STEM and the City

A Report on STEM Education in the Great American Urban Public School System

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For our math and science students over the years;
whether they were public school children or past and current college students.
It has been our honor to teach you the beauty of math, science, and foundations
of American education. And for K–12 children all over the United States
who didn't think STEM was for them: This book is for you.

RIP Dr. Sue McKinney
1960–2024

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Contents

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Introduction

It's January 25, 2021 and the COVID-19 pandemic is still raging. Millions of American parents are confused and panicky about how to help their children navigate the new world of online learning. Many of them are working full time and with day care centers closed as well, they are scrambling to help their children with the classwork that they feel inadequate to teach. As a mother of a then high schooler with autism, I too was trying to navigate this new reality. As a teacher educator and a strong defender of teachers, I (Berube) wrote an op-ed called "Teaching Earns Appreciation in the Pandemic" in the *Virginian-Pilot* newspaper. It had been called "There's a Reason you Suck at Home Schooling" but I figured the local newspaper wouldn't like that title. What I have here is the longer, unedited version.

Parents of America I have good news for you: you are not alone. You are not the only parents in the world today who feel woefully inadequate in the home-schooling of your spawn. Hundreds of millions of parents are coming to this realization almost at once; as you try to create a science fair in your kitchen, or a fractal tetrahedron tower in your den, or a challenge course in your backyard. There is a reason you are struggling, and it has nothing to do with how inept you are, or how brilliant you are in architecture or law or plumbing, or how lazy you are, or how incompetent you are, or how busy you are, or even how drunk you may be (#daydrinking). The reason you are struggling with the education of your home-schooled children is because . . . EDUCATION IS A PROFESSION!

STEM and the City, pages xi–xvi

As shocking and obvious as that statement seems, the reality is sinking in across the globe that teaching is an important profession. Just like medical doctors, who take courses in anatomy, organic and biochemistry, physics, and biology, so too do education majors take major specific courses. I know that we all "know" this so to speak, but we don't all "realize" it. Teacher education departments in universities and colleges across America require students to take any number of content area courses (sciences, history and social studies, English, foreign language, psychology, human growth and development, mathematics); methods courses (science education, language arts education, mathematics education, social studies education, etc.); pedagogy courses (best practices, classroom management, teacher education research, classroom organization, educational technology); and the like. In many of these courses there are cross-cutting themes that appear in all content, including differentiating instruction, technology and culturally relevant pedagogy. At the master's level there are courses such as research methods where teachers learn about T-Tests and ANOVAs and how to conduct action and quasi-experimental research in their own classes. Teachers know how to write complicated lesson plans to the extent that they know how to actually use Bloom's taxonomy to turn what they want your child to do into a daily objective that is measurable and observable. They know how to assess that objective, and they know how to teach the objective at several different levels of learning . . . all the way from memorization to comprehension to application and evaluation. And just like a medical doctor who knows how to prescribe a different drug if the one you are on isn't working, a teacher knows how to prescribe pedagogical practices to fit the needs of your child.

It is quite humorous to me, a former schoolteacher who now prepares future teachers at the college level, as I watch this realization unfold in household after household, while watching the funny YouTube videos of families struggling to educate their kids without expelling them from the house. We educators have known this for a long time: We are not the slackers society thinks we are; laying on the beach all summer while you schlubs work 9–5. We are not majoring in education because we couldn't cut anything else. We majored in education because we know serious content and we know how to get people to understand it which is no small feat.

One of the most amazing observations from an educator's perch during this pandemic is that society is actually coming to this realization. I mean, if you developed a brain aneurism tomorrow, would you try to get your husband to "home-doctor" it? Lay you on the kitchen table and get out the new set of Wusthof's? Of course not. And hubby (or wife to be gender fair) . . . you would not feel like a loser either if you knew you couldn't operate on your

wife's brain. So why is everyone feeling like they are failing their kids? Why? Because subconsciously after decades and centuries we have been conditioned to think that teaching is so easy that anyone could do it. Or maybe because most teachers are women there is a lack of respect for that reason. Society has "told" us for decades what things women do are not important, are easy or are not complicated. People that work with children don't need to know much at all. Maybe most of us still have this subconscious script running in our brain software. Or maybe . . . fill in the blank.

Teachers also need certain personality traits in order to be any good. They have to be patient, persistent and have a sense of humor. They need to be determined with your unmotivated child and they have to be supportive of your overachiever. They need to be a trusted source of information and they need to model the behavior they wish to elicit from their students. They need to be good writers because they are writing papers for presentations at conferences and articles for publication in scholarly journals. They are applying those research courses they took at the master's level and are using their classrooms to figure out which lessons work and which ones don't, which practices work and which don't and which battles to lose in order to win the war. They also need to be a little bit of a rebel because they need to care more about your individual child, than they care about that rule that threatens to derail their education and in doing so, their very future.

Teachers are so smart. They need to be quick on their feet and they need to be able to connect seemingly unrelated pieces of information so that your child can have that "aha" moment that changes their life forever and that they remember 30 years later as they tell their grandchildren about that moment over beers at a beach fire pit at sunset.

Teachers love your kids. Even if they don't like them sometimes. They don't judge them, in fact they "see" them as fully formed self-actualized people and they know how to get them from where they are now to where their fully formed self is waiting for them. They don't judge the kid who has old clothes or who lacks the newest iPhone . . . just as they also don't judge the more affluent kid with the perfect hairdo and expensive trinkets Mom and Dad bought for them.

It takes a lot of intelligence and schooling to be a good teacher. Teachers have to be constantly reading the latest books and articles in their field. They have to read the newspaper/news outlets and keep up with what is going on in the world, because literally everything going on in the world can be used in a lesson plan.

On a more serious note, some kids however, like my son John who has autism, are really in crisis mode. Unlike regular education students, he

cannot do virtual school, which means that legally, he is not getting anything at all. What are school divisions going to do about special ed kids? John is in a self-contained class for kids with autism in a public high school. The class is very small and is staffed by one teacher and two aids. With everyone else staying home in the fall why couldn't special ed kids go to school under careful consideration? Could they be COVID-19 tested along with teachers? What is going to happen to these kids? How are they going to get educated? Are special ed kids the collateral damage society is telling us we have to accept from having to home-school?

As for you parents of regular education students, you are all doing the best you can in this temporary crisis situation. Your kids will survive. Show them love and patience and grace under pressure, and they will learn that lesson for life. But go easy on yourself. Don't lose sleep if your kids are a few minutes behind in their calculus. They'll live and they'll catch up. Remember . . . no one expects you to be proficient in a whole other profession that takes a master's degree to achieve. But again, kids like my son may never catch up to where they were. I know one thing for sure: we are all stressed out.

So that's the reason you suck at homeschooling. There is a silver lining here: The whole world is finally starting to appreciate the teaching profession. Those of us in schools and colleges of education across America have known this for a long time. Teaching is a high-level profession not to be taken lightly. Teachers need respect and salaries to match. So, parents, relax and thank a teacher!

—Clair Berube
Virginia Wesleyan University

* * *

The introduction above was from a draft of an article I had published in the *Virginian-Pilot* on January 5, 2021 as "Teaching earns appreciation in the pandemic." Looking back, we now know that some kids are having trouble surviving in school post-COVID-19. I still think it was good advice to tell parents to not worry themselves with stress but to do the best they can. Kids are pretty resilient, but it is up to us as educators to step it up so they can achieve grade level competency. Hind-sight is 2020 indeed and now we know that most kids should have stayed in school. Of course, teachers worried about their health as well. No matter what choice was made back then, there were pros and cons for each.

The first edition of this book began the Introduction with this:

> This book begins with a sad reminder of how inspirational priorities can become sidetracked by politics and ideology. A couple of years ago, the last space shuttle was rocketed into space for the last time. From the NASA website:

> Space shuttle Atlantis lifted off from Launch Pad 39A at NASA's Kennedy Space Center in Florida at 11:29 a.m. EDT, July 8, 2011 on the STS-135 mission and final flight of the space shuttle program. Atlantis' final flight will cap off an amazing 30-year program of exploration, which launched great observatories, built an international space station, and taught us how humans can live, work and thrive in space. (Deiss, 2023, para. 4)

So ends the quest to return humans to the moon by 2020 (the project Constellation). In 2010, President Obama called for NASA to end its moon program, thereby cancelling the next generation of space shuttles (Malik, 2010). The administration suggests that the future of space exploration would be better served as a capitalistic private enterprise, with NASA buying tickets for its future astronauts to ride in aircraft built by others instead of NASA. Obama claims that ending the shuttle program would free up financial and human capital that would in turn, be funneled into new technologies and that space exploration would become an international endeavor; less tied to America's identity, and more to collaboration.

Unfortunately, in the current age of expanding wars and international financial collapse, it seems that space and exploration now take a backseat to more "practical" American concerns. This is counterproductive not only for America but for the world. Would a private sector space program truly have pure science at heart, or the interests of those funding the project? Should space exploration be a for-profit enterprise? Think about it; exploration is all about risk. With the government behind you, scientists are free to risk and experiment in the name of science. Private enterprise puts pressure on product and outcomes, and can be severely limiting to scientists who need to take risks. What private investor wants to risk his or her investment and money? How can this be good for science? And what does it say about a country that would rather finance multiple simultaneous wars than space exploration? Wars are fundamentally about our differences. Science, space exploration, and discovery are reminders of how we are all so very much the same.

Neil deGrasse Tyson, the director of the Hayden Planetarium and research associate in the department of astrophysics at the American Museum of Natural History and star of NOVA Science Now, has a lot to say about this topic. David Greene of National Public Radio (NPR) recently interviewed Dr. de Grasse-Tyson about the future of space exploration. de Grasse-Tyson (2013) explained:

> Space exploration is a force of nature unto itself that no other force in society can rival. Not only does that get people interested in sciences and all the related fields, [but] it transforms the culture into one that values science and technology, and *that's* the culture that innovates . . . What [the president] needs to say is, "We need to double NASA's budget because not only is it the grandest epic adventure a human being can undertake, not only would the people who led this

> adventure be the ones we end up building statues to and naming high schools after and becoming the next generation's Mercury 7 as role models, not only will there be spinoff products from these discoveries, but what's more important than all of those, what's more practical than all of those, is that he will transform the economy into one that will lead the world once again rather than trail the world as we are inevitably going to be doing over the next decade." (As told to David Greene, February 27, 2012, "Space Chronicles: why Exploration Still Matters")

While we have no choice but to give President Obama the benefit of the doubt, there is much to lose if he is wrong. We do want collaboration between nations, we do want to go further than the moon one day, and we do want new technologies that could enable us to reach these destinations. Questions and repercussions concerning the privatization of the space program will have to be dealt with eventually. Maybe the future of space exploration is not dead, maybe it is going through a rebirth process. The fate of the future of scientific space discovery rests on the outcome. (Berube, pp. ix, x)

Preface

A little over 10 years ago I started the preface to the first edition of *STEM and the City* telling readers of my middle school science teaching experience in an urban public school. I also taught in a private school as well, but the urban middle school—in Norfolk, Virginia—ignited a passion in me for educating underserved children. This led to me pursuing a PhD in urban studies and urban education at Old Dominion University. Learning about poverty, inequality, and educational injustice formed me into the teacher educator I am today. With this edition, I am enlisting the help of a colleague and friend from high school, Dr. Sueanne McKinney. Sue taught middle school math in an urban school in Norfolk, Virginia. Sueanne also attended the same PhD program as me in urban studies and urban education at ODU. Over the years we have been a dynamic duo—writing articles and books on urban children and how best to meet their educational needs. It is a calling that has been full of purpose and meaning.

Then COVID-19 came along in 2020. Not only did the COVID-19 pandemic turn American education on its head, it set millions of students in a backwards direction in terms of development and learning—and those students are still suffering from this gap today. Students who were in kindergarten, first, and second grades who were learning how to read in 2020 are now struggling with literacy as they enter middle elementary school with millions of them far behind where they should be. And as for college students—those who were in high school when American schools shut down—they are now finding themselves in college having never written a

STEM and the City, pages xvii–xviii

term paper or learned how to conduct scholarly research. Teachers and professors everywhere are playing catch up with bright young people who, through no fault of their own, have found themselves struggling. Although I highly supported the efforts of America's medical leadership of the time who were just trying to do the best and least harmful thing for school children, the data did not lead to the assumption that schools should have been shut down. Nonetheless, schools across the nation were shut down, leaving confused and working parents to scramble as they adjusted and tried to "homeschool" their kids the best they could, which parenthetically made many parents realize how hard teaching truly is. The educational and socio-emotional consequences have led to the current state where millions of school children are still trying to catch up academically, and it has led to more depression and anxiety that they have to deal with on top of playing catch up. This second edition of *STEM and the City* aims to address some issues caused by the pandemic, and to also bring to the forefront the importance of educating children who were underserved before the pandemic, and who are hanging on by a thread now. The workforce still needs STEM workers, but what does that look like after COVID-19? What happened to science classes during the pandemic? How can we not only get back to where we were but finally realize the great American dream? The United States has a gem in the American public school system, the greatest vehicle for democracy the world has ever known. Our kids deserve our best effort.

1

The History of STEM in American Public Schools

There was no such thing as STEM education when American public schools were conceived as an idea for fostering democracy and nation building. For starters, engineering would not be considered until George Washington realized its national importance, and technology had not yet exploded as a result of the industrial revolution in the 19th century. Science and mathematics were not seen as uniting concepts, but rather as separate, individual disciplines in the first American public schools. The idea that science and mathematics could be taught in relation to each other was centuries in the future, and certainly not on the minds of early settlers to the New World.

STEM as an acronym is fairly new; probably attributed to Vernon Ehlers, a congressman from Michigan; and is used to depict science, technology, engineering, and mathematics as fields that, while separate, are also interdependent and related. Ehlers was a professor of nuclear physics at the University of California at Berkeley before heading into political life,

STEM and the City, pages 1–9

and as a congressman was asked by Newt Gingrich to coordinate science and education policy. The year was 1998 and policy had not been rewritten since 1945. Ehlers (2010) states:

> I should note that, over the years, the business and education community collectively referred to science, mathematics, engineering, and technology education as "SMET," and I introduced legislation referencing SMET. More recently, the community decided a more pleasant acronym was needed and referred to science, technology, engineering, and mathematics as STEM instead. (para. 7)

Various STEM fields can include chemistry, psychology and other social sciences, medicine, geosciences, biology and life sciences, astronomy and space sciences, oceanography and environmental sciences, engineering, computer science, and science education and technical training. The concept of STEM would take centuries to realize.

The great American experiment known as democratic public education began with the arrival of the Mayflower and the settlement of Plymouth colony in southeastern Massachusetts in 1620 by a group of Puritans from Plymouth England. A very religious group, they were nonetheless unhappy with the control the Anglican Church exercised over their affairs, and so sought separation of church and state. The vast majority of these settlers were literate and wanted to ensure that their children would be too, so education was on the top of their agenda as they settled into their new surroundings.

Coming as they were from urban England, these settlers were not educated in the ways of agriculture. Jamestown, Virginia was settled in 1607 by British settlers (American Journeys, n.d., AJ-073, p. 15), followed by another group of Pilgrim Puritans in 1620, who landed on Plymouth Rock in Massachusetts (American Journeys, n.d., AJ-073, p. 106). It was in their best interests to cooperate with Native Americans, who traded goods with the settlers in return for teaching them about the land. In the new colonies up and down the eastern seaboard, partnerships amongst the settlers and Native Americans thrived for a few years until the Powhatan Indians in Virginia got fed up with being used for food while being systematically pushed out of their own land. They revolted against the English settlers in 1622 as a result (American Journeys, n.d., AJ-073, p. 358), leaving the city dwellers to go it alone on the land. In the meantime, the science of agriculture learned in large part from the Native Americans, enabled early American settlers to live off the land up until and during the time of the great Westward expansion in the late 19th century. The schools of this time were concerned with moral training in order to overcome man's inherently evil natures as was the belief. Childhood depravity and uncontrolled speech was the natural

state of man, and education, using the bible as the text, would purify society and turn people from sin. Science was mainly a practical matter in order to cultivate fields and build homes.

Universities took the lead. It took nothing less than warfare to get early American institutions of higher education interested in formalized science education. The United States Military Academy at West Point had been the most important military training institution in America since George Washington had overseen the building of the fortifications of the campus in 1778, enabling Washington to transfer his headquarters to West Point in 1779. From this perch atop a hill overlooking the Hudson River, Washington, along with other administrators including Alexander Hamilton and John Adams . . . all tired of America's dependence on foreign engineers . . . led an effort to create an institution of learning for the science of war at West Point, with civil engineering being the focus of the entire curriculum. Indeed, for the first half of the 19th century, West Point grads were responsible for the construction of most of the nation's bridges, railways, harbors, and roads (https://www.westpoint.edu/about/history-of-west-point/brief-history-of-west-point).

George Washington was considered America's first engineer. According to Boule II (2003):

> As a young man, Washington learned to survey. He had a natural talent for mathematics. At the age of 16, he apprenticed with several accomplished surveyors on a month-long trip to the Blue Ridge Mountains to survey Lord Fairfax's lands. He mastered the trade quickly, earning an appointment as county surveyor of Culpeper County, Virginia, at the age of 17. Washington later used his knowledge of topography and mapmaking to produce drawings of the Ohio River Valley in 1753, while on a dangerous mission to deliver a message to the French demanding their withdrawal from the region. These sketches represented the state of geographical knowledge of the area at the outbreak of the French and Indian War that occurred shortly after his trip. Even though he was heavily burdened as a Virginia planter, businessman, and legislator; commander of the Continental Army for eight years; and President of the United States for eight years, he is credited with conducting an extensive number of surveys. During his lifetime, Washington surveyed more than 200 tracts of land consisting of 60,000-plus acres. He is credited with drawing more than 100 maps, including a map of the city of Alexandria. He was involved with L'Enfant in planning the technical layout for the future capital city that would bear his name. (Boule II, 2003, para. 8–10)

Elsewhere in the country during the early to mid 1800s, the consensus for elementary curricula still seemed to be for a liberal education with the

classics at its core. The "1828 Report by Faculty Committee," consisting of Yale faculty at the urging of Yale's president and fellows in response to a movement for a more progressive curriculum, came out with a defense of the classical curriculum, heavy on Latin and Greek literature. It should be mentioned here that even at West Point the scientific premise was for practical country building via engineering, less so for the more natural sciences.

The natural world was still met with some suspicion that those who wished to study it were ungodly and atheistic (ironically, that point is still being argued by some today). Natural science was considered "feminine" at a time when women were thought to be less human than men. Anyone who was considered connected to nature was thought to be more animalistic; even savage-like than those who were not. Since women took babies to the breast, this was evidence that women were less evolved than men. Even so, notable naturalists changed natural science forever. In the mid 18th century, Swedish botanist Carolus Linnaeus (the father of modern taxonomy) was busy figuring out classes of animals and plants and creating the natural taxonomy system still in use today. His basis for this taxonomy? The male prototype. Scientists of the time thought of the perfection of the male gender as the natural prototype to which all other living things are measured. Not only male, but White and European. When it came time to categorize animals and plants into a taxonomy, this prototype (maybe subconsciously) was the measuring stick. Just as in the Adam and Eve story, the male is considered the perfection of the species, and the woman a sub-type or defective version of the perfect male being.

Natural and biological science has historically been "women's" domain. According to Schiebinger (1993),

> Linnaeus thus followed well-established Western conceptions when he suggested that women belong to nature in ways that men do not. As Carolyn Merchant has shown, nature itself has long been conceived as female in most Western intellectual traditions. For the seventeenth century alchemist Michael Maier, the earth was literally a nourishing mother. (p. 56)

This has been called "the sexing of science." By the time early settlers were on America's shores, the influence of this mindset was foremost, and the work of the early schools was to train boys (not girls) out of their natural savage state, into a more intellectual, noble one. Women were considered more "of the earth"; more savage and primitive. The gendering (sexing) of biology and natural sciences (women's science); and physics, astronomy, and engineering (men's science) was born.

An exception was Darwin. British naturalist Charles Darwin was not yet a household name in the 1830s as he was presently undergoing surveying expeditions on the HMS Beagle; later becoming the poster boy for anti-science arguments made by the religious literal interpreters of the Bible. Along with Darwin, there were creative people, not necessarily scientists, who were persuasively writing about science and its benefits for human culture. Among them were Herbert Spencer and Edward Livingston Youmans. Spencer (1820–1903) was an English Victorian who wrote about philosophy, biology, and sociology. It was Spencer who coined "survival of the fittest" after reading Darwin's *On the Origin of the Species*, and who was widely read and popular (Weinstein, 2008). The topic of evolution has always been at the center of educational controversy. The Scopes trial (1925) will be discussed again in Chapter 2, but it did serve as the cornerstone of science education in American public schools in the early 20th century, effectively outlawing the teaching of evolution in public schools.

The British were the first to have a bona fide science teacher at the elementary level. William Sharp taught at a British public school called the Rugby School during the mid 1800s, and it was he who was credited with introducing science as a subject in the curriculum. Sharp developed a model for science education that was adopted throughout Britain (Leary, 2005). Science was about to become accessible to the general public, after many centuries of "ownership" by wealthy home-tutored private citizens in Europe and now in America.

Science in American Schools

Before the standardization of science in American public schools in the 1890s, the topic of science was mostly a hit or miss proposition, depending on the preferences of whoever was teaching it. Much of the scientific work of discovery and innovation had been done in other countries such as England and Switzerland and was dribbling into America as her immigrants landed on her eastern shores. Science teachers as such were newly in existence in England but not yet in America as of the progressive era of early 20th century. The concept of scientific education did not get formal recognition until July 1892, when the National Educational Association met for their conference in Saratoga New York to present their recommendations for admission to college. The National Education Association (NEA) appointed the "Committee of Ten" and charged them with coming up with recommendations on the subject of "uniformity in school programmes [*sic*] (standardization of the curriculum) and requirements for admission to college" (NEA, 1894, p. 3). The committee decided that

the conference should convene meetings to decide about three areas of science: physics, astronomy, and chemistry; natural history; and geography. (Although not a Committee of Ten member, among the History, Government, and Political Economy conference was Woodrow Wilson, then a professor at the College of New Jersey. Other members included university faculty members and presidents, and head masters.) According to the Committee of Ten, the goal of education was to prepare most Americans for good citizenship, and some for college. The committee adopted a "citizen science approach" and said that elementary science should be based on observation of the natural world, while secondary science should focus on laboratory work and experiments; facts and principles should be taught, and that this should prepare students for college if they so desire. The committee suggested standardizing 12 years of schooling; 8 years of elementary and 4 years of high school and laid the groundwork for biology, chemistry, and physics during high school years. Natural science should be taught no less than twice weekly during elementary school (Mitchell, 1981). It took a while for these ideas to take hold.

Back in England in the meantime, the "Taunton Commission" was established to study the education of middle-class British boys. The commission decided to study girls also at the last minute. From 1864 to 1868 inspectors for the commission traveled throughout England—observing classes and interviewing teachers, headmasters, and other personnel. What they discovered was shocking; while science was barely being taught to boys, it was quite popular with girls in all-girl's schools. "While a boy's education was centered around Latin and Greek (thought to be more important), a girl's education included ample doses of botany, chemistry, natural philosophy, natural history and physiology" (Tolley, 1996, p. 129). Tolley (1996) also states that similar conditions were apparent in America during the same time frame. "The data supports the thesis that by 1840, the subjects of natural philosophy, chemistry, and astronomy had become more prevalent in American schools for middle and upper-class girls than in comparable institutions for boys (p. 129). This supported the mindset of the time that women needed to be "engineers" of their households and needed to be educated in science in order to run a proper home. According to Tolley's article, "Science for Ladies, Classics for Gentlemen: A Comparative Analysis of Scientific Subjects in the Curricula of Boys' and Girls' Secondary Schools in the United States, 1794–1850" (p. 131), the rationale for educating young women was to prepare them for their roles as mothers, wives, and teachers—not for leadership positions in society. Women "must be able to comprehend (her husband's) plans; she must sympathize in his feelings, or else she cannot be his helpmate" (p. 131). Secondary American science

education for young women was aimed at producing well-informed wives capable of helping someone else (her husband) achieve their ambitions.

Emergence of Science as a Separate Subject

Elementary science had not yet been implemented as a subject in late 19th century America, and there certainly were no science textbooks as of yet. "Readers" were the books of choice in many subjects; teaching children how to read especially. Any science that elementary students were exposed to happened by chance as a result of these "readers" that were teaching children history or reading skills. Readers and textbooks, in general, were popular because most public-school teachers were poorly trained and needed the textbooks in order to teach appropriately. According to Rillero (2010),

> Reading was the most important subject, and readers were the most important textbooks . . . The focus was on reading, writing, and arithmetic. There were no science textbooks, and science was not taught as a separate subject (Underhill, 1941). Students learned about science through content area selections in the readers. Thus, the science in readers was the origin of American elementary science education. The science lessons in the readers of the first few years of school were students' first exposure to school science. Most students did not attend school past the first several years. Prior to 1890, only 3.8% of the population between 14 and 17 years of age enrolled in school (Hurd, 1961). Thus, for many 19th-century American school children, the science selections in the primary readers may have been the only formal science education encountered. The science in these readers was for all students the first school science experience, for many it was the only science experience, and from a historical perspective it was the cradle of American science education. (p. 278)

Rillero (2010) conducted a study to examine the role of early "readers" in science education. The decline of science in the readers over the years, correlated with the emergence of science as a separate subject. Rillero states,

> In the mid-19th century, science was firmly embedded in the first "R" of the three "Rs" of education, and students received significant science education in their reading. As science was pushed out of readers it began gaining credibility as a stand-alone subject. Science education was free to evolve into more than just something to read about, and it could grow as a subject for children to directly examine in the living world and non-living materials. Yet it has never shaken its roots as a subject in a textbook. Unfortunately, as science was pushed out of readers, it was also pushed out of the day-

> to-day school experiences of many primary grade children. And it has not returned. (p. 283)

Engineering and Technology for Everyone

By the latter half of the 20th century, the focus had turned back to science education, due in part to the Soviet launch of the satellite Sputnik on October 14, 1957 and the start of the "space race" between America and Russia. The launch of Sputnik was directly responsible for the creation of NASA in July 1958, when Congress passed the National Aeronautics and Space Act, which sparked an interest in STEM subjects across America (Anonymous, 2013). According to Yager (2000),

> In the late 1950s, Soviet space exploits resulted in massive reforms—a new game—in U.S. school science that were drastically different from past reforms. The reforms of the late 1950s and 1960s were led by scientists whose aim was to change the game so that all learners would experience and know the science that scientists know and practice the skills that scientists use to understand the objects and events that make up the natural universe. Scientists in the various disciplines sought to produce visions of the big ideas of their disciplines that could provide the frameworks for new courses in schools. (p. 51)

Indeed, the idea of sending a man to the moon during that time was intoxicating, and spurred on a generation of children with dreams of becoming astronauts and scientists. It is interesting to note, however, that in sharp contrast to the current model of STEM education as integrating science, technology, engineering, and mathematics, the model that resulted from the space race purposefully omitted these other content areas:

> Leaders in school science also attempted to rid the curriculum of the subject of technology (e.g., television, transportation, communication, home appliances). Textbooks and science teachers ceased to refer to technical careers, a topic that then incorporated into vocational programs for the non-college bound student. (p. 51)

The irony of the short-sightedness of this mindset was to become apparent 30 years later as the Silicon Valley produced brilliant minds who would lead the entire world in a technology revolution, far away from the college classroom.

As was noted earlier, George Washington was America's first engineer, sparking the induction of the U.S. Army Engineer School. Early engineering