The Aesthetics of Experimentation: Conceptualizing and Actualizing a STEAM Program

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1 author:

Christopher Dignam
Governors State University

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Christopher Dignam

Governors State University, United States

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Introduction

Teaching and leading is both an art and a science. High-performing teachers and leaders educate to enrich the minds of educational communities while simultaneously lifting each spirit to inspire actualization. The blending of both disparate yet interrelated content areas such as Science, Technology, Engineering, Art, and Mathematics (STEAM) provides opportunities for teachers, leaders, and students to engage in blended leading, teaching, and learning for elevating both spirit and mind. STEAM is an interdisciplinary and transdisciplinary philosophical approach for providing meaningful cognitive and social supports in the acquisition of knowledge for learners (Bertrand & Namukasa, 2020; Colucci-Gray et al., 2019; Dignam, 2023; Küçükgençay & Peker, 2023).

The present chapter examines and explores qualities, systems, and processes of developing and implementing a school wide STEAM program. The author is a former secondary school science teacher, instructional coach, assistant principal, principal, and school district superintendent. While the author began his career teaching high school science for the better part of a decade, his latter two decades of experiences as an instructional, educational leader led to his current work as a professor of interdisciplinary leadership and educational administrative leadership in the United States. The author also possesses authentic experiences in developing and implementing STEAM course offerings and programs ranging from those in a large high school in an urban setting to a neighborhood high school in a suburban setting, as well as a small therapeutic school for students with special needs.

The Science of Art

Teaching and leading is both a science and an art. When we teach and lead we do so scientifically, and equipped with knowledge and facts concerning pedagogy, methodology, and theoretical constructs. Moreover, the social, emotional well being of students are brushstrokes of art that must be considered first, as students construct knowledge as a result of experiences and through social networks that promote connections for cognition (Kolb, et al., 1984; Vygotsky, 1978). When students are provided STEAM programmatic offerings, they are afforded opportunities to engage in experiential, constructivist learning, which is foundational for fostering social capital. The cultivation of social skills, collaborative learning, and constructivism presents students with avenues for enhancing conceptual understanding (Dewey, 1933; Piaget, 1972; Vygotsky, 1978).

A key approach to implementing any program is to embrace and put into practice both servant leadership and distributive leadership. Servant leadership naturally places the needs of others first, and by doing so, leaders are distinguished by serving the communities they lead (Blanchard & Broadwell, 2021; Greenleaf, 1998). Employing servant leadership also creates a sense of trust by the communities being served, which results in innovative behaviors and innovation within an organization (Khan et al., 2021). In addition, the utilization of distributive leadership provides school community members opportunities to be involved in decision-making, leading to a collaborative school culture and teacher job satisfaction linked to organizational goals (Jakobsen et al., 2023; Torres, 2019). When leaders provide opportunities to share leadership, the act of distributing leadership positively impacts students. Furthermore, teacher-student relationships improve as a result of teachers taking ownership of endeavors and recognizing the whole student and each student's personalized needs (Kallio & Halverson, 2020). The following passages provide a historical narrative analysis in both objective and first-person perspective regarding the forging of partnerships for supporting STEAM programmatic development, implementation, and sustenance.

A Canvas for Innovative Design

Coaching, Teaching, and Leading

After nearly ten years as a high school science teacher, the author transitioned from his role as a high school biology instructor to an area district-office instructional coach for high school science (primarily biology, chemistry, and physics). The position was valuable in terms of providing opportunities to develop administrative capacity, as the post required curricular supports and professional growth opportunities for teachers within a portfolio of 23 diverse high schools. Each school was unique in terms of community, culture, climate, instructional capacity, and school-based leadership. As an instructional coach, the author served high schools primarily located in Chicago's Englewood community. Schools within the area included neighborhood high schools, such as Englewood, Robeson, Harper, Tilden, Kennedy, etc. as well as York High School in Cook County Prison. District area office instructional coaching experiences afforded opportunities to evaluate and improve science curricula, assess opportunities for providing collegial coaching, and to support teachers with professional growth opportunities to improve professional capacity. The author was also able to work directly with each school's principal and administration to further develop perspective in terms of culture and climate, leadership style, and resulting leadership impact on the learning organization.

Professional Erudition

Teachers are better equipped to enhance student learning through engagement in professional growth (Kirner & Lebrun-Griffin, 2013). Typically, teachers receive professional growth through professional development, often involving attending a variety of workshops or presentations with a general focus. In contrast, site-based professional development distinguishes itself from traditional professional development by involving specific individuals with a defined purpose (Strike et al., 2019). Moreover, professional learning specifically targets skills to foster ongoing professional growth and is regularly revisited. During the author's tenure as a principal and superintendent, he developed and established a training service he refers to as *professional erudition*. Professional erudition combines elements of site-based professional development *and* professional learning, featuring *targeted* periodic development *and continuous*, preplanned learning with ongoing supports. Professional erudition is thematic and personalized, emphasizing both whole-group, targeted learning and individualized scholarship. The author continues utilizing professional erudition with instructing graduate and postgraduate higher-education students and professional erudition practices implemented during leadership roles in school and district communities. The term "professional erudition" is consistently referenced throughout the chapter.

External Partnership-Building

While serving a variety of schools and providing instructional leadership supports, the author established relationships and partnerships with universities for providing an array of district level supports for schools and their local communities. Those professional experiences provided invaluable leadership learning and practices for working with a variety of stakeholders for developing partnerships. Engaging diverse communities and creating an inclusive STEM (Science, Technology, Engineering, and Mathematics) program provides expanded opportunities, preparation for advanced STEM studies, early college-level coursework, and supports for underrepresented students (Peters-Burton et al., 2013). Supports for all learners while engaged in STEM learning has also been found to impart the development of perseverance and transferable skills as life skills in students (Bertrand & Namukasa, 2020).

An Artist's Palette in a Scientist's Laboratory

The author began his career in Chicago's North Austin community before later transferring to the north side of the city and then serving as an area district-office instructional coach. Those experiences provided opportunities to refine and employ science-based instructional leadership for teachers and administrators with an emphasis on affording students relational, experiential, project-based learning for active learning (Kolb, 1984; MacDonald et al., 2020). Those particular efforts took place prior to the acronyms STEM or STEAM originating or becoming commonplace in education. However, employing an artistic approach for blended science, technology, engineering, and mathematics learning was employed for engaging all learners (MacDonald et al., 2020). When active learning for learners of all backgrounds is provided through inclusion of the arts in STEM, the experience of learning is highly engaging for students (Bertrand & Namukasa, 2020; Jesionkowska et al., 2020).

After serving as an instructional coach for the sciences, the author was offered a position as an assistant principal on Chicago's north side of the city. That particular school, Lane Technical College Preparatory High School, is the school the remainder of the current chapter will discuss related to conceptualization and actualization of STEAM programming. Lane Technical College Preparatory High School is one of the largest high schools in the United States with approximately 4,500 students and 250 staff. The size of the school and campus is much more akin to a small college than a high school and possesses students of every socio-economic, racial, national, religious, and oriented background. The author was charged with overseeing curricular programs, scholarly programming, reinvigorating the school's science program, and serving as the school's curriculum director and Advanced Placement coordinator.

The previous coaching experiences in working with two-dozen diverse school communities and actively establishing and nurturing external stakeholder and university partnerships proved to be extremely useful in spearheading new STEAM course offerings. As teams developed and launched new courses, such as *Engineering Design, Principles of Engineering, Neuroscience, Art in Mathematics*, etc., they were able to expand innovative course offerings and increase the number of STEAM instructors. There was a very high demand for the dozen-plus new course offerings, which resulted in the science and art departments nearly doubling in size to deliver a supportive, transdisciplinary and interdisciplinary philosophically-based STEAM program (Bertrand & Namukasa, 2020; Colucci-Gray et al., 2019). STEAM approaches, such as the program deployed, significantly enhance students' grasp of both scientific and artistic concepts, while fostering a greater sense of preparedness and promoting individual responsibility and cooperative interaction (Bassachs et al., 2020).

The author also led the development and establishment of a transdisciplinary and interdisciplinary, cross-curricular program called Alpha-STEM for students specifically interested in research. The Alpha-STEM program consisted of groups of 28 students each for attending STEAM courses as a cohort for a four-year course sequence. Teachers assigned to the cohort collaborated as colleagues in constructing and delivering cross-curricular team lessons for authentic transdisciplinary, interdisciplinary teaching and learning.

During the first year of Alpha-STEM, the school was able to recruit 56 students for two cohorts. Within five years, Alpha-STEM grew to approximately 670 students in over 24 cohorts at four grade levels (Figure 1). Employing a cohort model is advantageous, as it enables students to identify connections across disciplines for improved relations, team-led learning, and self-reflection (Bassachs et al., 2020). Furthermore, critical reflection assists students in cultivating strategic competences, skills, attitudes, and emotions related to their future actions, while also aiding in the development of critical social skills for communal learning (Bassachs et al., 2020; MacDonald et al., 2020).

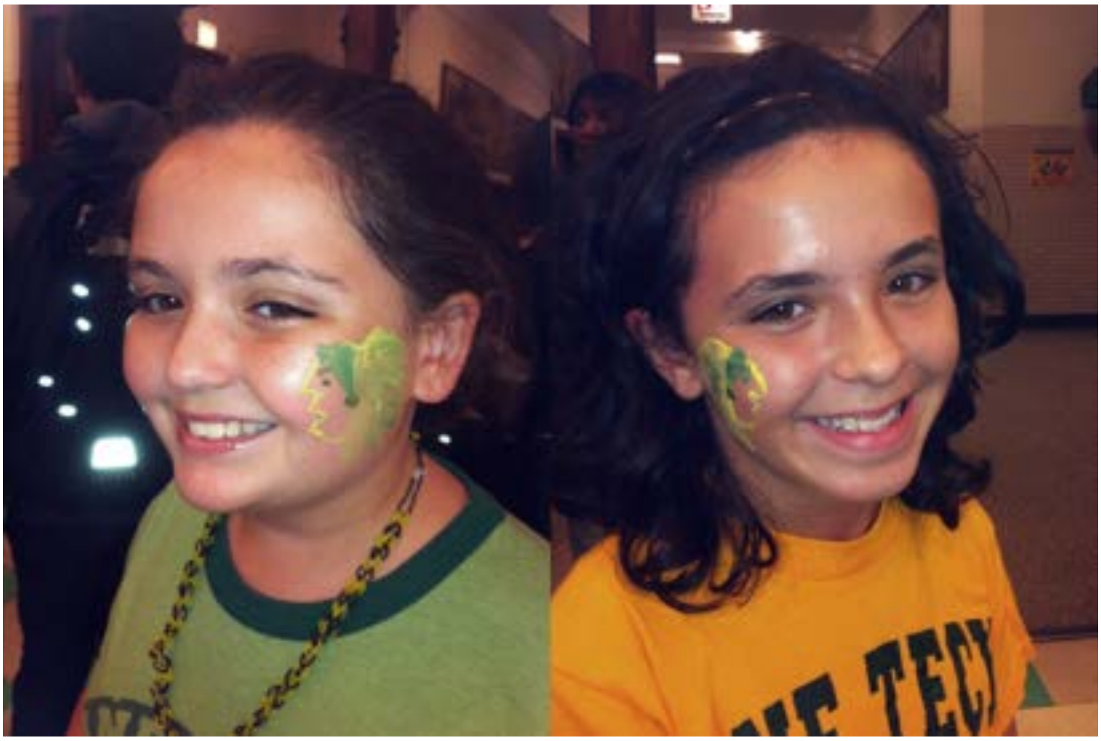

Figure 1. Students on campus

Science Olympiad and Robotics

Innovative Visions for Learning

Active collaboration with the school's science department chair as well as partnering with two newly hired physics teachers resulted in the establishment of Science Olympiad and robotics for students. Science Olympiad is a program that helps students develop abilities in STEM through challenging problems and social and life skills development. (Kulbago et al., 2016; Oliver & Venville, 2011). Science

Olympiad also provides opportunities for students to explore new disciplines, build community, and prepare for future STEM careers (Kulbago et al., 2016).

Participation in the Science Olympiad strengthens students' resolve to pursue STEM-related careers and refine twenty-first century skills through engagement in competition (Sahin et al., 2015). The administrative-physics teacher partnership formed resulted in the creation of Science Olympiad and robotics course offerings rather than simply presenting after school, extracurricular clubs. While being in a position to offer Science Olympiad and robotics as clubs or extracurricular activities was an exciting prospect, the partnership resulted in a like-minded administrative-teacher team for creating actual Science Olympiad and robotics courses for course credit.

Administrative efforts entailed reviewing costs, needs, and demands for implementing robotics as a course for students to earn physics credit. Time was devoted to exploring curricular units and material needs and space within the building to house the establishment of a robotics lab. Collaborative efforts included fundraising with parents, community, and alumni, as a three-year plan was devised with startup costs for creating a sustainable robotics program. After two years of development, the school began advertising robotics as a new course offering.

The team was open to exploring all creative curricular and facility possibilities for establishing a dynamic robotics program. Those efforts included researching a Verizon VGo Robot for use within STEAM program offerings and for supporting homebound students with serious illnesses to take part in classes (this was many years prior to the Covid-19 pandemic). Science Olympiad provides students with out-of-school STEM activities and exposes learners to a variety of new disciplines for piquing student interests. Engaging out-of-school homebound students also provides continued participation and connections to STEM (Smith et al., 2021). Science Olympiad supports students socially by providing a unique environment where students feel included, safe, and surrounded by like-minded individuals (Oliver & Venville, 2011). These meaningful attributes paved the way for establishing a creative, cutting edge program for students of all backgrounds to design and construct knowledge. Students partnered with outside organizations and battled in robotics competitions for fun as well as for testing robotics builds.

Robotics was designed to expose students to the branch of technology that deals with the design, construction, operation, and application of advanced, industrial grade robotic mechanisms. Students also engage in programming, which can be employed as early as early childhood education through the use of programmable toys and educational kits that helps children develop initial programming concepts in a developmentally appropriate and supportive learning environment (Hillmayr et al., 2020). Robotics provides students with the opportunity to use professional computer programming environments, 3D design software and industrial grade hardware to devise, program and build sophisticated robots for developing problem-solving skills, critical thinking abilities, and creativity (Arlegui et al., 2008). Students specialized in teams such as programming, drivetrain, pneumatics and electronics, and then, collectively, to create robots seen everywhere from science fiction to medicine, animatronics, and industry. Robotics promotes interest and scientific curiosity, as well as social skills through teamwork (Arís & Orcos, 2019; Arlegui et al., 2008). The curriculum developed was fun, exciting, and challenging for the entire school community. Rather than focusing on a linear progression of information (as in a traditional classes), robotics was project-based with students being experientially immersed for contextual, meaningful learning. Experiences included successfully programming digital and analog controller systems and I/0 units such the cRIO and RobotRIO using Java programming language, utilizing both vector and matrix math to inform programming decisions and strategies, employ calculations/measurements to determine the appropriate size or strength of industrial grade components working together in a system, and efficiently completing tasks.

Developing and implementing STEAM required administrative dedication and support. Educational leaders actively support robotics and the development of scientific inquiry and literacy skills through constructivism by ensuring professional erudition, allocating resources to enhance STEM education, and encouraging participation in academic competitions (Dignam, 2023; Swanson et al., 2021).

Affording students robotics as a course and budgeting to construct a large robotics research lab resulted in the creation of an environment for supporting the spirit and minds of each learner. In addition, robotics II was added as an upper-level course for students who successfully completed robotics I, as well as a course called adaptive robotics for students with special needs to provide multiple pathways of participation in robotics.

Six Guiding Principles

The author was named principal of the school and established a requirement for all new course proposals that served as a guiding principle for future course offerings leading to implementation. The *Six Guiding Principles* were grounded in distributive leadership and required that all course proposal approvals must provide for (1) inclusion of special needs students (for example, in the case of robotics, an eventual adaptive robotics course), (2) a "social change" mandate that course designs, recruitment, and implementation efforts ensure female and diverse student representation, (3) innovative, creative courses include a commitment to professional erudition for supporting annual course cycle review, (4) a commitment for innovative learning space evaluation (visiting other schools, organizations, professional associations, etc.), (5) considerations, whenever feasible or possible, for middle school students to participate in innovative course offerings (the high school also housed a middle school academic center), and (6) active collaboration among transdisciplinary and interdisciplinary planning teams take place with the goal of creating functional cross-curricular course offerings for approved courses.

In addition to creating multiple levels of robotics and adaptive robotics, the robotics research lab provided supportive, active instruction and hands-on construction and testing of robots students built. In addition, the school's Science Olympiad teacher and one of his students were invited to the White House's annual STEM Fair and robotics students began to actively build in the new robotics laboratory and compete in the FIRST International Robotics Competition (Figure 2).

Figure 2. Robotics laboratory

Aquaponics

Watercolors and Pipettes

Aquaponics provides hands-on, experiential learning by providing a rich environment in which students interact with aquatic and terrestrial growth systems for observing how a variety of organisms work together to produce life-sustaining products (Bice et al., 2020; Kolb et al., 1984). Aquaponics utilizes a structural, closed-water-loop for breeding and nurturing fish (tilapia were the chosen species) and plants. Tilapia in the closed-loop system supply fertilizer for the plants and the plants, in turn, utilize the tilapia fertilizer for their own growth. The water nourishing the plants is constantly cycled back to the tilapia as a natural, filtered sequence for the tilapia with the loop continually flowing. Aquaponics is also transdisciplinary and interdisciplinary, as it integrates concepts from various fields such as science, health education, and technology and affords students with authentic hands-on scientific inquiry and scientific literacy experiences (Bice et al., 2020). Aquaponics supports STEM education by providing a real-world context for teaching science, technology, engineering, and mathematics concepts, as well as promoting problem-based learning, inquiry, design-based learning, and collaboration for facilitating understanding with respect to urban farming and sustaining natural resources for twenty-first century learning (Baykir et al., 2023).

Within the school, there were eleven enormous, empty classrooms that were approximately 4,000 square feet (some were significantly larger and afforded over 7,000 square feet of classroom space) going unused. The classroom spaces used to house shop classes first introduced in the 1930s but by the early 2000s they were either filled to the brim with garbage or being used as storage or makeshift office space (most shop classes were phased out of the school beginning in 1999). There was no strategic plan on campus for repurposing the spaces, which provided an opportunity for creating and establishing a strategic plan for revitalizing tech programming and implementing STEAM-based, innovative learning spaces and curricula (Figure 3).

Figure 3. Learning environments prior to renovation and construction

An abandoned classroom that served as a machine shop for 70 years was chosen for housing the aquaponics facility. The school team engaged an external vendor for facilitating the design of the aquaponics lab. The vendor happened to be working with a local university on another aquaponics lab space, which provided an opportunity to work with an external stakeholder as well as learn the blueprint process for a university-level, aquaponics facility in a high school setting. External partnerships served as resources in providing additional insight with respect to urban agriculture, which became part of the curricular design, and for articulation with college level course content in mind. The team also worked on designing a curriculum that was inclusive for all learners. Efforts were made to confer with special education to ensure aquaponics lab tables and beds were spaced appropriately for ease of access. The spacing between each bed also provided flow for all students while working in the lab (Figure 4).

The sheer size of the space afforded the aquaponics facility to function as a multiuse space, allowing classes to work on one side of the room while another section of aquaponics conducted lab work. Materials and manipulatives for use with a variety of other content areas were also accessible in the aquaponics facility. Courses such as art, mathematics, and economics took place in the facility to work and engage in interdisciplinary learning in an authentic, multiuse space. Art classes such as photography and drawing engaged in class assignments while mathematics courses recorded measurements with Vernier probes for use with calculators for solving authentic mathematics problems. Special education courses conducted classes or teamed up with other aquaponics classes for adaptive learning.

Students in the school’s autistic program worked with manipulatives such as vermiculite or lava rocks to facilitate hands-on learning for the development of scientific inquiry and scientific literacy skills development. In addition, students in the middle school academic center also utilized the space for biology content and scientific research. Aquaponics curricular experiences enhance social skills development through the promotion of student engagement and interactions for imagining and constructing knowledge (Thompson et al., 2023).

Figure 4. Aquaponics facility

Computer Science and Makers Innovation Lab

The Body Electric

Endeavors were undertaken to visit a variety of schools and institutions that were offering various forms of "makers" clubs, extracurricular activities, or had created makers workstations within their schools. Makerspaces have been shown to foster creativity by providing opportunities for learners of all ages to engage in hands-on innovative and creative activities. In addition, research studies have illustrated that makerspaces rank the highest in fostering creativity and innovation (Novak, 2019). While the trend was to place small makerspaces in a library or as a workstation with a 3D printer in a classroom, the goal was to establish a true makers innovation lab, and there was ample preexisting, unused space within the building. There were no interests in following trends. The author's goal was to elevate the school to move beyond trends and for other schools to follow or compete with Lane Tech, rather than Lane Tech following or competing with what others were doing. Creating STEAM hubs throughout the school was a priority goal in the author's capacity as an instructional leader.

During this same time, the school's computer science program was shut down and discontinued due to low enrollment and antiquated curricular offerings. Computer science curricular offerings were severely archaic and consisted of students merely taking one semester of Word and a second semester of Excel for computer science (CS) credit. Students demonstrated frustration with both the lack of curricular relevance and lack of rigor. Consequently, aside from Advanced Placement computer science, the electives offered were irrelevant and non-sustainable in terms of student enrollment and applicability. There was a concerted effort to revitalize a CS program dedicated to transdisciplinary and interdisciplinary STEAM learning for computational thinking. Computational Thinking is a problem-solving approach that involves breaking down problems into steps that can be executed through computer use. Computational Thinking is a way of thinking that connects CS with other subjects and is used for investigating and solving problems in STEM and STEAM fields (Lee et al., 2020). Computational thinking helps students develop problem-solving skills and the ability to formulate solutions, and is related to art as it can enhance creativity, design thinking and problem-solving skills in the context of digital design and visual arts, which supported the school's vision (Settle, 2012).

The team spent a full year re-visioning computer science course offerings and creating a foundation for ensuring future course offerings would remain relevant and sustainable. The team worked on developing and creating new, exciting, cutting edge computer science course offerings. Partnerships were forged with internal and external stakeholders to develop curriculum and recruit new staff to support students. In addition, there was a desire to link and interweave mathematics and mathematical literacy within computer science to ensure mathematics remained a strong component of the school's STEAM program (Genc & Erbas, 2019).

Mathematical literacy is relevant for STEAM as it empowers individuals to develop mathematical thinking, reasoning, and problem-solving skills, which are essential for success in science, technology, engineering, and mathematics fields. At the time, newly designed courses included *OS Apps Development and Android Design*, *Human Interactive Design*, *Introduction to AI*, *Web Development*, and *Coding*. Coding was a major component of CS. Coding involves the application of mathematical and computational concepts, fosters critical thinking and problem-solving skills, and is often used in conjunction with science and engineering principles to create technological solutions (Popat & Starkey, 2019). A partnership was also forged at the university level to afford students a joint high school-university CS course credit.

New course offerings continued being developed and included *Computer Programming* for utilizing algorithmic problem-solving techniques for transitioning from consumers of technology to makers of technology, *Elements of Computing Systems* (which was the school's first computer engineering course), *Exploring Computer Science* for reviewing concepts related to human-computer interaction, problem-solving, web development, and robotics, *Media Computation* for creating expressive media by manipulating computational materials (like images and sound files) for computation, *Software Design Android Apps (Software App I)* for focusing on developing and bringing *Google Android Apps to Market*, and *Web Development* for introducing students to the programming and design skills needed to create modern interactive "Web 2.0" websites and applications. CS would grow further with the development of a fully functional makers lab with Computer Numerical Control (CNC) machines, laser cutters, and 3D printers (Figure 5).

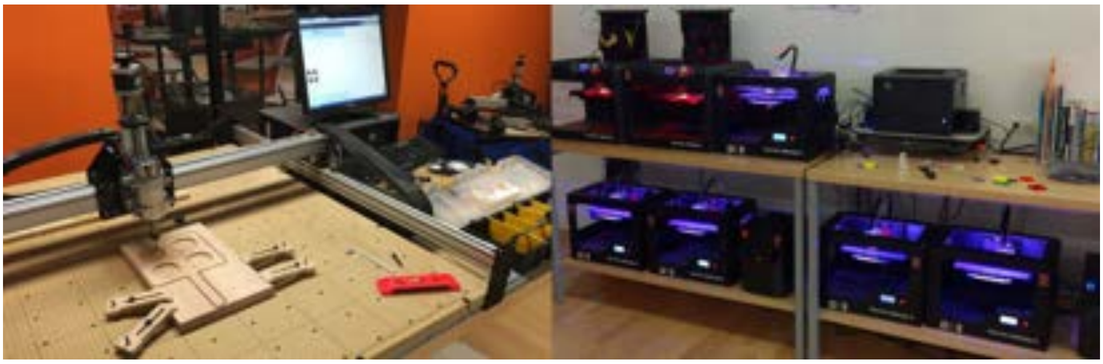

Figure 5. Laser cutter and 3D printers

ICL Makerspace

Full with Charge of the Soul

As a result of being able to re-establish CS, the school was in a unique position to not only completely revamp course offerings, but to also hire new staff with skills to deliver up-to-date CS core content. The author was also interested in creating a makerspace course and fabrication laboratory with additional emphases on coding, employing digit tools, and highlighting innovative thinking. Digital tools are interdisciplinary, interactive technologies that can be utilized across various subject areas such as mathematics, science, language arts, and social studies to enhance learning outcomes, motivation, and engagement (Alam, 2022). Coding was also a component of makerspace and supports students in developing skills such as mathematical problem solving, critical thinking, social skills, self-management, and academic proficiency (Popat & Starkey, 2019). A key benefit of makerspaces and a reason why the course was sought is its ability to engage all forms of learners, regardless of gender, background, or abilities. Research has shown utilizing a makerspace improves outcomes for underrepresented groups, such as females and students with diverse backgrounds in STEAM by sparking interest and building confidence (Konstantinou, 2021).

One of the school's newly hired computer science teachers requested a 3D printer and scanner to set up a small makerspace in a CS classroom. However, the school had a shop space that originally served as a foundry shop classroom 60-plus-years earlier before being closed and becoming a largely unused staff lunchroom. That particular space possessed a balcony that was configured differently compared to other potential learning environments (the balcony was more square than the other rooms).

An additional room was accessible just below the balcony that could be converted to privately house the makerspace's lab with its louder carvers and laser cutters. The team was excited to offer makerspace as a course for credit, as it afforded numerous benefits for students, including the opportunity to engage in hands-on, inquiry-driven projects that incorporate media arts through constructivism to construct and represent knowledge via student created work products (Dewey, 1933; Stornaiuolo et al., 2018; Vygotsky, 1978). The school was rolling out course-after-course in one redesigned creative, innovative learning space after the other. The school was also beginning to offer courses and learning environments that existed nowhere else in a district of 550 schools.

After a full year of curricular and budgetary planning, the school opened the district's first and only Human Computer Interaction Innovation Creation Lab (ICL Makerspace) housed in a 4,000 square foot facility. The ICL makerspace is a convergence of design, computer science, and art. It enables students to compose, prototype, and engineer innovative products for the world around them for deeper, personalized learning. Makerspaces help develop problem-solving skills in a hands-on and collaborative environment where students can engage in creative and open-ended projects (Hira et al., 2014). The course and learning environment serves to provide all students a forum to explore the design process and develop ideas for statements for solving problems (Stornaiuolo et al., 2018). The space also serves as a direct hub for transdisciplinary and interdisciplinary teaching and learning with computer science, robotics, mathematics, and art (Figure 6).

Figure 6. Human computer interaction innovation creation lab

Sound Engineering

The Spirit of Discovery

The school opened up the first high school sound engineering program with a fully functional state-of-the-art recording studio in the state, which was housed in a 7,000-plus square foot facility. The space was enormous and possessed enough room to afford multipurpose use for simultaneously utilizing a live room, mixing room, rehearsal spaces, and a second floor balcony with 30 Pro Tools workstations for students to edit projects. Diversifying the classroom into specialized groups that align with students' distinct musical interests allows for more tailored instruction and activities that tap into each learner's passion and motivation to drive engagement (Gage et al., 2020). Interestingly enough, the sound engineering and recording studio took residence in a space that was originally an aviation shop in the 1930's where students built airplanes (a plane was actually built in the aviation shop for the World War II war effort). The aviation shop was later converted into an auto shop in the 1960s. The school used to possess four auto shops but by 1999, there was only one remaining auto shop with dwindling student enrollment, which was eventually closed.

In addition to being a biologist, the author is also a recording musician and has been playing guitar since he was a child. A vision existed for repurposing the large, empty 7,000-plus square foot facility into a multiuse music- and physics-based sound engineering program, guitar program studio, and a music therapy space for students with special needs. Music is related to science through the study of cognitive science, neurophysiology, psychoacoustics, and cultural psychology to understand the cognitive and physiological aspects of musical perception and behavior and was a natural fit for the school's STEAM program (Cross, 1998). Dignam (2022b) stated, "Improvisation is experimentation of the spirit. Experimentation is improvisation of the mind. Free the mind and liberate the spirit (p. 44)." The goal of the program was to provide an environment for enabling students to summon their artistic abilities through a scientific approach.

There was also a demand in the school to offer additional levels of guitar as a course but there was no space to accommodate additional classes. The goal was to create a multifunctional, multipurpose use environment for hosting sound engineering, recording studio, and guitar which could take place simultaneously given the large size of the facility for fostering creativity and critical thinking. Understanding the linkages between music and science supports student understanding of scientific and social phenomena through transdisciplinary and interdisciplinary constructs such as STEAM, which enhances critical thinking and creativity for an authentic blending of art and science (Le Marec & Ribac, 2019).

The Science of Voice

A principal's Student Advisory Board (SAB) was established at every grade level. Students were a fantastic resource and representative body for learning student perspectives regarding a variety of initiatives, policies, and procedures taking place throughout the school. The author employed servant and distributive leadership with students to ensure they possessed a voice in decision-making. The SAB provided feedback and survey data for each of the new programs the school was developing and the repurposing of innovative spaces. There was genuine excitement about the prospect of creating innovative STEAM offerings for supporting academic achievement through a sound engineering program, recording studio, and expanding course offerings for guitar I, guitar II, guitar III, and adaptive music for special needs learners. Participation in music, especially instrumental music, is important for supporting academic achievement, as music positively influences exam scores in English, mathematics, and science and fosters competencies that support academic achievement (Gruh et al., 2020).

Teachers in the program were intrinsically motivated to develop and implement coursework that was innovative, creative, and included opportunities for students of all backgrounds to connect learning to their personal interests and lives. A high school sound recording program helps students make meaningful connections between school music education and students' personal musical lives by providing hands-on opportunities to create, produce, and distribute original and creative work (Clauhs et al., 2019). The administration oversaw building logistics for creating a one-of-a-kind program while teachers were provided academic freedom in designing curriculum and participating in designing spaces for eventual renovation and construction. Partnerships were also forged with external stakeholders, with whom the school would share both curricular and facility design plans for learning perspectives and for fundraising. As a result of mission and vision building, budget planning, and fundraising with internal and external partners, sound engineering and recording studio was established as the district and state's only high school sound engineering and recording studio program (Figure 7).

Figure 7. Sound engineering and recording studio

Multimedia Digital Art and Sculpture Studio

The Embrace of Love and Resistance

The school transitioned to an Apple school and initiated a new art curriculum, including a new *Film Studies* course and a variety of other STEAM courses that blended science, technology, engineering, and mathematics with digital and hands-on course offerings. The content that curricular course teams developed enabled students and teachers to not only study art but to also learn the engineering and technology side of media, as well as the science and mathematics of art project-based learning. Art and engineering are interrelated as they both involve finding answers to problems and seeking visual solutions using the design process (Bequette & Bequette, 2012). Art has influenced scientific innovation and discovery by stimulating imagination, improving observational and technical skills, fostering open-ended investigation, and positively impacting student attitudes and engagement in STEM fields (Adkins et al., 2018). The integration of computer graphics and digital art significantly impacts the art, film, and entertainment industries, allowing for the creation of convincing imaginary worlds and interactive art forms (Sickler-Voigt, 2019). Additionally, art and mathematics share qualities of giftedness, creativity, and storytelling in their works and final products (Dietiker, 2015; Leikin & Pitta-Pantazi, 2013).

The school also spent two years designing a new, Multimedia Digital Art and Sculpture Studio that was within proximity of the sound engineering program for recording and guitar, the Makers ISL for idea partnering and project design, robotics for competition and engineering, and aquaponics for urban farming. The goals for the Multimedia Digital Art and Sculpture Studio included creating a sustainable, multiuse space for meaningful hands-on, discovery-based arts curricula. Art was embedded and interwoven within STEM for an authentic STEAM program, as it contributes to STEM for STEAM by providing new ideas and creative approaches, which enhances innovation and creativity (Daugherty, 2013). Art was weaved into each new course offering to provide aesthetic perspective and to ensure each new course included creative, innovative points-of-view for design and flow.

As a result of the development of new innovative learning environments and course offerings (aquaponics, makers ICL, robotics, sound engineering, etc.), and a commitment to interweaving the arts in new, interdisciplinary STEAM curricular offerings, the art department augmented in size. Arts integration in the school’s non-arts subjects supported learning outcomes by highlighting creativity, innovation, and problem-solving as core practices, leading to deep learning with benefits beyond specific disciplines (Halverson & Sawyer, 2022). While programmatic growth was wonderful, and born from solutions for reimagining curricula, the planning required to shepherd blossoming programs necessitated forward planning to ensure sustainability (Figure 8).

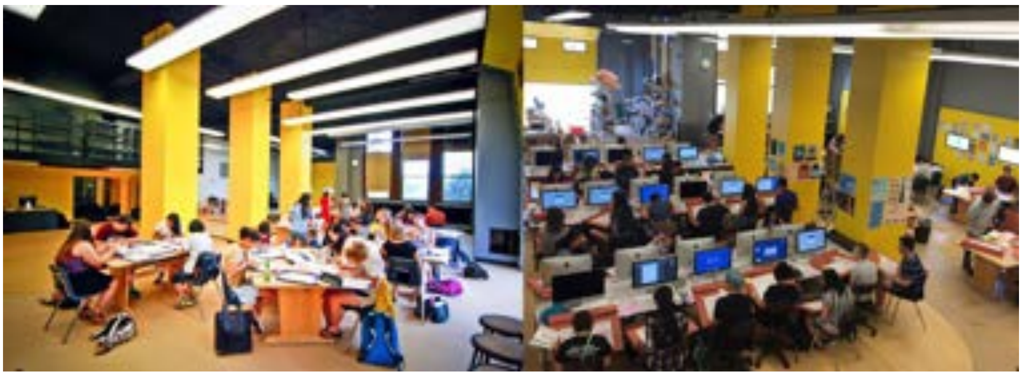

Figure 8. Multimedia digital art and sculpture studio

The programs that were developed were not designed to be momentary, but rather, they were created with a 10-year minimal vision and intended to be generational. All too often, principals and superintendents implement new programs, and within three years or so, they "fizzle" and then the next leader comes along to only repeat the same process. These experiences create jaded outlooks in teachers and staff and contribute to what eventually devolves into institutional inertia. When designing new courses and programs, the author mandated that courses had to be relevant for the four years students were in high school, an additional four years of college, and two more years as former students entered the job market. Possessing these criteria resulted in being able to easily discern if current course offerings were relevant, if they needed to be revised, or if they needed to be discontinued. The criteria employed also determined whether new course proposals possessed merit.

Reflections on the Many Facets of Learning

From the Author…

During the visioning, development, and implementation of our STEAM program, as teachers would construct curricular plans or propose space utilization proposals, I would review and push the curriculum and space design teams further by predictably stating, "We can do more than that." It became a somewhat predictable (and humorous) pattern, as we understood one another, and when educators feel valued and heard, they are more willing to "go back to the drawing board" to imagine with greater depth and breadth. The end results were imaginative curricular and space designs that captured the aesthetics of experimentation for conceptualizing and actualizing a STEAM program to support teaching and learning for all.

I was once asked by one of my doctoral students how I would summarize the role of an educational leader. She wanted to know my perspective through my lens of experiences. I replied with an analogy that has evolved over the years into a formal poem I now read to each new cohort of students. I later created a mural of my *thoughts and words, which I have proudly displayed ever since in my recording studio, as well as in my office (Figure 9).*

It reads, "Every educational leader is an artist. I am the artist and the community is the palette. I hold the brush and blend colors into facets of learning. My canvas is the school. I render a community of practice, designing opportunities for teachers to teach and for parents to be involved. Learners own the canvas. For everything I paint is for students" I hope you would agree (Dignam, 2022a).

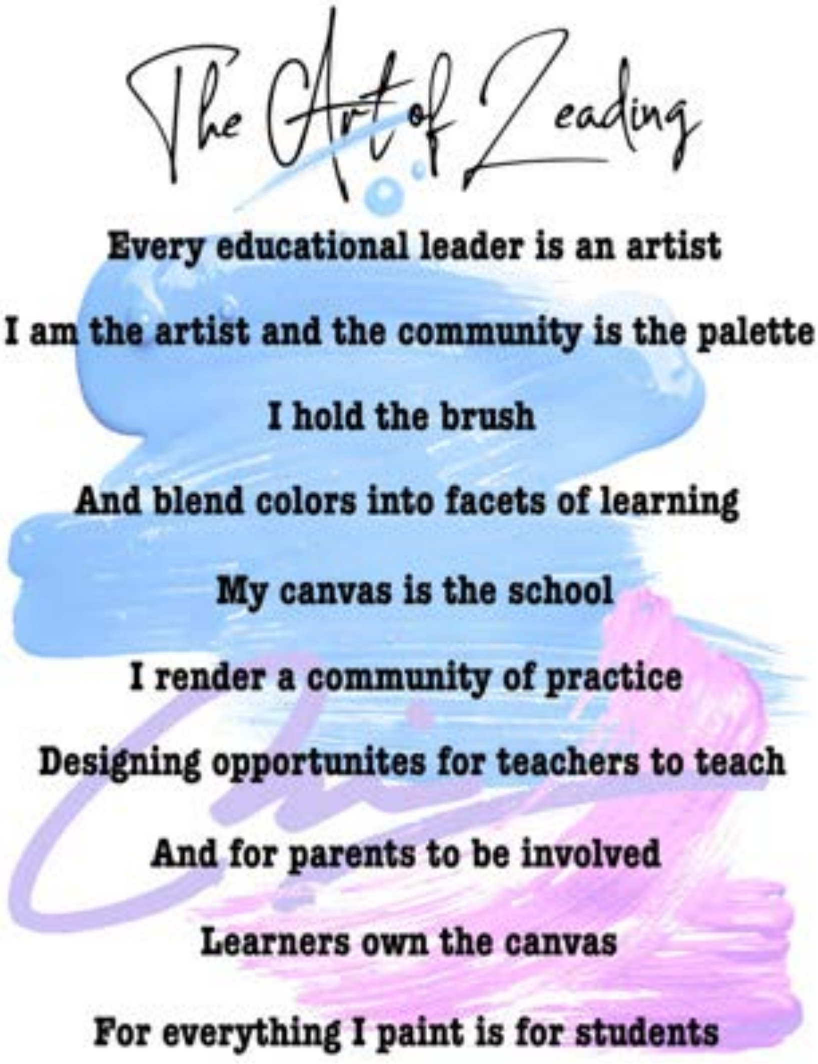

Figure 9. The art of leading (Dignam, 2022c)

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About the Author

Christopher Dignam completed his Ed.D. in Teacher Leadership and holds a Masters of Arts degree in School Leadership, a Masters of Education degree in Curriculum and Instruction, and a Bachelors of Science degree in Biology. He has served as a K12 educator for nearly three decades as a science teacher, principal, and superintendent of schools and currently serves as an Assistant Professor for Educational Leadership at Governors State University in the United States. Christopher leads Doctoral and Masters interdisciplinary and administrative coursework for educators pursuing principal and superintendent degrees/licensure. His research interests include STEM/STEAM education, curricular design, teacher leadership, and educational leadership.

E-mail: cdignam@govst.edu

The intersection of technology and education exerts a profound and far-reaching influence on societies and learning environments across the world. ***Current Academic Studies in Technology and Education 2023*** is the latest in a series of texts published annually from selected papers invited by the editors. The present edition consists of contributing international authors from Georgia, Türkiye, the United States of America, and Uzbekistan. All submissions are reviewed by at least two international reviewers.

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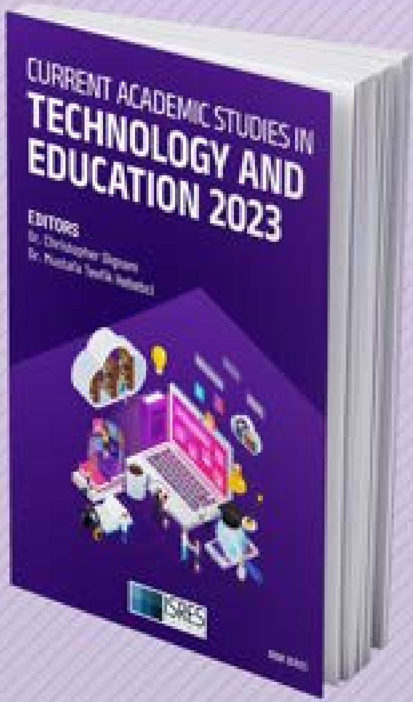

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