same time as everyone else over the top of the seat in front.) Digital devices are *flexible* and *extensible*, with one tool able to serve many functions with different software applications and various plug-in accessories. And they are increasingly *inexpensive* and *pervasive*, characteristics which make their functions infinitely *scalable*, able to serve one or millions equally efficiently. These characteristics don't automatically make digital devices effective learning tools, especially with children younger than eight; however, they do offer potential that isn't available with many traditional learning materials, including hands-on Montessori materials.

7. I don't include *SmartBoards* in this list because these devices lack most of the following characteristics and so promote the traditional "sage on the stage" role of the teacher as expert at the front of the classroom. They are essentially giant tablets reserved for use by the teacher or one student at a time by invitation from the teacher.

WHO ARE THE DIGITAL NATIVES?

Like all children born in the new millennium, my daughter is a “digital native.” Her comfort with digital technology has been imprinted from birth. She was fascinated the first time she watched television at four, but she couldn’t accept that a cartoon show she’d just seen couldn’t be replayed over and over like the short clips I’d played for her on YouTube! Having to be in the right place at the right time to watch something of someone else’s choosing is a twentieth century limitation that is incomprehensible to the “digital natives!” Those of us born in the analog past, who worry about where all this is going, are “digital immigrants.” It’s a question of particular concern to Montessorians: How does this new world of cheap, ubiquitous information, and the new ways of relating to one another, which digital technology promotes, change the ways children learn and think?

Some argue that digital natives are the “dumbest generation,” and that over-exposure to digital media has made them “a bunch of dull, celebrity-obsessed, net-addicted, shopaholic exhibitionists with a taste for violence” who are “woefully ill-prepared for work” (Tapscott 289). Don Tapscott and others believe that growing up with digital devices and the Internet at their fingertips has made the digital natives the antithesis of the passive television generation of their parents. Tapscott sees cause for optimism:

While there are many concerns...overall the kids are more than alright...With their reflexes tuned to speed and freedom, these empowered young people are beginning to transform every institution of modern life. From the workplace to the marketplace, from politics to education to the basic unit of any society, the family, they are replacing a culture of control with a culture of enablement. (6)

In Tapscott’s view, the nature of digital technology has molded this generation of youth into active initiators, collaborators, organizers, readers, writers, authenticators, and even strategists (in the case of video games) who don’t just observe but participate (21). On the Web, children have had to search for, rather than simply look at information, forcing them to develop critical thinking and investigative skills. Accustomed to scrutinizing websites, whether buying a product or chatting with a teenage movie star, this gen-

eration expects transparency and they are not afraid to use the leverage their market power gives them. They take freedom for granted in everything they do, from freedom of choice to freedom of expression. They value corporate integrity and openness in companies they buy from and work for. They love to customize, having grown up able to change the media world around them, from their desktop screensaver and ring tones to news and entertainment sources. Early and long experience with video games has promoted their outside-the-box thinking skills and led them to expect entertainment and play in their work, education, and social lives. They are at home with the brisk and accelerating pace of technological change and are always on the lookout for innovative ways to collaborate and entertain themselves. They inhabit a world where email is already too slow as a means of communication among their global networks of friends, colleagues, and superiors. Denied the streets and woods by overprotective boomer parents and banned from malls and 7-Elevens unless accompanied by their parents, the digital natives have colonized cyberspace where they network en masse and reclaim virtual private spaces of their own.

Digital technology is a form of intelligence, a medium for the expression and communication of information and is far more pliant and malleable than traditional media. It can augment and extend real-world experiences for children in exciting and motivating ways. Digital technology can deliver information in a variety of ways that is limited only by the infinite creativity of the human mind.

MOTIVATING MILLENNIALS

What motivates these young learners? There are four key attributes that have always been important for inspiring learners of all ages. They can motivate separately or in tandem in different learning activities. Their appearance changes as children get older, but they can be seen most clearly in the way a toddler learns:

1. *Autonomy*: Toddlers are not shy about demanding the freedom to choose. All human beings thrive when allowed some control over their own activities,

especially when their attention is not compromised by distractions.

2. *Authenticity*: Toddlers want to do things that matter, things that their parents do. All human beings want to feel that their work counts, and digital natives are especially attuned to making a difference in the world.
3. *Connection*: Toddlers crave interaction and connection with their parents, but as children get older they increasingly value connection with their peers over parents and teachers.
4. *Inquiry*: Learning is inherently interesting when it involves a higher order problem or question posed in a way that is compelling or relevant to children of a certain age, or when it arises from their own experience.

Growing up digital has made these four attributes more important, not less, for digital native learners. However the presence of digital technology in a learning environment does not automatically make an activity engaging to a digital native. And although they may be comfortable with the platforms, digital natives may still need dedicated time and guidance to learn how to use the technology to communicate effectively and to solve problems critically. Digital technology can be used to engage learners of all ages in activities that have one or more of these four attributes, even in Montessori classrooms. Of course young learners can experience these attributes when using traditional Montessori materials, and digital tools are not necessarily a good substitute for concrete materials for children under six (with some exceptions). But just as digital learning tools can be used in ways that don't engage students or encourage critical thinking skills, so can traditional Montessori materials.

What follows are a few examples of uses of digital technology that can complement and even add to the Montessori elementary curriculum without competing with or detracting from it, and without compromising Montessori principles. Bringing digital experiences

thoughtfully into the Montessori elementary classroom brings our students' classroom experience in line with their experience of the world outside; it gives the world to the child. In Dr. Montessori's words, it fits our students to take part in a civilization that is increasingly dependent on machines!

Technology Can Motivate with Autonomy

How can digital technology empower students with greater freedom and choice in managing their own learning?

Interactive books for iPad (figure 2) take audiobooks to a whole new level for emerging readers. Along with photography, this is one use of digital technology that may be appropriate for younger children before they have keyboarding skills. Their flexibility allows emergent readers autonomy in reading books at their level. Children can read them like traditional still books, with still or animated illustrations; they can listen to them like an audiobook while they follow along in the text; they can record themselves reading the

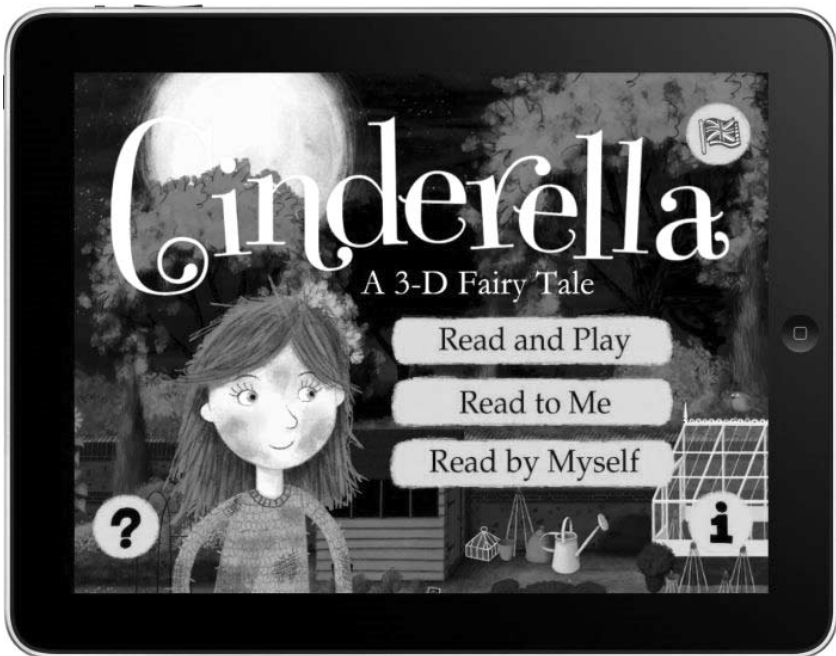


Figure 2. iPad reading apps take audiobooks to a whole new level for emerging readers.

book so their peers or teachers can listen to them later; and some interactive books allow readers to create their own illustrations with a simple paint program. An iPad is not necessary to do all this, but the touch screen makes it more accessible for younger children. Of course in an ideal Montessori environment, older students reading to younger children can fulfill this need in a way that is perhaps more developmentally appropriate. However when older students are not available on a regular basis, this technology may offer an effective, adaptable, and readily available means for early readers to gain independence with books that might otherwise have intimidated them.

iOS recording apps also allow young readers to make their own audio books without all the distractions that sometimes accompany commercial interactive books. (The animated illustrations in some interactive books can detract from the need for imagination that goes along with analog books, which makes those particular versions less desirable in Montessori classrooms.) This method may require a little more training for students to use but is more appropriate for Montessori elementary classrooms because it offers more autonomy than commercially available interactive books. Students can record themselves reading on iPads or iPods using one of the many free memo apps. Students can listen to themselves reading, or their recordings can be used by teachers for diagnostic purposes. With a few more steps, these recordings can be downloaded into a folder on iTunes and then synced with a classroom iPod where they are available for peers to use as homemade audio books. For better sound quality, a USB microphone can be plugged directly into a computer and the recording made in a quiet room using a sound recording application like Audacity.

Google Sites offers a free and easy way for teachers and older elementary students to create classroom websites. These sites can serve as portals for parents to view photos of students working in the classroom or on field trips, weekly newsletters, homework suggestions, a class calendar, and other information. With dozens of prebuilt templates and sharing permission settings that allow various degrees of privacy, this tool can be used by older elementary children to take on some of the management of their classroom. This tool may also motivate students with authenticity and connection.

Rosetta Stone is a computer-assisted language learning software that makes it possible for second language study to be individualized in Montessori elementary and adolescent classrooms. This system, known as *dynamic immersion*, uses photos, video, text, and voice-overs to prompt repeated responses from learners in the target language. Vocabulary and grammar are taught without translation as the software analyzes the learner's responses for accuracy. Students can choose their own second language and have greater autonomy over their progress.

iTunesU (the *U* stands for *university*) is an example of a trend towards online college-level courses that make it possible for anyone with a computer and an Internet connection to get a free college-level education online from anywhere at any time they choose. The *iTunesU* app gives access to more than 750,000 free courses taught by instructors from leading universities and other schools. More and more K-12 materials are also now available on *iTunesU* from museums, school districts, and other institutions. Curriki.org (combining the words *curriculum* and *wiki*) was started by *Sun Microsystems* founder Scott McNealy to develop and distribute free quality learning resources to educators, parents, and students around the world. Taking online courses may also motivate students with *authenticity* and *inquiry*.

Khan Academy pioneered the concept of free, online tutoring through an expanding library of short videos on an increasingly wide variety of subjects covered in schools. Some schools have used this resource as a way to “flip” the traditional relationship between classwork and homework. In “flipped classrooms” students watch a video at home as their introduction to the material (what Montessorians would call their *first period*) leaving more time for collaborative projects with peers in the classroom (second period). Montessori students might use such sites as a resource for independent learning or for pursuing extensions, or when a teacher is not available with expertise in an area of interest to them.

Technology Can Motivate with Authenticity

How can technology promote real experiences or activities that feel genuine and matter to students? Video as a reference resource is perhaps the most underutilized, low-hanging digital fruit avail-

able to Montessori elementary classrooms. A well-chosen video can bring alive topics that are too ancient, too far, or too small to be experienced directly. Of course watching a video is not as effective as experiencing something directly, but watching a video about FDR's presidency, for example, is a richer experience than listening to someone try to describe it. Many educational videos are inappropriate for Montessori classrooms because they are either too passive or too distracting; however, there are a few gems out there too. Appropriate videos let the viewer witness their topic audiovisually with minimal background music or distracting voiceovers that try to force conclusions on them. (One of my favorites is the 1996 movie *Microcosmos* by French directors Claude Nuridsany and Jacques Perrin. (See a short clip at http://youtu.be/_HbJCzh9VYk, which includes 40 seconds of narration, the only speaking in the whole 75 minute movie.) Discovery Education is an online media library for educators that features thousands of short educational videos on demand on just about any topic.

Productivity tools (figure 3) can motivate students with authenticity once cursive handwriting and reading are fluent. Children who are ready find these tools motivating for the same reasons adults use them: They make editing and revising easier, it's simpler to store and search digital text, and typed work can be shared easily and printed multiple times. Seeing adults use the same productivity applications gives them *authenticity* in students' eyes. Late lower elementary is often a good time for students to start using a keyboarding tutor such as Type to Learn so they can learn basic touch typing in time to use these applications in upper elementary. By upper elementary students are generally quite ready to learn to use multimedia presentation software such as Keynote, Powerpoint, or Prezi. Delivering an engaging presentation to an audience with images, video, and sound is a very different skill than reading a paper in front of a group. Posterboards with pictures glued can work for science fairs where small groups mill around, but don't work for large audiences where only the first row can see.

Upper elementary and older students in Montessori classrooms may also be ready for Google Docs, a Web-based suite of productivity applications that are essentially wikis—applications that allow multiple users to edit the same document from different computers.

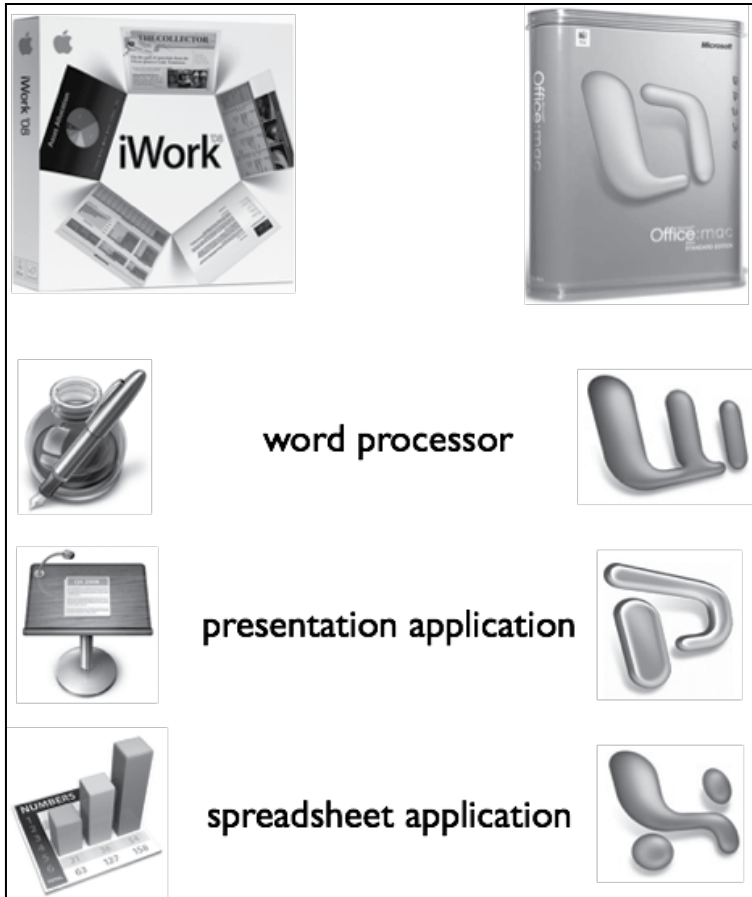


Figure 3. Productivity tools like these can bring authenticity to learning for the same reasons adults use them: They make editing and revising your work much easier, it's easier to store and search work, and they make our efforts more productive.

Google Docs allows students to collaborate from anywhere at any time on the same document and also makes it easier for teachers to monitor their progress. And it means students will never forget to bring in files they've been working on at home! This short video [<https://www.youtube.com/watch?v=muVUA-sKcc4>]⁸ explains the advantages of *Google Docs* using a stopmotion video with paper

8. Commoncraft (<http://www.commoncraft.com>) makes a series of 3-minute "explainer" videos to introduce complex subjects. Many videos in the Commoncraft library can be found on YouTube, and are an excellent "first-period" resource on a variety of topics.

cutouts, a technique that upper elementary students can easily use themselves in the classroom as a follow-up activity.

When offering productivity tools in a Montessori environment, it's important to remember that children often perform many tasks to develop themselves, not simply to finish the task. If children are not developmentally ready for digital tools, these tools may diminish qualities such as self-discipline, sustained concentration, and in-depth deliberation by reducing the amounts of time, effort, and energy needed to perform tasks. The bells and whistles offered by productivity tools may also cut short opportunities for students to master the art of speaking and presenting authentically. Montessori students will finish work for the satisfaction of doing the work itself because this sustained focus develops their critical thinking, writing, and speaking abilities, all the faculties which digital productivity tools may threaten if offered too early.

Digital storytelling is a new multimedia genre pioneered by Joe Lambert at the Center for Digital Storytelling (<http://storycenter.org>) in Berkeley, CA, and inspired by the storytelling tradition of Studs Turkel. With advances in computer processing speeds over the last two decades, it is now accessible to elementary children as a publishing option in the writing process. Children follow the same steps in the writing process that they are used to (e.g., think, write, share, revise, edit), but instead of publishing their story on paper they go through another process of creating a multimedia presentation that weaves together three elements (voiceover, still images, and background music) with easy-to-use software such as Apple's iMovie (<https://www.apple.com/mac/imovie/>) or Adobe Premiere Elements (<http://www.adobe.com/products/premiere-elements.html>). From their edited draft, students first create a storyboard on paper that sketches out how these elements will weave together. They then record and edit their narrative using sound editing software (such as Audacity or Sound Studio) and collect digital or scanned photos. Background music can be downloaded free from production music sites such as FreePlayMusic.com or custom created by students using Apple's GarageBand application. With smartphones now capable of editing video, being able to craft multimedia stories is arguably the new paper and pencil. This form of digital literacy gives a more intimate window into the personality and viewpoint of the author

and is very empowering and motivating for children...and yet it takes nothing away from the traditional Montessori elementary curriculum! See My Best Friend Moira (http://youtu.be/oFpFM_5OjjI) by ten-year-old Montessori student, Nina Brady. For an example from an older student, see Beyond the 50 States by thirteen-year-old Nathaniel Solley (<http://youtu.be/nwzs-cyUWoU>).

Clay animation is now relatively easy to do in the classroom with a cheap video camera or iPad and Stop-Motion software such as iStopMotion (<http://boinx.com/istopmotion/ipad/>). Clay figures are made over wire frames, then moved incrementally. The software runs the photos together at set intervals like a flip book to tell a short visual story. Sound and music can be added in post-production using video editing software like Apple's iMovie or Adobe Premiere Elements. Animation is highly motivating for upper elementary students and these skills can be used in Montessori classrooms to show an understanding of topics as diverse as how a snake moves, the evolution of the horse, or the Battle of Bunker Hill.

The burgeoning array of cheap USB devices offers another area where technology brings authenticity by allowing students to cheaply and easily measure and observe their surroundings with scientific accuracy. A favorite USB device of elementary children is the Proscope (<https://www.bodelin.com/proscope>). Previously, good quality microscopes were prohibitively expensive. The Proscope costs around \$280 for a basic unit that plugs into a laptop, making it easy for a group of children to view on-screen. Its internal light means that specimens don't have to be killed and mounted and can be viewed in their natural habitats. Children particularly enjoy seeing into their own nose or ear! Lenses of various powers can be attached to capture still images, video, or time-lapse sequences with a stand, and these images can then be used in reports or presentations. There are many other scientific USB devices now available (e.g., sensors to measure water quality used for local pollution studies) that can help make science projects accessible and easy to manage.

Photography provides a cheap and easy way to introduce technology to students before they can touch type. Digital photography is a worthwhile activity for Montessori students of any age because, as Dorothea Lange once said, "The camera is an instrument that

teaches people how to see without a camera.” Young children often have quite a different view on the world than those of us who have become used to seeing it in a particular way (see figure 4 for example). Photography can be offered as a follow-up activity after a geometry lesson on angles or a biology lesson on leaf shapes, for example, where children take photographs of their environment and download them as illustrations in a book of angles or leaves. In another example project, my lower elementary students wrote simple copycat verses based on the book *Today I Feel Silly* by Jamie Lee Curtis, then took photographs of one another expressing the feeling they wrote about. The photos and poems were published as Apple Books (<https://www.apple.com/mac/print-products/>) as keepsakes for families.

The Web also provides easy access to authentic locality-specific information. For example, if students are studying the Midwest



Figure 4. Photograph taken by a first-grade student using a Kodak point-and-shoot digital camera. Her spontaneity and six-year-old interests drew her attention to something that may have been missed by an older child or adult. The reflection of the trees, the focused stare of the cat, and the texture created on the window pane by the dust all make this a beautiful composition.

floods of the early 1990s the best resources are available online through the midwest agricultural co-ops. Every state has an official website that can be found by typing its two-letter abbreviation before the suffix .gov.

The Web is also full of *primary source documents* that can add authenticity to research on any topic. For example, Congress.gov allows students to go directly to the source in following the progress of a bill through Congress.

The Globe Program is another way of bringing authenticity to the Montessori elementary classroom. Students can take measurements of their local environment and contribute to data collection for US government scientists. Another website, Journey North (<https://www.learner.org/jnorth/>), engages citizen scientists in a global study of wildlife migration and seasonal change. Students share their own field observations with classmates across North America as they track the coming of spring through the migration patterns of monarch butterflies, robins, hummingbirds, gray whales, bald eagles, and other birds and mammals, the budding of plants, changing sunlight patterns, and other natural events.

Other worthwhile and authentic experiences for Montessori elementary students on the Web include simulation games such as the Stock Market Game (<http://www.stockmarketgame.org>) and the Model UN Program (<http://www.nmun.org>).

Technology Can Motivate with Connection

Every human needs to feel connected with others, either personally or with a cause greater than themselves. One of the most important reasons we communicate is to affect the behavior of others. Inexpensive global communication is the next great potential offered by the Internet. There are two kinds of communication possible through the Internet: *synchronous* (at the same time) and *asynchronous* (not at the same time). Asynchronous communication doesn't require users to be online at the same time, so it offers the opportunity to reflect on another's message before responding. There are various types that may provide invaluable experiences for Montessori classrooms.

Email is a great way to get elementary students writing to others across the globe because it is more immediate than surface mail. ePals (<http://www.epals.com>) is a website that connects classrooms around the world with matching interests. For example, a student or class studying Chinese in America can connect with a student or class studying English in China or Taiwan. Email can also be a useful means of communication between teachers and their older students, who might respond differently to a personal email than to a verbal communication!

Email discussion lists and forums are digital message boards that allow users to interact online with large or small groups of people sharing common interests. They can be open to the interested public or limited to a closed group who want to keep their discussions private. Messages can be read as emails (listservs) or online (forums). Google Groups is a free service that lets anyone with a Gmail account apply to join a wide variety of open discussion groups or start their own. VoiceThread.com is a fee-based service that facilitates asynchronous discussion of photos, video, or audio files in any format in a secure collaborative online environment. Online discussions groups may seem superfluous in a Montessori environment since students are generally allowed freedom to interact at will during class time. However these interactive online environments offer Montessori classrooms venues for focused discussion from anywhere at any time about particular topics that may not get attention if left to face-to-face meetings where social distractions may take over. Email discussion groups also offer teachers an opportunity to coach students on the “netiquette” of online written communication.

Blogs are “Web logs” or Web pages containing a log of entries listed chronologically with the most recent entries at the top, making it easier for return readers to skim through the most recent additions. Blogs can be used as a collaborative, class diary where students and teachers share photos and reflections of their classroom activities for their community on their classroom website. Blogger.com is a free blog publishing service hosted by Google.

Synchronous communication is a live event where people interact online at the same time, offering opportunities for spontaneity.

Instant messaging (IM) gives computer-to-computer communication the relative immediacy of a phone call while still giving both parties time to consider their responses. It can be done with various degrees of privacy: text only, voice only, or audio-visual. Instant messages tend to be brief and more conversational than the leisurely formality of email. Instant messaging requires that both parties be online at the same time and have accounts with the same IM service. SMS (“short message service” or “text messaging”) occurs between text-enabled phones and is universal, needing only a phone number to find its recipient. Apple’s updates to its Messages application have integrated IM and SMS services across their iPhone, iPad, iPod, and Mac platforms. IM and/or SMS are favored for casual conversation outside of school by digital natives who leave email to their digital immigrant parents still living in the slow lane!

Skype video calls between computers and smartphones are free anywhere in the world. This technology provides unprecedented opportunities for promoting global awareness in schools, especially for foreign language learners. *Skype in the Classroom* (<https://education.skype.com>) offers a library of suggested lessons involving *Skype*, a directory of teachers around the world interested in connecting their classrooms with others via *Skype*, lists of virtual field trips that students can witness using *Skype*, and a rotating list of experts, guest speakers and authors willing to present to classrooms via *Skype*. There are several other websites dedicated to global networking of classrooms and educators using technology, including Kidlink, iEarn.org, and Teacher Tap: Ask An Expert (<http://eduscapes.com/tap/topic14.htm>). Scholastic offers live webcasts for virtual field trips and author visits via *Skype*, and Jason Learning (<http://www.jason.org/live>) offers live interactive webcasts focused on science and engineering including talks with STEM role models.

These and many other powerful Internet tools have taken the World Wide Web beyond the more passive, read-only nature of the first generation of websites. Web 2.0, as this second generation of the Web has come to be known, allows users to interact and collaborate with one another in a social media dialogue. This Commoncraft stop-motion video [<https://www.youtube.com/watch?v=FOKJk-7K9gY>] explains how these Web 2.0 communication and collaboration tools

work together (Google Docs, Email, Moodle,⁹ Wikis, and blogs) to promote greater collaboration and attention to individual needs in *conventional* classrooms.

In quality Montessori upper elementary and adolescent classrooms, face-to-face collaboration and genuine individualization should already be core attributes. In this context the addition of Web 2.0 tools may offer more distractions and lead to fewer opportunities for genuine discussion. However, when presented at the right time and with sufficient guidance, students might also experience social media and Web tools as sources of greater productivity rather than means of socialization and entertainment.

Technology Can Motivate with Inquiry

The Web's hypertext environment means that users can jump around tangentially and discover things they might never run into accidentally in reference books or traditional card catalogues. There's bound to be something for everyone on the Web, so it offers opportunities for bringing students' personal interests into classroom projects like never before! But this strength—its "flatness" or the absence of a gatekeeper—is also a weakness. It's sometimes difficult to find reliable information, especially for those of us raised in the hierarchical world of books!

Finding answers on the Web is made easier by using the right search tool. Search engines index resources on the Web (including Web pages, images, and other types of files) automatically by running mathematical algorithms on an Internet bot that crawls the Web searching for useful content. Google Search is the most popular engine because it is simple and accurate, but Google's Advanced Search page allows a more targeted search that will narrow down results more precisely. Google's Related Searches tool automatically breaks down search results into categories. Google Search can even classify the reading level of each result it finds! Metasearch engines

9. Moodle is an online course environment that makes it possible for older students to manage their own learning from anywhere. Students in traditional classrooms can safely distribute documents, collaborate on projects, drop off assignments, discuss readings, seek help, and share experiences. Previously found only at the college level, it is now common in US high schools and is starting to be used in many conventional middle schools.

such as Dogpile (<http://www.dogpile.com>) aggregate the results of several other search engines into a single list of results.

Directories or indexes organize information into categories or lists that can either be created by people or sometimes by computers. These are essentially attempts to impose a hierarchy of meaningful order onto the Web. This was feasible back when the Web had fewer high-quality, unique pages. Google used to maintain its own directory but quietly dropped it in 2011 noting that, since the Web now has more than a trillion pages, it's impossible to maintain a useful directory so algorithmic search engines are the only ones that can manage this scale.

For children however, directories can be a useful starting point. There are many, but DMOZ (<http://www.dmoz.org>) is perhaps the largest human-edited directory of the Web and is maintained by a community of volunteer editors. Subject guides display resources that have been selected and organized by people. They are good for large, unfocused topics and will show fewer resources than algorithmic search engines. KidsClick! (<http://www.kidsclick.org>) is a child-friendly subject search site designed by librarians that allows subject searches by Dewey Decimal number. The Internet Public Library (<http://www.ipl.org>) will categorize topics with many meanings (e.g., tigers) and list a limited set of results with a brief description of each with information about its reading level. Educational portals, such as 42eXplore.com, provide pathfinders or limited doorways into the Web that direct students to appropriate resources on particular topics, often with background, definitions, search strategies, and activity ideas.

The Web also offers a smorgasbord of collaborative, inquiry-oriented projects such as *WebQuests*, which allow students around the world the opportunity to work together toward a single goal. They emphasize higher-order thinking skills, rather than just acquiring information, and may include writing projects, creating travel guides, building databases of information for experiments, or creating polls or surveys.

Robotics and programming make up a burgeoning field of inquiry-based science that have become accessible to children with

advances in digital technology. With Lego Mindstorms even lower elementary children can build then program their robots to interact with their environment in intelligent ways. In the Information Age, programming is increasingly becoming part of what it means to be “literate.” Freeware programs like Scratch (<http://scratch.mit.edu>) allow children to learn programming concepts by building computer games of their own design without having to learn a coding language.

INTELLIGENT TOOLS FOR INTELLIGENT CLASSROOMS

Visual technologies offer extraordinary potential as brain accessories, coaches for certain types of skills, and motivators. Educators have no choice but to come to grips with their power in the worlds of our children. (Healy 19)¹⁰

These are only a few of the myriad ways that our modern Montessori “children may be fitted to take part in a civilization which is entirely based on machines.” Many are concrete hands-on experiences, others more abstract; what distinguishes them all from the passive, dulling experience of television and screen games is that they are interactive and involve creativity on the child’s part and not just on the part of the software designer.

Digital technology is a form of intelligence, a medium for the expression and communication of information and is far more pliant and malleable than traditional media. It can augment and extend real-world experiences for children in exciting and motivating ways. This is hard for digital immigrants to comprehend because books and television deliver messages in one direction through a limited number of modes (e.g., text and pictures and images and sound). Digital technology can deliver information in a variety of ways that is limited only by the infinite creativity of the human mind.

Like modern battery-powered toys however, many digital experiences that children are exposed to are essentially passive events that allow only slivers of interactivity. It is these slivers that children crave as they try to squeeze their desire for creativity through win-

10. Jane Healy is a great admirer of Montessori in the world of traditional education and the author of *Endangered Minds* and other books on the risks of technology with children.

dows not designed with their needs in mind. While it's tempting to ignore digital technology because of a lack of understanding of the child on the part of most software designers, this would be to blame the medium for the message and would grossly underestimate the potential of this medium for enhancing Montessori education in the Information Age. In the hands of Montessorians who understand that their educational objective is not "the mere transmission of a greater amount of information" but is instead "the cultivation of the personality itself, of man himself," digital technology can add to Montessori elementary and adolescent environments with engaging, meaningful, and flexible ways to "give the world to the young child."

If Maria Montessori were alive today it is a safe bet that, like the scientist she was, she would not be resting on assumptions but would instead be using her iPad to explore many of the new ways that digital information technology can motivate children to be creative, communicative, collaborative and curious.

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