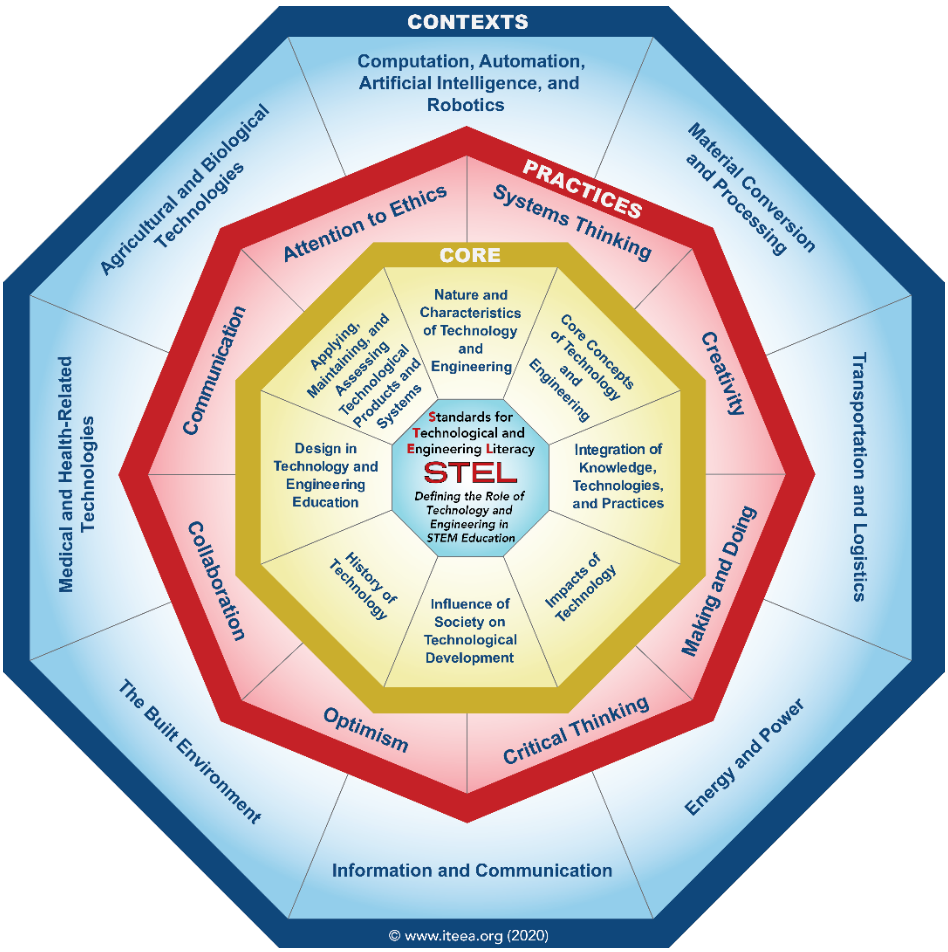
PART 2: THE THEORETICAL FOUNDATIONS OF SUSTAINABILITY EDUCATION IN ACTION: FALLS CHURCH CITY PUBLIC SCHOOLS

By Ray Wu-Rorrer, Peter Mecca, Kenny George, Stephen Knight, Carolyn Pollack, and Valerie Hardy

It is essential that the next generation of learners acquire not only knowledge about systems, but also how this knowledge may be used to effectively integrate modern technology into traditional and alternative business enterprises.



This reflective essay provides the theoretical foundations for the Falls Church City Public School (FCCPS) System's new Academy for Sustainable Thinking. Students in the marquee sustainability education program learn and develop an appreciation for the basics of growing food and the importance of water in an urban area through integrated applications in environmental science, energy, design, technology, and engineering education settings. This article provides a general overview of the theoretical foundations in which the FCCPS sustainability team has and will continue to build upon in the future. The five foundational areas directing the team's work include sustainability, Information and Communications Technologies (ICT), the Internet of Things (IoT), Agricultural Internet of Things (AgIoT), and Urban Agriculture (UA).

As stated in the *new Standards for Technological and Engineering Literacy (STEL)* (ITEEA, 2020, p. 9), "now is the time for the field of technology and engineering education to clearly, concisely, and accurately define core disciplinary Standards for Technological and Engineering Literacy." The program described in this article specifically addresses multiple core contexts (Figure 1) such as:
1. Computation, Automation, Artificial Intelligence, and Robotics; 4. Energy and Power; 5. Information and Communication; 6. The Built Environment; and 8. Agricultural and Biological Technologies (ITEEA, 2020).

Theoretical Foundations

Definition of Sustainability

Sustainability is the process of responsibly meeting the social, economic, and environmental needs of today in such a way as not to compromise the ability of future generations to meet theirs. At a philosophical level, "Sustainability is about stabilizing the currently disruptive relationship between Earth's two most complex systems—human culture and the living world." (Hawken, 2007, p. 1).

Sustainability has been defined as "the study of how natural systems function, remain diverse ,and produce everything it needs for the ecology to remain in balance" (Sharma, 2016, p. 1). Although this definition of sustainability is one of the most commonly used, there is no consensus as to the author or first use of the definition. A thorough review of the Proquest and Google Scholar databases yielded 68 results of its use in scholarly writing with none of the sources providing a direct citation of its origin. The earliest found use of the term sustainability in its current context in this article's review process was by Adams (2006).

According to the U. S. Environmental Protection Agency (EPA), the National Environmental Policy Act of 1969 committed the United States to sustainability, declaring it a national policy "to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations." (EPA, 2020, n.p.) For the purpose of this article, the definition to be used is "Sustainability and sustainable development focuses on balancing between competing needs of moving forward socially and economically, while simultaneously protecting the environment."

Information and Communications Technology (ICT)

Progress in Information and Communication Technology (ICT) is "having a profound effect on modern life" (Warschauer and Matuchniak, 2010, p. 179). Information and Communications Technology refers to the convergences of computers, computer networks, electronic communications, and satellite communications in the context of social relations that surround their applications (Southern and Tilley, 2000, p. 141). ICT is an essential infrastructure platform for the United Nations Sustainable Development Goals (SDGs) to accelerate technologies such as Additive Manufacturing (AM), Artificial Intelligence (AI), Augmented Reality (AR), Autonomous Vehicles (AVs), Internet of Things (IoT), Mechactronics, and Nanotechnology. Unfortunately, many state-of-the-art ICTs and immersive technologies have not yet been fully developed and deployed to specifically address the SDGs. (Kostoska & Kocarev, 2019). ICT may play a fundamental role in modern systems allowing for more efficient cultivation practices coupled with different human interactions. Therefore, it is essential that the next generation of learners acquire not only knowledge about systems, but also how this knowledge may be used to effectively integrate modern technology into traditional and alternative business enterprises.

Internet of Things (IoT)

The Internet of Things (IoT) refers to "an emerging reality where more and more devices are connected to users and other devices via the Internet" and that "almost any device or product with electronic on-off controls can now be equipped to connect to the Internet" (FCC, 2020, n.p.). Stated another way, the IoT "refers to an interconnection of uniquely identifiable physical devices spanning a wide variety of applications" (Ramohalli & Adegbija, 2018, p. 168). As of 2020, the smartphone is the most commonly used device within the IoT realm used to run application software or to remotely control equipment.

Existing technologies, however, are heavily based on legacy architectures and offer little to no flexibility for a rapidly changing mobile age (Ramohalli & Adegbija, 2018). The goal of the IoT is "to reduce reliance on human beings for data acquisition, visualization, and use towards creating novel and intuitive solutions and services" (Adams, 2006, p. 168). Future developments in IoT will be driven by interconnected devices such as smart homes, intelligent medical devices, and even smart cities. "A solution to the current gaps in IoT consumer products is to leverage the iSTEM ecosystem to give students and non-experts the ability to build devices” (Ramohalli & Adegbija, 2018, p. 170) they need and that can easily be replicated and distributed to others.

Agriculture Internet of Things (AgIoT)

The agriculture-based Internet of Things “ensures accurate and timely communication of real time data or information related to dynamic agricultural processes like plantation, harvesting, weather forecasts, soil quality, and the availability/cost of labor required to the farmers before-hand” (Vaseela, Rajasukumar, Aravinth Kumar, Gowtham, Geethanjali, 2017, p.2). The steps for operating within the agriculture-based IoT system are based upon the four principles of data collection by smart devices, data transfer using networks, data storage and computation on cloud servers, and data analysis using big data tools. These principles are prevalent within most of the four systems currently operating in the FCCPS programs. Our goal here is to help students transfer the knowledge and skills acquired in classrooms, labs, field investigations, and afterschool activities to real-world agriculture-based IoT systems. Some AgIoT systems under consideration include compilation of performance and crop yield data; the use of bio-monitoring devices to measure temperature, heart rate, and the respiration/movement of livestock; and the need to adjust crop yield growth automatically or remotely based on existing climate conditions and nutrient availability. Within TEE programs, this can include fields of study around green roof/vertical gardens (in lieu of a greenhouse), UAVs, sensors, microprocessors, mechatronics, and automation.

Urban Agriculture (UA)

In the United States and around the world, urban gardening and agriculture has become increasingly popular. Urban gardening and agriculture involve the practice of cultivating crops in densely populated areas such as open spaces within a city (Ernwein, 2014). Urban agriculture (UA) is “the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities” (Brown & Bailkey, 2003, p. 4). In a future article, the authors will explain and share examples on how one school system used urban agricultural research to create a multidisciplinary environment that promotes cross-disciplinary learning through an integrated STEM education approach.

Conclusion

Availability and access to nutritious food and clean water are essential components for the health, safety, and survival of communities. To ensure these components, community members need to understand how the knowledge and skills in the sciences and engineering work to secure the sustainability of these natural resources. Community members also need to understand how the practices of science and engineering work to manage them. Therefore, safe and nutritious food, along with clean water, requires that educators and community members examine and understand how factors in the air, on land, and in the water sustain life on Earth. This knowledge will empower and guide local communities as they take action to conserve and protect our natural resources for current and future generations. In order to establish an Academy for Sustainable Thinking within the FCCPS System, educators, with assistance from partners, will design courses and experiences that reflect the intentions of the five foundational areas (sustainability, ICT, IoT, AgIoT, and UA) described above. Now is the time for educators, community leaders, and partners to put into place an educational program to benefit current and future learners.

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Ray Wu-Rorrer, Ed.D., *is a technology, engineering, energy, and sustainability educator at Mary Ellen Henderson Middle School/Meridian High School. He can be reached at wurorrerr@fccps.org.*

Peter M. Mecca, Ph.D., *is an adjunct professor of biology at the University of Maryland Global Campus, a science education consultant, and an environmental biologist. His areas of interest include STEM, climate change education, and stream monitoring. He can be reached at peter.mecca@faculty.umgc.edu or pmmecca@gmail.com.*

Kenny George *teaches Design and Engineering at Meridian. Kenny has been a secondary educator for 14 years and has taught in the fields of Visual Art, Business, and Technology Education. Kenny holds a Bachelor of Fine Arts from the University of Akron, and a Masters of Fine Arts from The George Washington University.*

Steven Knight *has 25 years of educator experience. He began his career in an elementary classroom where he quickly found a passion for integrating technology into instruction. His passion for educational technology helped him move from a K-6 computer lab to an Instructional Technology Coordinator in a high school during the implementation of a 1 to 1 program. Now along with running cyber security and robotics clubs at Meridian HS, he works with all schools as the Falls Church City Public Schools' PK-12 Instructional Technology Coordinator. Steven supervises the Career & Technical Education Department and is part of the Sustainable Thinking Team at Meridian High School.*

Carey Pollack, MAEd, NBCT, *is an Earth and Environmental Science IB educator at Meridian High School and serves as the collaborative team leader of the science department. Her scientific training is in*

Geology (BS), as well as the Geographic and Cartographic Sciences (MS). She can be reached at pollackc@fccps.org.

Valerie Hardy *is entering her 23rd year as an educator. She began her career as a middle school special education teacher in Charlottesville, VA and served as a middle school teacher and school counselor in the Durham Public Schools & Wake County Public School Systems, before returning to her native Virginia. Mrs. Hardy has spent the majority of her career in Fairfax County Schools serving as a school counselor, director of student services, central office administrator and elementary assistant principal. Mrs. Hardy served as the principal of Mary Ellen Henderson Middle School prior to her appointment as the division's first head of secondary schools.*

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