Kristina Prozesky, Lauren Cifuentes

The Montessori approach to integrating technology

Problemy Wczesnej Edukacji/Issues in Early Education 10/1(24), 29-38

2014

PROBLEMY WCZESNEJ EDUKACJI / ISSUES IN EARLY EDUCATION ISSN 1734-1582
1 (24) / 2014

Kristina Prozesky
Children's House Montessori School, Atascadero (USA)
khoracek@gmail.com
Lauren Cifuentes
Texas A&M University - Corpus Christi (USA)
lauren.cifuentes@tamucc.edu

The Montessori approach to integrating technology

Summary

The authors address the controversy surrounding the effects of technology on children. They also discuss the ten main principles of the Montessori perspective on teaching and learning. According to the authors, Montessori's philosophy aligns precisely with theories of instructional design and educational technology. Given that alignment, the authors conclude that Montessori would have approved of making use of today's technologies, but would select technologies to address individual students needs and capabilities.

Keywords: impact of technology on children, Montessori's approach to education, instructional design, technology integration in learning

Introduction

The purposes of this manuscript are to address the controversy surrounding the effects of technology on children, including what we and others believe would be Maria Montessori's response. We summarize the foundational principles of learning for children under six years old and over six years old according to Montessori. We define instructional design and educational technology and conclude that, in fact, Maria Montessori was a pioneer instructional designer and educational technologist who would, were she living today, embrace the affordances of digital technologies for education, while remaining wary of their potential negative applications.

Educational researchers, practitioners, and theorists explore the impacts of technologies on children's learning and different conclusions abound. Findings in a study of six thousand children who grew up using the Web were that the Internet has affected the way they access, select, explore, probe, pore over, and skim information. Now grown up, they skip around constantly discriminating what is pertinent from what is not. They rarely read whole books (Tapscott 2008). "Calm, focused, undistracted, the linear mind is being pushed aside by a new kind of mind that wants and needs to take in and dole out information in short, disjointed, often overlapping bursts- the faster the better" (Carr 2010: 9). Neuroscientists fear that the Internet "promotes cursory reading, hurried and distracted thinking, and superficial learning" (p. 116). Mental activity develops our neural circuitry and some warn that those who do not take the time to focus and think deeply about a topic for a sustained period of time may never develop the ability to do so (Doidge 2007, LeDoux 2002). Carr contends that-

> Through what we do and how we do it- moment by moment, day by day, consciously or unconsciously- we alter the chemical flows in our synapses and change our brains. And when we hand down our habits of thought to our children, through the examples we set, the schooling we provide, and the media we use, we hand down as well the modifications in the structure of our brains. (Carr 2010: 49)

The concern is that poorly implemented technology has the potential to over-stimulate and create cognitive overload by saturating learners' minds with sounds and images that are beyond what the mind requires for learning (Clark & Meyer 2008).

While some schools such as Waldorf ban technology in classrooms with the idea that students learn and thrive in a natural environment, most schools embrace technologies as critical preparation for success in the twenty-first century. Educational technologists argue that to overcome potential superficial technology use, instruction in meaningful use of technologies should be part of curricula (Roblyer & Doering 2013).

Even though digital technologies were not available when Montessori was developing her theories and methods, the Montessori philosophy can still inform best practices when it comes to the use of technology in the modern classroom. Montessori was, in fact, a user of technology. She created technology to help her students learn, building into materials pedagogical elements such as control of error. She used the materials that were available to her: wood, paint, beads, etc. Contrary to a common assumption that Montessori would have shunned technology in favor of more "natural" or even old-fashioned materials, a closer look at her philosophy indicates that she was actually at the cutting edge of educational technology for her time, and that the affordances of today's technologies would be extremely attractive to her. When applied as recommended by educational technologists, they address the principles of her philosophy of teaching and learning.

Montessori philosophy of teaching and learning

Montessori focused on the strong connection between the brain and the hand. The child should teach himself, working from the concrete to the abstract, with the teacher as a guide. Additionally, the ten main principles that underlie the Montessori perspective are described below.

Planes of development

Maria Montessori systematically observed children and noted patterns in their behavior, abilities, and interests during growth in order to better understand their development and needs. Compiling vast quantities of observational data, she developed her own theory of development and referred to stages, or "planes," of growth in groupings of six years. Each plane is made up of a rising (attainment) and falling (refining) progression. The first plane, which she called "The Absorbent Mind," includes the first three years of life, as well as the preschool and kindergarten years. Montessori treated the child under six specially. She believed that this child possessed an exceptional capacity to absorb the world through experience, and that the most natural and effortless learning at this age takes place through the senses and through body movements. For children in the "first plane," she set aside rote learning and writing on a slate that dominated classrooms at the time, and instead created activities where the child manipulates objects.

The second plane spans the elementary years (ages six-twelve). Montessori called this plane the "metamorphic age" (Seldin and Epstein 2006: 44), and observed that children at this age have an increased capacity for synthesizing information. While first-plane children learn best through movement and direct action in their environments, second-plane children can investigate the unseen and learn best through the imagination. They can synthesize information that was absorbed during their younger years in new ways and venture into abstract ideas that are out of the younger child's reach. Digital technology as it exists today holds the most potential for children over six, but potential uses of technology for both age groups, and the principles that would govern use of technology in a Montessori environment are worth exploring.

Engaging the senses

Montessori observed that her students learned extraordinarily well when their senses were engaged. For the child under six in particular, she created "didactic materials" designed to awaken and refine the senses, and then challenged students to employ their heightened senses in traditionally academic tasks such as learning to read or count. Where students of her time traditionally sat on benches and recited out loud, or wrote on a slate, she made sandpaper letters for the child to trace with the fingertips, or blocks for the child to sort while wearing a blindfold. She occasionally even engaged the senses of taste and smell, though her materials more often addressed sight, sound, and touch. An additional sense, proprioception, the ability to tell how the body is positioned in space, features prominently in her materials, as she found that, particularly with students under age six, the ability to tell where the body is in space is both an area of sensitivity for the child, and also leads to almost effortless concept acquisition. Many of her activities look very much like play, and involve carrying objects of varying sizes, or sorting large collections of objects on the floor using the full body, rather than simply matching sets on paper. When the child carries rods of varying lengths across the room, he more readily understands the differences between their lengths, and absorbs this knowledge into his body. While applications for engaging sight and sound are obvious, those that would fully engage the senses of touch and proprioception are worth investigating. Wii technologies that detect movement in three dimensions have promise and with the arrival of the multi-touch iPad the hand-to-brain connection seems more accessible. However an educator should keep in mind the limited size of the interface and the two-dimensional reality of the screen and not use it to replace three-dimensional materials manipulated in real space.

Concentration

Montessori felt that the ultimate work of a child is developing the ability to concentrate. She observed that, when children were given the opportunity to work uninterrupted on a self-chosen activity, they would fall into a state of deep engagement. She also observed that certain tasks evoked this response at different ages, and called these periods of development "sensitive periods." When a child is sensitive to a particular developmental challenge, whether it is the acquisition of letter sounds, or developing the fine motor skills to lift tiny objects or control a pencil, he is deeply drawn to that task, and intense concentration is the result. In order for this beneficial concentration to take place, Montessori advocated for an environment in which all unnecessary stimulation is removed.

When we do not see children concentrating, she believed, it is because we as adults are standing in their way. We distract them with bright colors or sounds meant to entertain them, and over-stimulate them. Many so called educational "apps" or toys are full of beeps and buzzes, distracting cartoons, and meaningless animations. When applications are designed to both teach as well as stimulate and entertain, the required attention span is often very short, and the opportunity for concentration is lost. We could create a "Montessori-like" environment in digital interfaces by simplifying layout and doing away with colors and graphics that do not directly contribute to understanding the concept at hand.

Isolation of concept

Montessori believed that materials should be designed with an isolated single concept, allowing the child to concentrate on that single factor alone. For example, the pink tower is a series of blocks that vary only in size. They are the same color, and are not decorated with letters, nor are they painted in different colors. Because all distracting factors have been eliminated, the purpose of the material is very clear to young children, and it has proved to be very effective in holding a child's attention for extended periods of time. Additionally, as children progress from basic material to more challenging concepts, only one factor at a time is introduced and highlighted. In more advanced work, subsequent lessons may contain concepts that have been taught before. Therefore, the correct sequencing of lessons can be very important, ensuring that the student has been prepared with the "sub-skills" necessary. Each skill has a unique lesson that is part of the sequence. Current technology allows for tracking of concepts acquired by individual students. While Montessori tracked her students' progress in her mind and through elaborate notes, she certainly would have welcomed spreadsheets and databases to keep such information organized, and would have likely been eager to have students' progress tracked in a format that would allow them to take ownership of their own progress.

Control of error

Montessori felt that the teacher should be a „guide" rather than a transmitter of knowledge, a revolutionary idea during her time, though much more widely recognized now. She developed and implemented self-correcting materials that allowed the child to receive immediate feedback and work independently. She called this built-in feedback "control of error," and considered it essential for almost every material found in the primary (three-six) classroom. Control of error might take the form of placing color-coded dots on the back of the material in the case of a matching activity, or limiting quantity of pieces in a set, so that an incorrectly placed piece would stand out. The child could then check his own work and strive independently toward mastery of the task. While built-in control of error requires some creativity when constructing handmade materials, computer programs and games can be designed to control error, providing feedback instantaneously. Well-designed and implemented technologies are a good match for a learner-driven environment such as a Montessori classroom.

Sequencing concrete to abstract

Another important characteristic of Montessori materials and lessons is that they are sequenced from concrete to abstract. For the youngest students the curriculum starts with materials that are "real," as opposed to representational. For example, the teacher might provide the child with an experience exploring the parts of a real flower before offering a wooden puzzle of the "parts of a flower." Following this, the child might work with picture cards and labels, a more abstract representation. He would rarely start with the pictures from the beginning.

Additionally, the child works with the wooden pink tower, red rods, and brown stair to become familiar with manipulating objects in space before being introduced to the concept of quantity. Once the child has been introduced to quantity, he will count wooden "spindles" or glass beads before representing matching those quantities to written numerals on cards. Once he has become familiar with representing quantities with numerals, he will perform operations with "unit beads," "ten bars," and "thousand cubes" well before doing these operations abstractly on paper. In fact, several intermediate steps remain, including working with "stamps" (where various tiles represent units, tens, and thousands), and working with a bead frame (similar to an abacus, and considered the most abstract before on-paper operations).

Each of the carefully designed Montessori lesson sequences continue into elementary, where students represent algebraic concepts such as squaring a binomial concretely with color-coded wooden pegs before notating the formula on paper. The root of each abstract sequence is found in the primary years, before age six, and elementary lessons regularly harken back to concrete experiences "absorbed" during those younger years. Foundations are laid through as many concrete experiences as possible, and abstract concepts remain tied to real references in the child's environment.

An example of an emerging tool for self-guided learning is "Khan Academy," in which students are able to watch lectures in a video at their own pace. Montessori would have applauded the move to put the lessons in the learner's own hands to allow for repetition and concentration on the concept being presented. She would caution, however, that the videos are still fully abstract, as is a white-board lecture. She would integrate video with a hands-on activity, treating video as a guide for using concrete learning materials in real space.

Creativity and imagination

When a child enters the elementary phase of life his greatest and most novel ability, according to Montessori, is his capacity to imagine. Stories about imaginary characters are as real to preschool child as the story of the tadpole turning to a frog. Montessori encouraged educators to assist children's confident transition into the world by allowing them to delve into experiences in the "real" world as much as possible. She believed that fantasy should originate from the private life of the child, rather than be imposed from the outside by an adult. Particularly during the period under age six, the child is in a phase of credulity. He is assimilating his view of reality, and cannot tell the difference between fairy stories and stories about the workings of the world, like those that would be told in a science lesson. She argued that the adult often uses this credulity for his own amusement, not thinking about the confusion and even fear that can be created for the child as a result. School, she believed, was not the place to be providing the child with non-realities such as stories of dragons and fairies. The child that chooses to play fantasy games alone or with peers, however, shows an ability to generate these fantasies himself, and thus distinguishes truth from reality.

The elementary child, on the other hand, can distinguish fact from fiction and can call up imaginary characters through his own will. He can tell a story, knowing full well that he is the creator of the characters and visions, and he can understand the figurative language of others in a way that a preschooler cannot. His focus shifts away from absorbing as much as he can of the physical world and of the mechanics of language, and he is suddenly able to synthesize information in new ways. It is this capacity for imagination, Montessori says, that leads to a very different educational approach in Elementary school (Montessori 1948).

Lessons for elementary students are designed to appeal to the imagination. In her "Cosmic Curriculum" for children older than six, students are asked to visualize beyond what they are able to experience with the senses and wonder about ideas such as "What lies beneath the earth?" and "How long have humans been around?" They might be asked to try to hold in their minds a vision of the vast numbers of fish in the sea, or imagine how invisible building blocks like Oxygen and Hydrogen can come together to make something tangible like water (Montessori 2012).

True creativity, Montessori believed, comes from generating new ideas, not simply reflecting the ideas of others. Montessori would likely feel that technology for children in the first plane should avoid cartoon characters in favor of realistic images that would connect the child with the environment. Popular educational videos for toddlers such as *Baby Einstein*, deliver myriad cartoonish abstract images to a passive child. Montessori would certainly not have approved, both because of the cartoon representations as well as the fact that the child is not actually manipulating objects or interacting in the real world. She would also be wary of toys and materials in which the inner workings remain a mystery, or seem to work by magic. She was in favor of providing simple machines, such as gears and levers, to children in order to help them to understand physical forces. She would certainly consider a battery-operated walking dog or talking doll to be an inappropriate toy. Not only do such toys fail to encourage any inquiry into the reality of the world, unless perhaps if a curious child takes it apart, they actively encourage passive interaction, providing more of the same "junk" stimulation mentioned earlier.

Technology does, however, possess the power to transport the child in the plane of imagination to new levels of conceptualization. Powerful tools such as infographics can serve as a jumping off point for students to stretch their minds and make sense of their world. Video can connect students with experience that they might not otherwise have - like visiting an erupting volcano or watching a dangerous chemistry experiment up close. Digital microscopes can help students to access the small-scale world, and share their images in ways that analog microscopes cannot. NOVA Elements is a great example of an iPad app for elementary learners that brings them face to face with the parts of an atom and allows them to construct various elements from their various components.

Rewards and competition

Montessori felt strongly that children should not be, manipulated by extrinsic rewards. She found that when students are fully involved in their learning, they pursue knowledge for its own sake. Research shows that rewards can be very *de*motivating when it comes to learning, because the reward becomes the end goal in itself, and learning becomes secondary (Kohn 1999). At the same time, many educational technologies available attempt to make use of systems of rewards such as digital "merit badges" and competitive point systems. Montessori would argue that a well-designed learning system that allows the learner to see the big picture would be highly motivating, with progress through a sequence as its own reward.

Collaboration

Montessori felt that students should be grouped by planes of development, rather than years of birth, and thus Montessori students share a classroom with multiple ages. They collaborate often, learn in a social environment, and demonstrate their knowledge by teaching younger students. Younger children are able to get a view of the "bigger picture" by seeing what concepts older, more experienced students are working on. To Montessori, the beneficial effect of multiple age groupings was so great that she encouraged educators to group as many students together as possible- often as many as fifty in a class. Technologies such as discussion forums and shared applications are now available online allowing students to collaborate on projects and problem-solving. With social media bringing people from all over the world together, classrooms can be expanded to include "classmates" from other schools or cultures.

Peace

Finally, one of Montessori's most foundational principles was her hope that education would lead to a more peaceful world. Her "Cosmic Curricula" focus on relationships among parts of nature and human beings. She spoke often about her wishes for a peaceful world, and the book *Education and Peace* (1972) documents her speeches. She pointed out the problem of people being brought up to regard themselves as isolated individuals who must satisfy their immediate needs by competing with other individuals, and argued that understanding "social phenomena" was crucial for progressing toward a more peaceful society. Certainly connecting learners with other learners could be a powerful tool for creating harmony in the world as well as increasing understanding among cultures.

Instructional design theory and technology integration in learning

Current definitions of instructional design and educational technology emphasize human invention and processes. Richey, Klein, and Tracey (2011) combine process and function in their definition of instructional design as follows: Instructional Design is "the science and art of creating detailed specifications for the development, evaluation, and maintenance of situations which facilitate learning and performance" (Richey 2013: 157-158). The Definition and Terminology Committee of the Association for Educational Communications and Technology defines educational technology as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Richie 2013: 103). Within these closely related fields the emphasis is on using technologies selectively as tools for improving learning processes and outcomes.

The above definitions lead one to conclude that educators have always applied educational technologies to facilitate their processes at varying levels of sophistication. Pre-industrial technologies included slates and text-based books. The industrial age brought the factory model that focused on preparing students for success on tests and having them practice skills by using behavioral applications of stimulus-response theory. That theory led to the technology of programmed instruction. Even Waldorf education, introduced in 1919, proclaiming rejection of any sort of technology entering the educational environment, enjoys the benefits of "detailed specifications" and "creating, using, and managing appropriate technological processes and resources" (Richtel 2011). However, early in the 20th century, Montessori found technologies commonly used in schooling to be insufficient and created her own technologies to educate with what was available at the time. Examples of her inventions include the pink tower, racks and tubes division materials, cubing materials, and sentence analysis materials.

Technologies such as those created by Montessori facilitate active, tactile experiences that develop proficiencies in children as described by her ten principles. As with Montessori's approach to education, current instructional design and educational technology theories emphasize student performance, such as proficiency in problem solving (Jonassen 2007), critical thinking (Paul & Elder 2004), and authenticity (Herrington, Reeves and Oliver 2010). According to such theories, technologies should not be adopted willy-nilly. Rather, they are integrated into curriculum after identifying a relative advantage, establishing what students will be able to do as a result of using the technology, and selecting an approach to assessing those outcomes. Technologies are integrated into student-centered, performance-based instructional strategies that are implemented in complex, designed learning environments that may include whole-body, real world experiences to engage the senses and support proprioception. Always keeping the learner in mind, implementation processes and outcomes are continuously evaluated to inform revision (Roblyer & Doering 2013).

Social constructivist learning theory, a dominant theoretical framework for instructional designers and educational technologists, indicates the importance of learning through collaboration with experts as well as peers. Discussion and shared effort provides for multiple modes of feedback that lead to reflection and revision of mental models. Social interaction, beyond individual study, expands students' views and provides students with multiple perspectives upon which to question previously held beliefs and explore new ones. While collaboration can induce disagreement and struggle, placing learning activities in a social context often makes learning pleasurable and engaging. In addition to encouraging collaboration, learner control is emphasized in the current instructional design literature that recommends having students play a role in selecting problems to solve, cases to address, and projects to complete; the strategies, supports, and resources they use; and the activities they do while learning (Jonassen 2004). Normative feedback that encourages students to compare themselves with others or feedback such as "well done!" that draws attention to the ego and away from learning is discouraged (Clark & Mayer 2011). Learning is its own reward and punishments for taking alternative approaches to learning are inappropriate.

To generate guidance for educational designers and practitioners, researchers in instructional design and educational technology conduct design and development research. Such research is often a form of peace work because the goal is specifically to address societal problems. Additionally, the best design and development research emerges from long-term collaboration among researchers and practitioners unifying the two communities (McKenney & Reeves 2012). Findings of design and development research indicate that the role of practitioners is to focus on student-centered instructional strategies, classroom management, and curriculum. Learning environments, whether real-world or virtual, should provide rich resources with universal appeal and provisions for self-assessment and adjustment on the part of the learner.

Conclusion

We can only conclude that Maria Montessori was a pioneer in the field of instructional design and educational technology by today's definitions. Her philosophy aligns precisely with theories of instructional design and educational technology. Given that alignment, we conclude that she would surely have approved of making use of today's technologies, but would select technologies to address individual students needs and capabilities. In today's Montessori classroom, following her philosophy of design of learning environments, technologies would be available as learning tools to support inquiry, self-expression, building things, and access to and communication of ideas.

The ideal scenario is for technology to facilitate real-world experiences, not to replace them. If a video, article, or Blog can instruct a student in how to do an experiment or use a tool, and the student can then follow-up with the experience, then the technology takes the role of guide, and enables children to do just what Montessori proposed - to be their own teachers. Technology can function to connect the child to the environment, or to other children for the purpose of collaborative learning.

In planning the use of educational technology, the age of the child should be carefully considered. Although technology is changing quickly, human development is not. Very young children still have a need to hold concrete materials, to build in three dimensions, experience interaction with basic physical laws, and feel the weight of objects in their hands. It seems safe to say that Montessori would have limited the use of digital screens and electronic media in the under-six environment. If she did choose to create digital technology for these youngest children, she would follow her principles of engaging the senses, supporting concentration, isolation of concept, control of error, and working from concrete to abstract, while ensuring that the child is well prepared with experiences in the physical world before being thrown into a digital interface.

In organizing the use of technology, Montessori paid close attention to each child and would follow her own principles of education to make sure that technology affordances are used to the best effect. Montessori herself said that technologies alone cannot make man progress. Rather, progress depends on man. It is up to today's educational technologists to carry on the revolution in education that Montessori began, and to perhaps begin a new and continuing revolution based on materials that are available today and will become available tomorrow.

References

Carr N. (2011), *What the Internet is doing to our brains: The shallows.* New York, W. W. Norton & Company.

Clark R. C., & Mayer R. E. (2011), *E-learning and the science of instruction.* San Francisco, Pfeiffer.

Definition and Terminology Committee of the Association for Educational Communications and Technology. (2008), *Educational technology*. In: R. Ritchie (ed.), *Encyclopedia of terminology for educational communications and technology*. New York, Springer.

Doidge N., (2007), *The brain that changes itself.* New York, Penguin.

Herrington J., Reeves T. C., & Oliver R. (2010), *A guide to authentic e-learning.* New York, Routledge.

Jonassen D. H. (2004), *Learning to solve problems: An instructional design guide.* San Francisco, Pfeiffer.

Jonassen D. H. (2007), *Learning to solve complex scientific problems.* New York, Taylor & Francis Group, LLC.

Kohn A. (1999), *Punished by rewards.* New York, Houghton Mifflin.

LeDoux J. (2002), *Synaptic self: How our brains become who we are.* New York, Penguin.

Montessori M. (1948), *To educate the human potential.* Madras, Ill, Kalakshetra Publications.

Montessori M. (1955), *The formation of man.* Madra, Ill, Theosophical Publication House.

Montessori M. (1972), *Education and peace*. Chicago, Regnery.

Montessori M. (1973), *From childhood to adolescence.* New York, Schocken Books.

Paul R., & Elder L. (2004), *Critical thinking: tools for taking charge of your learning and your life* (2nd ed.). New York, Prentice Hall.

Richey R. (2008), *Educational technology*. In: R. Ritchie (Ed.), *Encyclopedia of terminology for educational communications and technology*. New York, Springer.

Richey R.C., Klein J.D., & Tracey M.W. (2011), *The instructional design knowledge base: Theory, research, and practice.* New York, Routledge.

Roblyer M. D., & Doering A. H. (2013), *Integrating educational technology into teaching* (6th Edition). Upper Saddle River, NJ, Pearson.

Seldin T., & Epstein P. (2006), *The Montessori way*. Chicago, Montessori Foundation Press.

Internet resources

Love A., & Sikorski P. (2000), *Integrating technology in a Montessori classroom.* ERIC document, ED441600. Document type = RIE, Guides - Non-Classroom. http://eric.ed.gov/?id=ED441600

Montessori M. (1912), *The Montessori Method by Maria Montessori.* Translated by Anne Everett George. New York, Frederick A. Stokes Company. Retrieved online at http://digital.library.upenn.edu/women/montessori/method/method.html

Powell M. (March 30, 2013), *Technology and Montessori* http://montessorimadmen.com/blog/2013/3/30/toddlers-technology-and-montessori

Richtel M. (2011, October 22), A Silicon Valley school that doesn't compute. "The New York Times", Retrieved from http://www.nytimes.com

Rosin H. (April, 2013), *The Touch-Screen Generation*. "The Atlantic". Retrieved from http://www.theatlantic.com/magazine/archive/2013/04/the-touch-screen-generation/309250/

Tapscot D. (2008, November), *How to teach and manage 'Generation Net'.* "BusinessWeek Online". Retrieved from http://www.businessweek.com/technology/content/nov2008/tc20081130_713563.htm

West J. (Posted Dec. 13, 2012 by Victoria Estrada), *What Would Maria Montessori Say About EdTech?* Retrieved from http://www.nmc.org/news/what-would-maria-montessori-say-about-edtech