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Exploring the Path That Has Led to a Fragmented Curriculum, Driven by High Stakes Testing, Sidelining Science

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EXPLORING THE PATH THAT HAS LED TO A FRAGMENTED CURRICULUM, DRIVEN BY HIGH STAKES TESTING, SIDELINING SCIENCE: WHAT IS THE PATH FORWARD TO A MORE INTEGRATED CURRICULUM THAT NURTURES THE WHOLE CHILD?

by

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SYNTHESIS*

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* The Synthesis can take a variety of forms, from a position paper to curriculum or professional development workshop to an original contribution in the creative arts or writing. The expectation is that students use their Synthesis to show how they have integrated knowledge, tools, experience, and support gained in the program so as to prepare themselves to be constructive, reflective agents of change in work, education, social movements, science, creative arts, or other endeavors.

ABSTRACT

This paper explores the current state of science instruction in classrooms, particularly concerning the fragmented curriculum resulting from high-stakes testing and the subsequent side-lining of science education. The study examines the historical context, starting with the implementation of standardized tests such as MCAS (Massachusetts Comprehensive Assessment System) in 1998 and the subsequent impact of the No Child Left Behind Act in 2001. These reforms led to a punitive system for underachieving schools and a narrowing of instructional time for subjects other than math and English Language Arts (ELA). The focus on improving test scores resulted in limited time allocated for science instruction, with studies indicating that, on average, only 20 minutes per day is dedicated to science and social studies. The paper argues for a shift towards an integrated curriculum that nurtures the whole child and proposes integrating science and social studies content into ELA programs. By aligning units and themes, teachers can create opportunities for cross-disciplinary learning that enriches the ELA curriculum while supporting science education. The paper provides various models and examples to guide the implementation of curriculum integration, emphasizing the importance of hands-on science experiences and their contribution to reading skills and comprehension.

Keywords: science instruction, standardized tests, curriculum fragmentation, integrated curriculum, whole child, ELA, cross-disciplinary learning, curriculum integration, hands-on science experiences, reading skills, comprehension

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Prologue

Science Instruction in the Classroom is down to 20 minutes.

In 1998 as part of the Massachusetts Education Reform Act, the first MCAS (Massachusetts Comprehensive Assessment System) tests were administered. These standardized tests began a controversial road that we're still on today, aiming to improve student achievement and school accountability. The road has been fueled by the No Child Left Behind (NCLB) that was approved by Congress in 2001, propelling us into a punitive system for underachieving schools, labeling them as "failing" if they didn't meet the state accountability standards of math and ELA (English Language Arts). Out of this work came many state and national standards of teaching to guide instruction; in 2009 the Common Core Standards for math and ELA were published, and the Next Generation Science Standards in 2013 followed by the Massachusetts Framework standards in science, math, ELA and social studies in 2016-2018.

An unintended consequence of NCLB and this standards-based system was a fragmentation of core content and narrowing of content other than math and ELA. Increasing instructional time to improve test scores became the focus. A 2007 survey conducted by the Center of Education Policy found that 62 percent of districts reported an increase in time devoted to reading and mathematics[1]. Research based curricula that schools have adopted requires 90 minutes per day of reading, 45 minutes of writing and 60 minutes per day of math to ensure efficacy. Accounting for lunch, recess, and transition there are few minutes remaining for social

[1] Hardiman, Mariale M. (2016) Education and the Arts: Educating Every Child in the Spirit of Inquiry and Joy. Inquiry and Joy. Creative Education. 2016. Volume 7 pp 1913-1928

studies and science in the fragmented day, nationally, over 10,000 teachers report that science, alternating with social studies, is given 20 minutes per day[2].

Science builds background knowledge and helps children learn to read, why then would we reduce science instruction time in schools?

The large body of research on the science of reading articulates that organized, explicit and deliberate instruction of phonics, fluency, vocabulary, and comprehension contribute to reading success.[3] These research-based practices demand this extra time that is now devoted to ELA in the school day, how then can we reconcile only 20 minutes per day for science and social studies? I propose that we build on work that has been done and focus on integrating more of the science and social studies content into the ELA programs, this will not only increase efficiency but will enrich the ELA curriculum. Students will build background knowledge and vocabulary knowledge supporting ELA instruction. This is curriculum integration can take many forms along the spectrum and throughout the year. It starts with alignment of units and themes where there are skills and content that connect, this project gives several models that can be used as a guide and several examples of how those models can be implemented. This will increase time students have to do hands-on science while supporting reading skills and comprehension.

The Role of a Science Coach

A coach, as defined by my district, supports teachers in building their content knowledge and choosing the best instructional models for each subject area. As a science specific coach, my role is defined as increasing teachers' science knowledge and improving their science

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[2] Banilower, E., Craven, L., Smith, P., Trygstad, P. (2020) Elementary Science Instruction in the US: Warning Signs and the way Forward. The National Survey of Science & Mathematics Education. Accessed 4/17/23 at: http://horizon-research.com/NSSME/wp-content/uploads/2020/03/Elem-Sci-RPS.pdf

[3] Vaughn S, Fletcher J. (2001) Explicit Instruction as the Essential Tool for Executing the Science of Reading. Read Leag J. 2021 May-Jun;2(2):4-11. PMID: 35419568; PMCID: PMC9004595.

instructional models. Through this project I reveal my role to align and integrate the core content curricula and determine what we need to push it forward. Working across the disciplines with the ELA coach is strengthening our models of instruction and determining the tools that teachers need.

Behnam Tarizi in the Harvard Business Review[4] has distilled effective leadership down to 4 defining characteristics; change leaders have a North Star and they talk about it, change leaders use a GPS to guide them toward their North Star, change leaders work across boundaries, and change leaders move fast.

[4] Tarizi,Behnam. (2014) The Key to Change Is Middle Management. Harvard Business Review. October 27, 2014. Accessed online 2/3/23 https://hbr.org/2014/10/the-key-to-change-is-middle-management

Introduction: Why Science

Walk down the street and ask people along the way where the big oak tree gets its mass from, chances are not many will be able to explain it. You may get varying answers about the mass coming from the soil, water, or sunlight. Rosalind Driver and her colleagues did extensive work around misconceptions in science and found that there is a "persistent intuitive conception ... that plants get their food from their environment, specifically from the soil; and that roots are the organs of feeding".[5] If this were the case, wouldn't there be massive holes in the ground around the base of trees? Instead, trees get their mass from the carbon in the atmosphere, and this is what makes them such good mitigators against climate change. This is an example of the science it takes to understand news headlines and snippets on topics like climate change, it is how misconceptions in formative years can persist into adulthood. Science like this helps us understand the world around us, how to improve medical treatments, create more efficient technologies and how to protect our environment. At this larger scale of justification on science it's easy to feel disconnected but, at the granular level like trees gaining mass from absorbing carbon from the air it becomes obvious how these big ideas transfer to our lives.

I'm a lifelong science educator driven by a curiosity of the world, of how things work and how to solve problems; the education setting, and systems are like a puzzle to me, the pieces of the puzzle are sometimes obvious and sometimes more subtle. The pieces of the educational puzzle currently in front of me are time, priorities, mandates, and learning content of literacy (reading & writing), social studies, math, and science. Students are currently given on average,

[5] Driver, R., P. Rushworth, A. Squires, and V. Wood-Robinson. (2005) Making sense of secondary science: Research into children's ideas. New York: Routledge.

20 minutes of science or social studies instruction per day[6]. While math and reading are essential subjects, elementary students need more science instruction. By creating time for science, school leaders and educators give students the space and opportunity to build knowledge, interact with classmates, problem-solve, and engage in important content at an age when they are at their most curious. Today's young people need to study and understand their world so that as young adults they can make decisions that have a positive impact.

My goal in this project is to understand the pitfalls and barriers of more integrated curriculum while always being guided by my North Star of science; science takes on a new meaning when you integrate it with the whole of who we are our daily lives, science in the way we view the world and interact with those in it, I consider it to be environmental and social. I'll guide us through what I feel are important frameworks that I've learned about integrating curriculum and why, I'll end with examples of integrated curriculum in this fragmented place we've found ourselves in public education year 2023.

[6,4] Banilower, E., Craven, L., Smith, P., Trygstad, P. (2020) Elementary Science Instruction in the US: Warning Signs and the way Forward. The National Survey of Science & Mathematics Education. Accessed 4/17/23 at: http://horizon-research.com/NSSME/wp-content/uploads/2020/03/Elem-Sci-RPS.pdf

The Path of Education Reform in the United States

What does the historical research and political perspective tell us about what has led to the fragmentation of curricula in our schools?

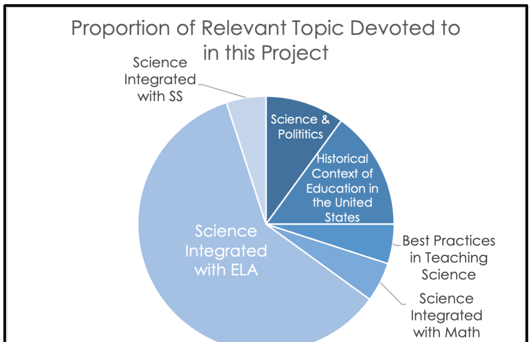

Figure 1

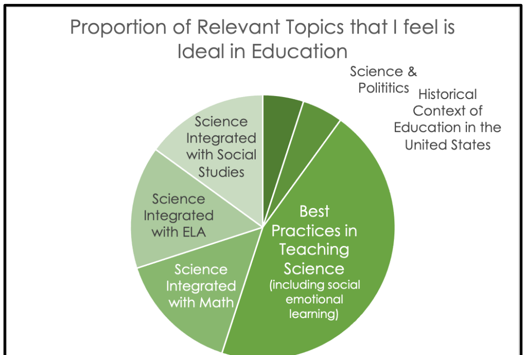

Figure 2

In education there are names that you can't avoid hearing, whose theories and teachings have endured centuries, whose ideas have become the building blocks of education even as we see it today. John Dewey, Lev Vygotsky, Jean Piaget and Aristotle; our differing interpretations of their contributions and framing of education has led to differing methodologies and curriculum content, to a system that aims to create high quality education for all in a democratic society. I've highlighted points that weave a story of a system of good intentions that has sidelined science in the general public education schools (fig 1); however, this is only a fraction of the story as I'm currently seeing it. Much of the story is excluded (fig 2) because of the scope of this project. Topics of relevance when teaching the day-to-day are not focused on science and politics or the historical context of education, the focus becomes best practices and what students need in the moment. When zooming out to understand the path to this point and the path forward the perspective needs to change as in figure 1.

Further zooming brings the Greek philosopher, Aristotle in 336 BC into perspective. Aristotle believed that knowledge should be divided into three areas of inquiry: the theoretical (telos) of pursuing truth for its own sake, the productive (eidos) of making *things*, and the practical (praxis) of making *judgments*. Aristotle put the telos as the highest priority in that the gaining of knowledge and the contemplation of that knowledge is where we reach enlightenment. The most enlightened would act based on sound reasoning or detailed reflection. In the eidos people begin with a plan or design, an idea of the object to make, their frame of mind is that of the artisan or mechanic in that they have the skills necessary to make action and create the object. This productive inquiry can be seen as a process and product with the focus on the product. The purpose of the final inquiry, praxis, is the cultivation of wisdom and knowledge put into practice. When people begin with a situation or question and are guided by moral disposition to act truly and rightly, this enables them to engage with the situation as thinkers and come to a process. In praxis there is no prior understanding of the outcome, there is a fluidity through the practical[7].

This breakdown of Aristotle's inquiries could lead to seeing the origins of the content silos that the system is currently in, where academics, theoretical physicists and mathematicians are in the telos silo, the skilled workers of plumbers and trades people as well as artists are in the eidos silo and the practitioners of doctors, educators and lawyers are in the praxis silo. However, the lines are blurred as people move in and out of these inquiries and therefore it cements the belief that many types of knowledge are used simultaneously or congruently. This tension between the silos and across the silos is what teachers and students move in an out of building knowledge. The subliminal message that one silo of knowledge is more important than another such as math and ELA over science and social studies over music, gym and art is counterproductive to building knowledge.

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[7] Smith, M. K. (1999). 'Aristotle on knowledge', *The encyclopedia of pedagogy and informal education*. https://infed.org/mobi/aristotle-on-knowledge/. Retrieved: 2/14/23

Fast forward to April 1983, the National Commission on Excellence in Education and the U.S. Secretary of Education, Terrel H. Bell, released the report *A Nation at Risk*. The most famous line of the widely publicized report declared that “the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people” (U.S. Department of Education, 1983). Bell takes a national and global view of our education system, “The world is indeed one global village. We live among determined, well-educated, and strongly motivated competitors. We compete with them for international standing and markets, not only with products but also with the ideas of our laboratories and neighborhood workshops. America's position in the world may once have been reasonably secure with only a few exceptionally well-trained men and women. It is no longer.”[8] A study between 1955-1961 showed that the Soviet Union was training three to five times as many scientists as US[9] in the sputnik race to space against the Soviet Union at the end of the Cold War. Bell made it clear that there was a need for the country to get a competitive edge, at the same time the economy was still recovering from a recession and global production and trade was down[10]. Increased achievement and education reform were natural goals of the Secretary of Education leading to this nation-wide reform.

Massachusetts, in large part because of Horace Mann, who knew that the quality of rural schools had to be raised, and that teaching was the key to that improvement[11] was ahead of the curve nationally. Mann was a lawyer and legislator elected as Secretary of the newly created

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[8] U.S. Department of Education, Gardner, et al. (1983) A Nation At Risk: The Imperative For Educational Reform. An Open Letter to the American People. A Report to the Nation and the Secretary of Education. April 1983.
[9] Kaiser, David (2006). "The Physics of Spin: Sputnik Politics and American Physicists in the 1950s". *Social Research*. **73** (4): 1225–1252. doi:10.1353/sor.2006.0030
[10] United Nations. (1983) World Economic and Social Survey 1983. United Nations Department of Economic and Social Affairs, Economic Analysis. 26 December 1983. https://www.un.org/development/desa/dpad/publication/world-economic-and-social-survey-1983/ Retrieved 2/22/23
[11] Public Broadcasting Systems. (1992) PBS Online: Only A Teacher: Schoolhouse Pioneers. https://www.un.org/development/desa/dpad/publication/world-economic-and-social-survey-1983/ Retrieved 2/25/23

Massachusetts Board of Education in 1837, he enacted major educational reform and moved Massachusetts ahead. Over the next 100 years pioneers including Horace Mann worked to develop the Common Schools and train teachers to ensure that democratic and secular education flourished.

In February 1993, in McDuffy v. Robertson of the Massachusetts Supreme Judicial Court ruled that the constitution's education clause imposes a duty on the Commonwealth to ensure the education of all children and declared that the funding system violated that duty. In response, Massachusetts enacted a new school funding system, the Massachusetts Education Reform Act (MERA) that improved equity and opportunity for all students [12]. This historic legislation created the framework for unprecedented improvements in student learning, teacher professionalism, school management, and equity of funding. Chapter 69, Section 1D specifically states[13] ;

> *The board (of elementary and secondary education) shall establish a set of statewide educational goals for all public elementary and secondary schools in the commonwealth. The board shall direct the commissioner to institute a process to develop academic standards for the core subjects of mathematics, science and technology, history and social science, English, foreign languages and the arts. The standards shall cover grades kindergarten through twelve and shall clearly set forth the skills, competencies and knowledge expected to be possessed by all students at the conclusion of individual grades or clusters of grades. The standards shall be formulated so as to set high expectations of student performance and to provide clear and specific examples that embody and reflect*

[12] *Massachusetts | Education Law Center*. (n.d.). https://edlawcenter.org/litigation/states/massachusetts.html
[13] Department of Education. (2015) History of Content Learning Standards in Massachusetts. https://www.doe.mass.edu/instruction/History.docx Retrieved 2/19/23

these high expectations and shall be constructed with due regard to the work and recommendations of national organizations, to the best of similar efforts in other states, and to the level of skills, competencies and knowledge possessed by typical students in the most educationally advanced nations. The skills, competencies and knowledge set forth in the standards shall be expressed in terms which lend themselves to objective measurement, define the performance outcomes expected of both students directly entering the workforce and of students pursuing higher education, and facilitate comparisons with students of other states and other nations.

MERA gave validity to all the content areas and major increases in the amount of state funding that still flows to schools today, and it also established high standards and required more accountability across the entire education system. Through this process emerged the need for State assistance to support underachieving and under-resourced schools. As schools were struggling to meet these high expectations, especially in rural, under-funded communities. Further reform under MERA led to a set of content teaching and learning standards with the intention of equity for all students. At the national level the creation of the National Assessment Governing Board in 1991 and reforms of the federal Title 1 law in 1994, required states to adopt content standards and assessments tied to them, reflected a growing national consensus in support of standards-based reform[14]. This has led to state and national content standards in math, ELA, social studies, and science. The first Massachusetts Science Technology and Engineering Frameworks were first drafted in 1996 then revised in 2006 and again in 2016 guided by the Next Generation Science Standards. The goal of these standard sets continues to be to prepare

[14] Chester, M. (2014) Building on 20 Years of Massachusetts Education Reform. https://www.doe.mass.edu/commissioner/buildingonreform.pdf Retrieved 2/19/23

students with the skills and knowledge to pursue a career in any field. The Science Technology and Engineering (STE) framework set aims to prepare all citizens to be able to "analyze current events, make informed decisions about healthcare, or decide to support public development of community infrastructure"[15].

Measuring the success of this funding and standards-based system is a parallel storyline of assessment at the national level. At the top of President Bush's agenda was education reform and Reading First which emerged from Bell's report: A Nation at Risk, was The No Child Left Behind Act of 2001 (NCLB). This legislation established funding and performance criteria for schools. In order to receive these Title 1 funds, schools must administer annual assessments in reading and mathematics, show "adequate yearly progress" in student achievement, and ensure that all teachers are "highly qualified". Massachusetts was again ahead of the curve and had developed Massachusetts Comprehensive Assessment System (MCAS) in 1998. These tests are aligned with the framework standards across the content areas of math, ELA and science. Grades 3-8 are assessed yearly in math and ELA and in grades 5 and 8 for science with no testing administered for social studies content.

This focus on ELA and math was because children were entering schools with low reading comprehension and phonemic awareness. In 1995 head start programs were started across the country to address the link of reading readiness and income level. Because children of privilege are afforded more of these opportunities in life, ways to build background knowledge and vocabulary[16,17]. The fact that education should not need privilege to be effective holds these

[15] Massachusetts Department of Secondary and Elementary Education. (2016) Science and Technology/Engineering Massachusetts Curriculum Frameworks. Malden, MA www.doe.edu
[16] Wexler, Natalie. (2019) The Knowledge Gap. Random House Publishing. New York. ISBN 9780735213562
[17] Wolf, Maryanne. The Reading Brain; we were never meant to read. Ministry of Education, Science, and Culture. Reykjavik, Iceland. Accessed: 3/16/23 https://www.stjornarradid.is/media/menntamalaraduneyti-media/media/maryanne-wolf/iceland-lecture827final.pdf

structures in tension. When we consider that in K- 2nd grades students are learning to read and then in 3-5th grades students are reading to learn, this fundamental idea can be flipped if science and social studies content are used to teach students to read, giving them background knowledge that aligns them with their peers rather than sets them back. There's also a working false premise that history is too abstract for young children and that the focus in the early years should be spent on reading to equip students with the skills to acquire knowledge about the world later[18]. The lesson learned here is that we need to expose all kids to grade-level reading material and content, even if some students need accommodations to make it more accessible[19]. Math does not rely on this skill set of reading, instead it relies on more basic skills that can be built on more easily and students can progress more rapidly independent of language-based skills. Therefore, it makes sense that reading, and math were the focus leading up to NCLB and continue to be based on the standardized tests that dictate funding to our public system. This drives schools and teachers to purchase research-based curriculum that requires more time in the schedule.

As a result of the high stakes testing and move toward research based curricular models

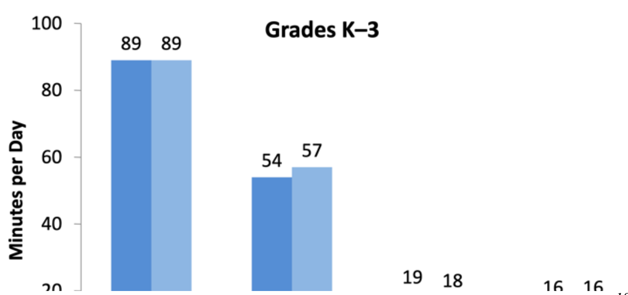


Figure 4: National Survey of Science & Mathematics Education[18] 10,000 teachers responded that they are spending an average of 18 minutes per day on science and 89 minutes per day on English Language Arts.

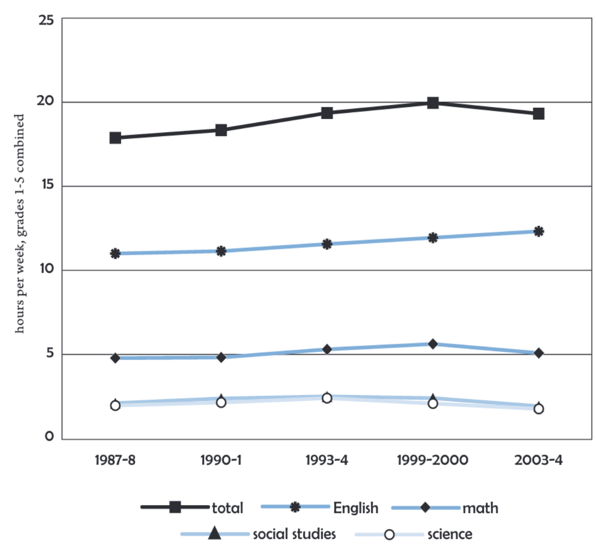


Figure 3: Time Allocated to Four Major Subjects in Public Schools Grades 1 to 5 [17]

[18,20] Marcelo, K., Levine, P., Lopez, M. (2008) Getting Narrower at the Base: The American Curriculum After NCLB. The Center for information & research on Civic learning & engagement. Accessed 1/8/231/8https://search.issuelab.org/resource/getting-narrower-at-the-base-the-american-curriculum-after-nclb.html
[19] Moran, H. Personal Communication with Reading Specialist. January 2023.

multiple studies show the decline in time devoted to social studies and sciences across the country; a 2007 survey conducted by the Center of Education Policy found that 62 percent of districts reported an increase in time devoted to reading and mathematics[20], Figure 3 shows a review of data from 1987 to 2003 that tells the same story[21], a study in Kansas found that of the 164 teachers who responded to a survey, 59.1 percent indicated they decreased the amount of science instruction in their classrooms since the implementation of NCLB[22]; studies by the National Survey of Science & Mathematics Education (fig 4) found that students in grades K–3 were taught science for an average of just 18 minutes a day, compared with 89 minutes for English language arts and 57 minutes for math[23].

This reduced instruction time in science and social studies continues in 2023 with continued pressure from high stakes testing and NCLB, schools have turned to research-based curricula that show efficacy at 90 minutes per day of reading, 45 minutes of writing and 60 minutes per day of math (pers com Richardson, 2023). Accounting for lunch, recess and transition there are few minutes remaining for social studies and science in the fragmented day, in many instances science and social studies are given 20 minutes per day on an alternating schedule. The result is a fragmented education with most of the time devoted to skills and comprehension of math, reading and writing. What if there were a more efficient whole brain approach utilizing and practicing these skills across the content areas?

[20] Hardiman, Mariale M. (2016) Education and the Arts: Educating Every Child in the Spirit of Inquiry and Joy. Inquiry and Joy. Creative Education. 2016. Volume 7 pp 1913-1928

[22] Griffeth, G., Scharmann, L. (2008) Initial Impacts of No Child Left Behind on Elementary Science Education. *Journal of Elementary Science Education*. *20*(3) 35-48.
[23] Banilower, E., Craven, L., Smith, P., Trygstad, P. (2020) Elementary Science Instruction in the US: Warning Signs and the way Forward. The National Survey of Science & Mathematics Education. Accessed 4/17/23 at: http://horizon-research.com/NSSME/wp-content/uploads/2020/03/Elem-Sci-RPS.pdf

This project explores the intellectual and practical sense of a successful curriculum integration[24] *to consider ways to restore the functionality that high stakes testing focus has taken away.*

Intellectual Sense of Integration

How would connecting the different subject areas within the current public-school curriculum be beneficial to the whole student?

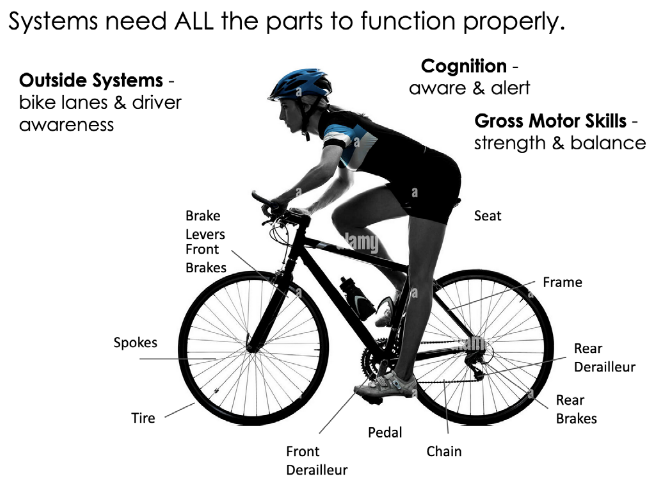


Figure 5 A system model of a bike, showing the integral parts and subsystems that make the bike function properly.

Aspects of life can be seen as systems within systems to function properly. At its most basic level, just as the bike needs all its parts to function properly, so does our way of learning. Considering the system of a bike, if the chain of a bike falls off or the bike gets a flat tire the bike will not function; if the seat is missing or the brakes are not adjusted properly the bike will not function. The rider in this system is a subsystem of the whole that also needs to function properly, the rider needs cognition to stay aware and alert to make cognizant moves and the rider needs gross and fine motor skills for practice and exploration with the mind and body as a unit to hone the skill. The system extends externally to the outside world, where there is a shared agreement with the community in maintaining the roads, creating bike lanes and drivers who share the road and are aware of bikers. These systems within systems make it possible and safe for bikers to ride for recreation or commuting purposes.

[24] Ackerman, D. B. & Perkins, D. N. (1989). Integrating Thinking and Learning Skills across the Curriculum. In H. H. Jacobs (Eds.), Interdisciplinary Curriculum: Design and Implementation (pp. 25-38). Alexandria, VA: Association for Supervision and Curriculum Development.

This phenomenon of bike riding and the system(s) that make it possible can be extended and applied broadly, consider the phenomenon of learning new information; we can zoom out to the national level of our education system as we've already done to consider the historical, political and financial systems that contribute to the how and the what of what children learn and we can zoom in to the function and elasticity of our brain as it makes connections and cognition. At the heart of acquiring and building this knowledge and skills may likely be critical thinking. This transfer of knowledge is what we're all aiming for, getting them to be independent critical thinkers applying skills in all different ways.

Elementary schools can be a place to nurture the whole brain as a system. What is understood on the science of reading is that it takes many parts of our brain to form meaning around our written and oral language. When students hear you read a passage about for example, how forces act to move an object, they are hearing new word sounds, new concepts even that they cannot fully comprehend yet. So, you show them a video and they start to put more pieces together, to build on the vocabulary and make meaning out of the words. Then you give them objects to apply force to while at the same time using the academic language, this causes their neural pathways to fire and connect in ways they didn't before. The elastic brain builds on itself in this way and the effect is that they comprehend the language you are using. This is building background knowledge.

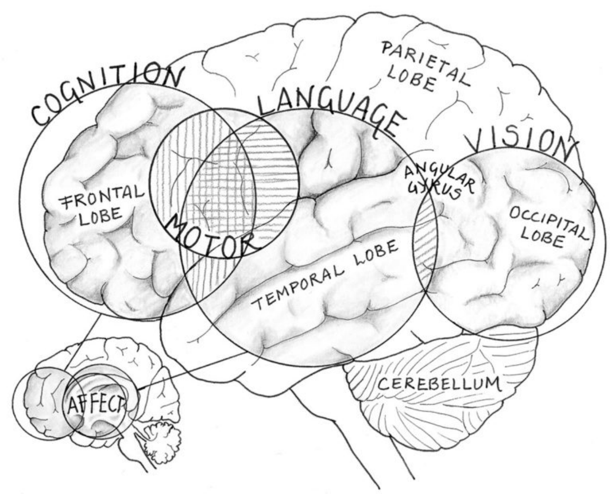


Figure 6: A visual of the regions of the brain and their dominant function[22].

In an interview with Susanna Arceiri, Maryanne Wolf explains that some regions of the brain already exist for other functions (fig 6), like the visual system and language system. Other regions have to do with our ability to think and make hypotheses, our ability to feel, and to move. All those functions had their own connections, but they were all never connected in one single and unique circuit for the purpose of reading.[25] Maryanne Wolf also articulates that reading isn't a skill that is in our DNA that we are born with, it takes repetition and deliberate practice, and for some children it takes more.

Originally created by Hollis Scarborough in 2001[26], a leading researcher of early language development and its connection to later literacy, this image of the rope (Figure 7) it is still widely accepted and used as a way to understand the complexity of what children are undertaking when learning to read.

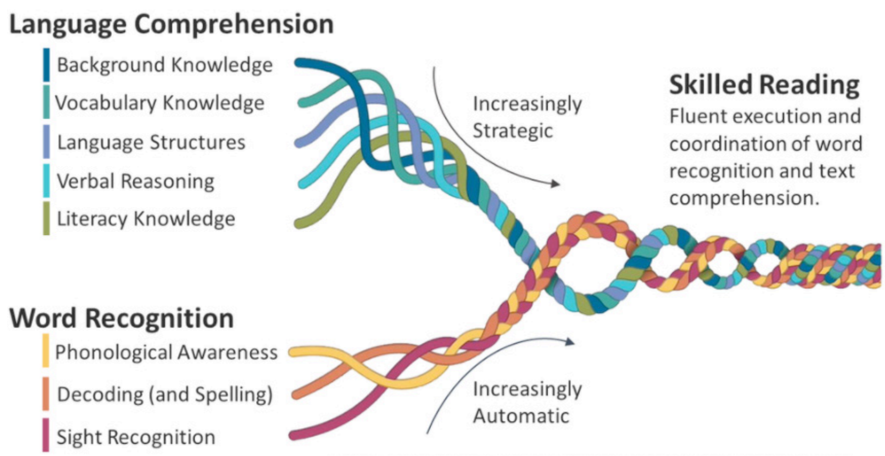


Figure 7 Scarborough's Rope[26] – a visual to understand the development and connections in literacy.

What I suggest is that we find every opportunity to help strengthen this rope for children and in science that is through building background knowledge and vocabulary knowledge.

Practical Sense of Integration

[25] Arcieri, S. (2019) Interview with Maryanne Wolf. Criminal Law and Human Condition. Retrieved 2/7/23 https://dirittopenaleuomo.org/en/interviste/interview-with-maryanne-wolf/

[26] Scarborough, H. S. (2001). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (Eds.), *Handbook for research in early literacy* (pp. 97–110). New York, NY: Guilford Press.

How might we leverage the existing public-school curriculum to foster a more integrated and interconnected approach to learning that prepares students for the complex challenges of the 21st century?

To address declining student achievement seen through high stakes test scores districts are turning to vetted standards-based curricula; the intent of these curricula is to improve student achievement in a high-stake testing world, but the pressure on the system is breaking it down into silos. These curricula are complex in that they integrate multiple best practices and take multiple years for teachers to master implementation. Compounding the problem is that each different content curricula is siloed and requires more minutes in the day to teach than is available in the day. Anecdotally I'm seeing students feel this pressure as stress and lack of content connection, disengaging the already struggling students.

How can we effectively support teachers in bringing back practices that increase student achievement while also increasing student engagement, reducing stress and nurturing the whole child and brain? Increased efficiency. Through curriculum alignment, thematic integration, and transfer of skills across content we can increase efficiency and support student's capacity foIn 1987 the National Council for Critical Thinking defined critical thinking as "Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action."[27] These critical thinking skills are congruent with the Next Generation Science and Engineering skills and practices, with the Common Core literacy, social studies and math standards and culminate into what we want all students to be developing as learners.

[27] Scriven, M., Paul, R. (1987) 8th Annual International Conference on Critical Thinking and Education Reform. Summer 1987. Accessed March 26, 2023 https://www.criticalthinking.org/pages/defining-critical-thinking/766

Figure 7 An example of the first steps to parallel curriculum alignment. Here the science, social studies and ELA units were mapped and rearranged by a 2021 science, ELA and social studies coaching team based on potential common themes. The overlayed circles show where that alignment was found across content areas.

Lining up the curricula for integration is the first step in creating efficiency for teachers to be able to see where the transfer of skills or combining of content into one project is possible, it will make visible the places for integration, figure 7 above is an example of sequencing the units to have common themes align throughout the year, this is considered parallel alignment.

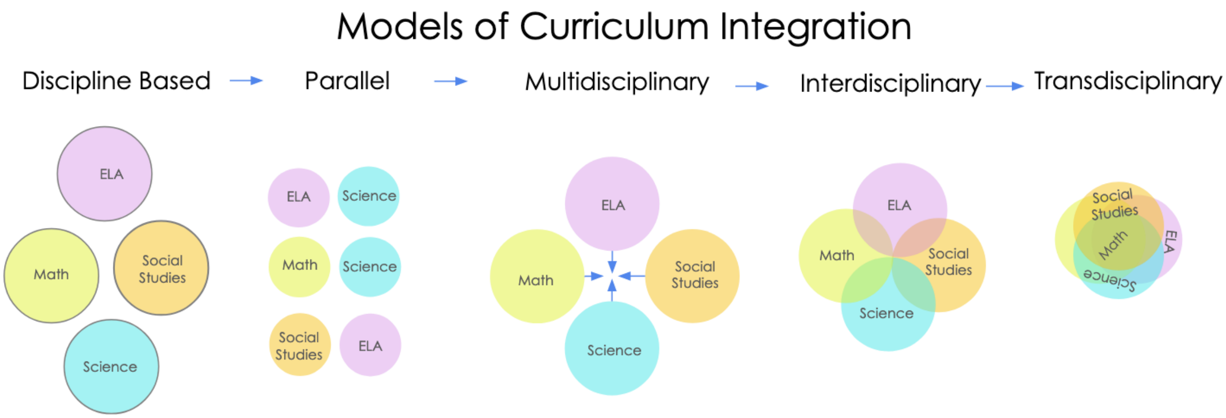


Figure 8: A model on the spectrum of curriculum integration, adapted from Interdisciplinary Curriculum: Design and Implementation[28]

Most of our public middle and high schools are discipline based wherein the approach focuses on a strict interpretation of the disciplines with separate time blocks throughout the day. This encourages teachers for specialization, depth of content knowledge, and integrity to the conventions of their discipline. In elementary school this still holds true in that the day is chunked by one teacher who covers all the disciplines and moves throughout the day from one to another on a prescribed schedule. Teachers are expected to be specialists in math, ELA, science, and social studies content. To know the standards, methods, and strategies to teach a wide breadth of across the content areas becomes a burden for teachers and inevitably content will be glossed over.

The parallel based approach sequences lessons to correspond to the same area in other disciplines. This is where current packaged curriculum programs are making this possible. Such as Savaas' MyView that has social studies and science content woven throughout, Great Minds' Wit and Wisdom that incorporates text that is rich in building background knowledge or Amplify Science that uses reading and writing strategies to go in depth on content. This is where the

[28] Adapted from Jacobs, H. (1989) Interdisciplinary Curriculum: Design and Implementation. Association for Supervision and Curriculum Development. ISBN 0-87120-165-8

current opportunity aligns. These curricula are vetted, aligned to the standards, and incorporating all of the best practices and pedagogy that we know works for students.

The multidisciplinary approach connects two or more disciplines such as math and science, while the interdisciplinary approach starts with the disciplines and connects them with each other, the overall theme, or the issues. The gold standard of this is Expeditionary Learning where students do long-term in-depth studies of a single topic that explore compelling social and environmental questions, incorporate vital standards, involve fieldwork, and culminate in an authentic project, product or performance.[29] Casco Bay High School in Portland Maine is an expeditionary high school that uses college prepatory and AP classes while infuses in-depth interdisciplinary model. Lastly, the transdisciplinary approach, the content and the theme are the same, and there is no division between the disciplines.[30]

Years of work was done to create our standards-based systems that guide teachers on what students should learn and know. District curriculum maps have been created and assessments have been designed around these standards. They aren't going anywhere. Within each of the disciplines are lofty goals that spiral through the grades building on one another to accumulate to what we want students to know by the time they graduate. These standards have been designed based on developmental research to guide us on what typical developing students are capable of. This is the framework that we must create connections within.

My Director of Teaching and Learning agrees that "there is value in building schema through looking at content in multiple ways"[31] with her support and the support of a principal I

[29] Casco Bay High School. (2023) About page. Accessed 4/5/23 https://cbhs.portlandschools.org/about/school-profile
[30] Jacobs, H. (1989) Interdisciplinary Curriculum: Design and Implementation. Association for Supervision and Curriculum Development. ISBN 0-87120-165-8
[31] Richardson, A. Personal Communication with District Curriculum Director. 2/8/23

led a professional development workshop on "Content and Brain Connections" that is essentially the work of this paper and an ongoing element of the project. The most profound learning out of PD session, personally, was that students that are struggling readers prefer non-fiction texts. These are the text with many text features of pictures, captions, graphics and text boxes with definitions or highlighted points. These are the texts that are used in science, underscoring the need and applicability of this integrated approach.

Questions posed to teachers to elicit feedback:

- What pathways to you see to do more science (or other curriculum connections such as social studies, art, and music)?
- What do you need to integrate more curriculum content? Keep in mind we can start with small steps, so don't ask for the moon *yet*.
- Thinking optimistically, what is one thing you can implement soon?

Sample of most useful and connected feedback from teachers:

- "I think it would be so cool if specialist teachers knew what we were learning about in MyView or Science and incorporate art, music and dance into their learning during these times."
- "Maybe CPT [common planning time] can be teacher driven and planning with specialists to plan across the disciplines."
- "Science is embedded in so much of our daily life, it can be incorporated throughout all parts of the curriculum and specials. "
- "Writing about science in ELA"
- "Create a center that will incorporate science during ELA"
- "having flexibility to teach cross curriculum content, being able to have learning center time, vs. just literacy centers and just math centers."
- "trying to have a science exploration activity during a center block."
- "Potentially incorporating cross-curricular topics in a PBI [project-based inquiry] week

Workshop feedback also revealed that all teachers aren't comfortable with teaching science and would prefer to have science specialists like art and music[32]- but this sidelines science further, so what do teachers need in order to be more confident teaching science content. Get them excited about teaching the whole brain, that they're job as an elementary educator is to not be the expert on content but find ways to build the critical thinking and to "borrow" and build skills from one task to another. As Benson pointed out in the 80's "if the connection among the disciplines contemplated by integrative studies is nothing more than a matter of borrowing insights or methods from one or more disciplines to illuminate problems in another, it seems fair to ask why such extra-curricular borrowing is called integration."

There are a finite number of minutes in the school day to accomplish these expectations we put on our teachers and students; how then can we make the best use of our time? How can we ask teachers to synthesize these demands into a cohesive curriculum that students gain the skills and critical thinking time that they need? The work that has been done before us sets the stage for this in a way that we are missing. I propose that if we assist teachers in their efficiency of teaching and take advantage of the transfer of knowledge then we deepen students understanding of content and give them the tools to hone their skills. This idea applies to all content where we can see efficient connections and applications.

The puzzle becomes in what ways can we find commonality between standards per grade level in ways that are manageable for teachers to plan for and that create efficiency in the teaching and learning of students while still nurturing the arts & humanities and social emotional skills of empathy, communication, and teamwork to build positive relationships knowing that the whole child is important.

[32] Flaherty, E. (2023). *Professional Development Workshop for Integrating Curriculum for Elementary Teachers. Salem Public Schools.*

Models and Tools

How might the existing public-school curricula be leveraged to foster a more integrated and interconnected approach to learning that prepares students for the complex challenges of the 21st century?

In a K-3 grade classroom teachers are teaching every subject, whereas grades 4&5 are specialized to one subject or narrowed down to teaching two subjects. While this gives K-3 teachers ample opportunity to see where the skills from one content to another transfer it also is an overwhelming situation to implement each new initiative. It will take time and consideration to find the pathways. Below are three potential pathways to integrating skills and content.

1. ***Transfer of Skills***

It is possible to integrate curriculum if no alignment is possible and content needs to remain in silos. The key may be to intentionally name the skill and what other content it is used in; ELA, science and social studies use all of the following skills often and are named in the standards of each subject.

Transfer of Annotation Skills from ELA to Science	
Highlight yellow	important
Highlight red	I understand
Highlight blue	I don't understand

Annotating Text is something that structures a first read and a second close read for students; in the first read they highlight important facts or idea, things that they understand and things they don't understand, in the second close read they look for the gist of the story and check their understanding again. Using this technique

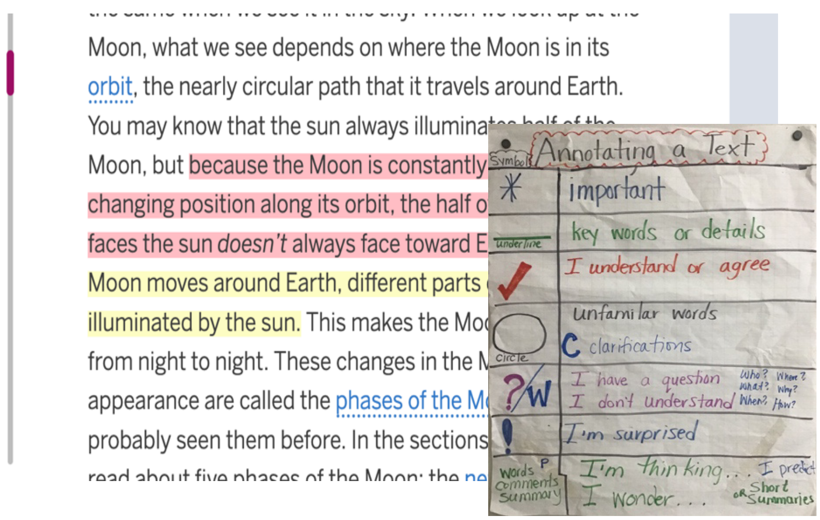
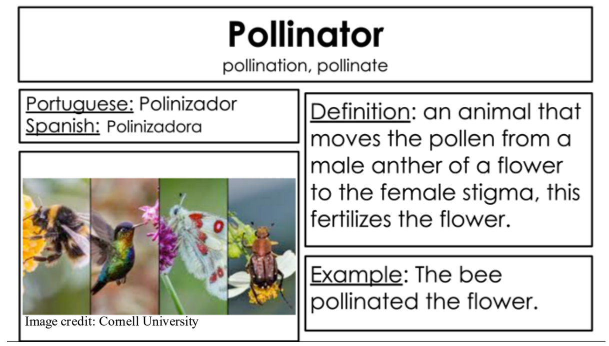


Figure 9: Student work of an annotated text from Amplify Science online curriculum article. The keys guide students in which color to use with the online tool or pen & paper.

helps students with cognition and metacognition.

Vocabulary

Vocabulary instruction is key to reading comprehension and building background knowledge. Going over academic vocabulary either with or without curriculum alignment is a transfer of knowledge and skill. For multi-lingual learners who are learning English and academic content at the same time teaching vocabulary across the content areas intentionally is an important practice.



Finding the Central Theme or "Gist"

This is a skill that is taught in ELA crosses over to science and social studies well. In ELA it is a skill that is practiced while in science and social studies it can be a skill that is utilized when reading about a topic. In ELA they read short sections of a long passage to find the gist of each small section, typically using a two column note format where the teacher inserts the text into the left and students fill in the gist to the right. In science and social studies, rather than slow down the lessons to teach this skill it can be used when discussing articles to build understanding of a topic, either in group discussions, partner reading or individual work.

Argument from Evidence

This is a skill that is taught in science, social studies and ELA, in science it is taught with a framework of claims-evidence-reasoning in order to build a scientific argument using evidence to support the claim or main argument. In ELA and social studies, it is often used to build an opinion. The differences between the two are nuanced but important to explicitly teach students. For example, in social studies student may develop an argument on why they feel universal health care strengthens our communities while in science they are gathering evidence on why vaccinations strengthen our community. In social studies they may find fact to support their opinion while in science they are finding fact to support a scientific claim.

Core Literacy Skills - Oral, Writing, Listening and Reading

These four core literacy skills have place in all content area of math, science, social studies and ELA and can be practiced with strategies that all teacher use. This website https://www.readingrockets.org/strategies has a library of these strategies that can be used across the content areas to build these oral, writing, listening and reading skills.

Framework for Planning

This model can be used as a generic framework when planning units of study across ELA and science content, a way to consider where skills and content can cross over in parallel alignment or project-based learning.

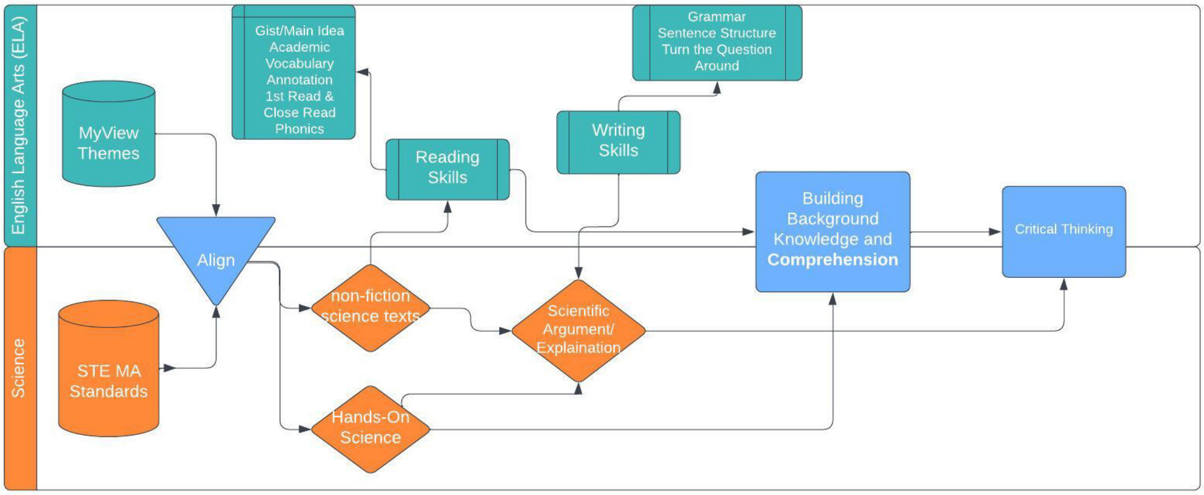


Figure 11 A model for ELA and science connections in aligned themes and units. Putting lessons and units through this model can result in deeper connections for students, increased knowledge and skills.

Further Alignment of Content

Whether alignment is done toward parallel as in Figure 6, multidisciplinary, interdisciplinary, or transdisciplinary there are benefits. Below are two examples.

There are curricula on the market that are integrating one another, for example, Savaas's MyView and Great Minds' Wit and Wisdom are using science and social studies content to teach ELA skills while Amplify Science and Great Minds' PhD Science are using ELA skills to teach science content. Figures 6 gave an example of **parallel alignment** using the science and social studies units with the MyView ELA curriculum which uses science and social studies content to teach reading and writing skills.

The Venn diagram in figure 12 shows where there is alignment of the national standards. This can be a useful tool for teachers that may be teaching all content in one classroom or for teams of teachers that work closely together. This can also be a framework or starting point for creating project-based learning.

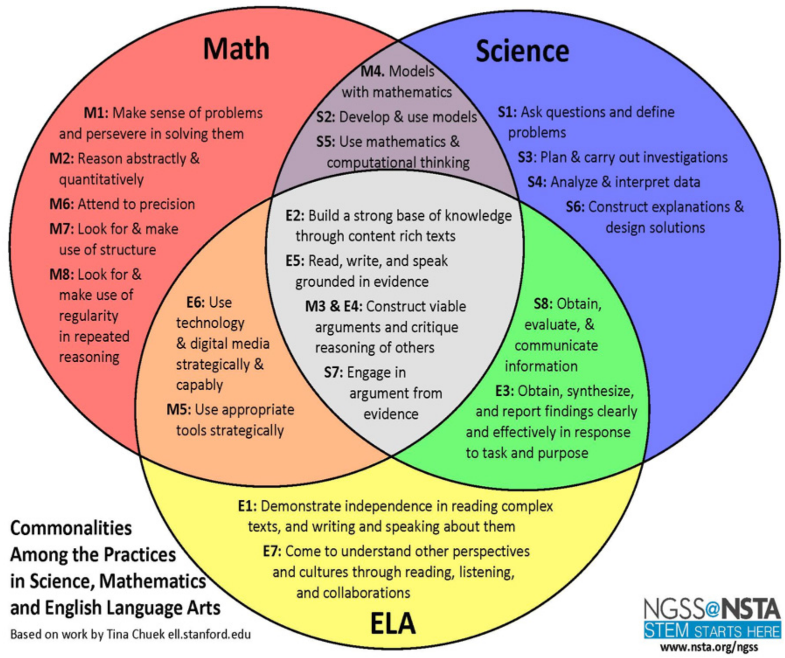


Figure 22 Alignment of math, science and ELA national standards as a starting point for finding curriculum alignment.

Development of Project Based Learning

If there is parallel alignment of the curriculum it will be possible to develop more in-depth projects that give students an opportunity to explore skills and content in multiple ways and times in the day. The first step is to determine what the “organizing center” is that can create a cohesive unit of study. If the parallel alignment has already been done than the common priority standards can be easily identified, and a scientific phenomenon can be determined. Instructional sequences are more coherent when students investigate compelling natural phenomena (in science) or work on meaningful design problems (in engineering) by engaging in the science and engineering practices. We refer to these phenomena and design problems here as ‘anchors.’ What makes for a good phenomenon to anchor an investigation[33]?

[33] Institute for Science and Math Education. (2016) Using Phenomena in NGSS Designed Lessons and Units. Accessed 4/19/23 https://stemteachingtools.org/brief/42

In afterschool and out of school time there is more flexibility, and this is an attainable goal, take for instance this overview of a school vacation STEM camp. In this case the "knows" were the grade level: 4&5, the math standards: geometry and the need for active hands-on science; the unknown was the science standards and the anchoring phenomenon. As a reflective practitioner in the Creative and Critical Thinking program I can say that my thinking was guided by Taking Yourself Seriously[34] in that it was a process of zooming in and out of creative thinking getting a seemingly linear model using a non-linear approach to find connections and pathways.

	Math Common Core Standards			**Massachusetts Science Technology & Engineering Frameworks**	
Standards:	4.G.2 Classifying 2-D figures by lines and angles	4.MD.3 Area and perimeter	5.MD.5 Volume, volume of a right rectangular prism, including the formula	4-ESS3-2. Evaluate different solutions to reduce the impacts of a natural event such as an earthquake.	4.3-5-ETS1-3. Pan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.
	Math Goals			**Science Goals**	
Goals: students will....	apply volume, area and perimeter to a real setting	compare and contrast 2D and 3D objects	accurately and consistently know how to find the volume and area of an object	understand natural disasters and the cause of earthquakes	use the engineering design process
Anchoring PHENOMENON	Earthquakes happen when Earth's crust moves, tension builds up and is released as the plates slip past one another.				
Summary	The recent earthquake in Turkey is used as the anchoring phenomenon and case study; the cause of such devastation in Turkey was the faulty construction of buildings in the region. Students will become engineers that design and build structures that can withstand an earthquake. They will measure the area and volume of structures that they build.				

In a typical education setting this will take more time to develop into something that works for large teams of teachers during the school day.

[34] Taylor, P., Szteiter, J. (2019) Taking Yourself Seriously: A field book of processes of research and engagement. The Pumping Station, Arlington, MA.

Further Work

Provide more Professional Development

Studies show that teacher professional development is down[35] and that student achievement is directly linked to teacher practice[36]. Teachers are asking for "CPT [common planning time] to be teacher driven and plan with specialists across the disciplines."[37] For these reasons it is clear to me that I need to create and deliver more professional development workshops on the science and where it can be best integrated into our current set of curricula. Working closely with individual teachers and small teams of teachers I can determine their level of comfort with each content area and find entry points toward the integration process.

Continue to Advocate for an Increase in Science Time

Literacy and math will continue to be priority when determining schedules and instruction time for each content area. However, it is impossible for teachers to fit rigorous and meaningful science lessons into a 20-minute block, therefore I will advocate across our district to make science instruction blocks longer. This advocacy can be stronger knowing that there is a transfer of skills and practice in comprehension through building background knowledge, as well as the four literacy skills of reading, writing, oral and listening.

[35] Banilower, E., Craven, L., Smith, P., Trygstad, P. (2020) Elementary Science Instruction in the US: Warning Signs and the way Forward. The National Survey of Science & Mathematics Education. Accessed 4/17/23 at: http://horizon-research.com/NSSME/wp-content/uploads/2020/03/Elem-Sci-RPS.pdf

[36] Taylor, J., et al. (2015) An Efficacy Trial of Research-Based Curriculum Materials with Curriculum-Based Professional Development. American Education Research Journal. Volume 52, Issue 5. DOI: 10.3102/0002831215585962

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