EasyChair Preprint

№ 15215

STEM Environments In Secondary Education Sustainability Programs: a Case Study On The Application of AgroLab Framework

Ray Wu-Rorrer and Peter Mecca

October 8, 2024

STEM Environments In Secondary Education Sustainability Programs: A Case Study On The Application of AgroLab Framework

Ray Wu-Rorrer and Peter Mecca

Falls Church City Public Schools, Falls Church, VA, USA

wurorrerr@fccps.org and pmmecca@gmail.com

ABSTRACT

This illustrative case study details the evolution and continued progression of multiple, non-traditional STEM learning environments at an urban secondary school campus. These environmental-focused ecosystems support integrated STEM learning by aligning with the United Nations Sustainable Development Goals. By providing direct application of sustainability practices in STEM education through student projects and school courses/activities, the review calls attention to broader issues and topics related to environments supportive of STEM learning.

The AgroLab Uniandes model emerged from an initial review of models, programs, and projects by the key stakeholders of the Falls Church City Public School's (FCCPS) sustainability program in fall 2019. The AgroLab Uniandes was implemented in the FCCPS Academy for Sustainable Thinking during fall 2022. The model served as a framework to streamline efforts of the new and existing environmental science, energy, and design programs under the umbrella of an urban agriculture program focused on sustainability within the city's public schools and the adjoining community.

The results of the case study found that students in the FCCPS sustainability program are developing deeper understandings of urban agriculture and environmental science each subsequent year through multiple, intentional experiences. Those experiences combine their classroom instruction with project-based activities in the school's aquatic education facility, the vivarium (indoor greenhouse) facility, the school gardens (pollinator, native plants, food production), and living labs (water retention area designed ecosystems). Multiple exhibits are presented of the student experiences within the educational facilities.

Keywords: STEM, Environmental Education, Goals for Sustainable Development, Sustainability

This illustrative case study presented in this paper details the evolution and continued progression of multiple, non-traditional STEM learning environments at an urban secondary school campus. Through the recent application of the agrolab framework, these environmental-focused ecosystems support integrated STEM learning by aligning with the United Nations Sustainable Development Goals (SDG).

Purpose

The purpose of this research is practice oriented; specifically, the extension and refinement of practices. By providing direct application of sustainability practices in STEM education through student projects and school courses/activities, the study calls attention to broader issues and topics related to environments that are supportive of STEM learning.

Research Question

As Yin (2018) notes, “how” and “why” questions are the most appropriate for case study research. The research question here is: How effective is the AgroLab framework in supporting the hands-on, project-based experiences of a secondary (6–12) campus’s sustainability program? This case study details high school students’ experiences of participating in an AgroLab framework-based sustainability program’s various sustainability projects. The case study focuses on the students’ attainment of educational standards, the students’ experiences, and community perceptions of the program.

Environment

The AgroLab Uniandes framework emerged as a prime model for implementation in the Falls Church City Public School’s (FCCPS) Academy for Sustainable Thinking during fall 2022, after an initial review of models, programs, and projects by the key stakeholders of the FCCPS’s sustainability program in fall 2019. The model served as a framework to streamline the efforts of new and existing environmental science, energy, and design programs under the umbrella of an urban agriculture program focused on sustainability within the city’s public schools and the adjoining community.

The programs described in this case study address multiple standards used in STEM education for the United States and/or internationally: Next Generation Science Standards, International Technology and Engineering Educators Association (ITEEA) Standards for

"Technological and Engineering" Literacy, and Common Core "Math" State Standards (Figure 01). Additionally, the SDGs are identified here given the direct application of sustainability practices through student projects and school courses/activities.

Figure 01. Discipline-specific Standards Used in STEM Education and Sustainability

Science	Technology & Engineering	Math	Sustainability
Next Generation Science Standards (2018)	International Technology and Engineering Educators Association (ITEEA, 2020)	Common Core Math Standards (2022)	Global Goals for Sustainable Development (United Nations, 2016)

Organization

FCCPS is a full IB district, with all four program levels offered. By offering tailored course loads combining IB courses with STEM/Career and Technical Education electives that focus intensively on sustainability and providing numerous seminars, field experiences, internships, clubs, and activities, the IB program's uniqueness affords FCCPS students the opportunity to complete specialized projects tailored to their individual needs and interests.

Locale

The Meridian High School and district stakeholders have committed to sustainability as a mission, which includes the pursuit of environmental integrity. Studying the environment through hands-on experience with ecosystems and wildlife is a best practice in education, and the availability of those experiences will be augmented significantly through the proposed project. In considering the three pillars of sustainability, as defined by FCCPS, each domain of sustainability (economic, environmental, social) is addressed in the projects and learning environments. Students can study ecology and biology topics and issues, as well as consider countless sustainable design possibilities.

The various projects and content connections previously described are examples of how the proposed space provides direct educational benefits and readiness to learn benefits for our students

and community at large. The spaces are used to teach about freshwater systems, pollution, conservation, classification of life, cells, art concepts, experimental design, resource management, systems thinking, and provide opportunities to improve skills in writing, design, computing, technology, executive functioning, organization, and occupational therapy.

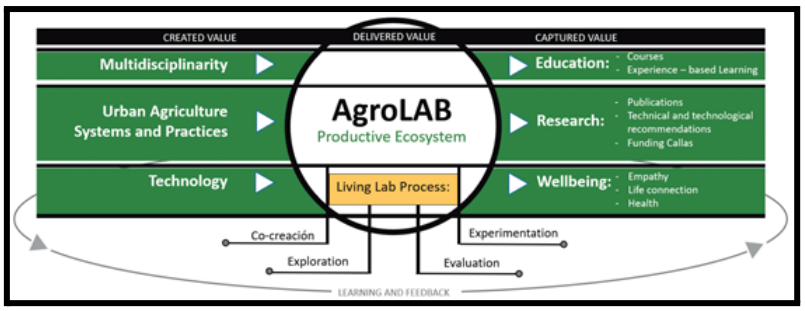
Protagonist

During the summer/fall of 2022, faculty in the FCCPS Academy for Sustainable Thinking came together to brainstorm various options for the future development of the vivarium and aquatics room. It was determined that the best approach would be to move away from a production-based focus towards an environmental focus, where projects would be integrated into the high school curriculum in the areas of ecology, restoration, native species of the mid-Atlantic region, and local watersheds. This proposal allowed for a more directed focus for the sustainability efforts and environmental education programs.

Situation

The AgroLab Uniandes's mission is to: "Provide an open-space for the dialogue, co-creation and experimentation in which traditional, experience and specific knowledge are integrated for the research, education and awareness raise concerning food production, use and interaction" (Zapata, Barbieri, Ardila, Akle, Johann, and Osma, 2019). The AgroLab Uniandes originally proposed "an environment for multidisciplinary interaction at the Universidad de los Andes in Bogotá for research and education in urban agriculture, and for the wellbeing of the participating people and communities" (Zapata et al., 2019). The FCCPS sustainability program's development, although not intentional, closely resembles the AgroLab Uniandes framework (Figure 02). The program has developed organically through the contributions of many stakeholders' efforts over the past decade. It is important to note "how unique it is for two separate educational initiatives on different continents, with different objectives and with stakeholders who have never met, to have developed in much the same way" (Wu-Rorrer, Mecca, Pollack, George, Knight, and Hardy, 2021).

Figure 02. AgroLab Framework



Source: Zapata, Barbieri, Ardila, Akle, Johann, and Osma, 2019.

Constraints and Requirements

Constraints

Case study research strategies can be complex and may have constraints because they generally involve multiple sources of data, may also include multiple cases within one study, and produce large amounts of data for analysis. This case study limits many of these constraints by sorting the cases into three main categories for easier collection and analysis, thereby also limiting the scope. This case study is a snapshot of the cases' status in spring 2024.

Requirements

The FCCPS Academy for Sustainable Thinking's definition of sustainability is "the integrated pursuit of social equity, environmental integrity, and economic security for current and future generations." (Wu-Rorrer et.al., 2021). As the academy continues to grow, innovate, and change the lives of those in the Falls Church community and beyond, importantly each piece, small or large, is a part of a larger international puzzle. The AgroLab model's framework is just one of the many pieces used by a group of dedicated faculty and staff members to prepare their students for careers in sustainability education. As the academy continues to develop, the team is dedicated to sharing their experiences and knowledge with those around them and those in need.

Methodology

This case follows the case study method, with the specific set of guiding principles of an illustrative case study method of inquiry. More specifically, this case study uses a subset of illustrative case study known as a program effects case study. A program effects case study is "a research method that evaluates the effectiveness of a particular program or intervention by examining its outcomes or effects" (EvalCommunity, 2023). The purpose of this type of case study is to provide a detailed and

comprehensive account of the program's impact on its intended participants or target population" (EvalCommunity, 2023). The researchers chose to complete an illustrative case study as it allows for the identification of themes or categories of behavior and events, rather than the collective case study method that seeks to document similarities and differences to test hypotheses. An illustrative case study is more effective in capturing the value, or lack thereof, of the educational cases/exhibits through the review process.

Data Collection

This case study uses a subset of illustrative case study methods to complete data collection of direct and participant observation, archival data, physical artifacts, and meetings. The specific methods used for the study include (1) the comparison of national/international educational standards for each case; (2) researcher collected quantitative and qualitative data related to the each project such as a general overview, the origination date, longevity of project, number of students involved (yearly and cumulatively), coded results of student learning experiences, and the coded student impacts of the project on student learning; and (3) post-study completion meetings with key stakeholders. The data analysis is completed through the use of pattern matching and data reduction through open coding.

During the post-study meetings, the key informants review of the draft study report was included and a clearly established chain of evidence was established with only the two researchers having controlled access to the data. All data presented to stakeholder meetings were in aggregate form with no personally identifiable information being made available.

Data analysis

Yin (1989, 1994) suggested three types of data analysis: pattern matching, explanation building, and time series. Dul and Hak (2008) also mention pattern matching and visual inspection as ways of analyzing data. The researchers chose to combine these two approaches to include pattern matching and data reduction through open coding. Since this is not a grounded theory study, there was no need to complete axial and selective coding. The data analysis is completed through the use of pattern matching and data reduction through open coding.

Reliability and validity

Kirk and Miller (1986) define reliability and validity as "an account of the particular relationship between the researchers' definition, the generation of data, and its interpretation: for reliability to be calculated, it is incumbent on the scientific investigator to document his or her procedure." Ebneyamini (2018, p. 4) insists that "this must be accomplished at such a level of abstraction that the loci of decisions internal to the project are made apparent." The validity, meaningfulness, and insights generated from qualitative inquiry have more to do with information richness of the cases selected and the researcher's observational/analytical capabilities than with sample size (Patton, 1999). The use of multiple sources of data (data triangulation) has been advocated as a way of increasing a study's internal validity. The three data sources collected (standards, researcher collected, and stakeholder meetings) triangulate the data used in this study.

Researcher collected information.

Quantitative Data.

This section aligns the national and international educational standards and the SDGs to the AgroLab projects and provides the results of quantitative and qualitative data collected for each project. The quantitative data includes the project's origination date to establish longevity and student involvement, yearly and cumulatively, since inception. These two tables, shared with the community stakeholders reviewing the results of the study for validity purposes, are not included as a part of this paper.

A comprehensive report was created for the collection and analysis of qualitative data that provided a general overview of each project, reasons for project origination, examples of student learning experiences, and impacts of the project on student learning. This report, shared with the community stakeholders reviewing the results of the study for validity purposes, is not included as a part of this paper.

Qualitative Data.

This case study used an inductive content analysis process to analyze the qualitative data. Delve, a computer-assisted qualitative data analysis software was utilized for thematic analysis coding by looking for themes or patterns across the qualitative data set for the first round of analysis. The

software coded the qualitative data into five primary codes (Figure 03): participants, life skills gained through experiences, time when activities/events offered, setting, and rationale for participation. A second round of analysis was completed by the researchers using structural coding. Forty secondary codes were created. The tables of coded data are the results of a data analysis process that included direct and participant observation, archival data (report on AgroLab projects), and physical artifacts. In order to establish additional construct validity, the qualitative data report and coding results (not included in this paper) were provided to stakeholders for approval and validation of coding results as the third component of data triangulation.

Figure 03. *Definition of Primary Codes*

Participants	A person who takes part in, becomes involved in, or provides support for a particular activity.
Life Skills Gained Through Experiences	A mix of knowledge, behavior, attitudes, and values and designate the possession of some skill and know-how to do something through experiences in an educational setting.
Time When Activities / Events Offered	The time of day/week a project was available for student participation.
Setting	The physical location, structure, and/or area where a project took place.
Rationale for Participation	The reason why a student took part in, became involved in, or provided support for a particular project activity.

A holistic rubric emphasizes what the learner is able to demonstrate, saves time by minimizing the number of decisions raters make, and can be applied consistently by trained raters increasing reliability. A holistic rubric with a four-tier rating scale was used to identify the connection of each secondary code to multiple projects.

Research study post completion stakeholder meetings.

The post-study completion meetings with key stakeholders were included by the researchers to establish data validity and reliability and the study's findings. As provided earlier, establishing the validity and reliability of a qualitative study is imperative for those not directly involved in the study to easily understand the accuracy of the information being presented.

An initial review of the qualitative data was completed in February 2024. The review was distributed electronically to stakeholders with knowledge or awareness of the AgroLab projects from

the FCCPS community. In order to establish construct validity, the qualitative data report and coding results were provided to stakeholders for approval and validation of coding results as the third component of data triangulation. Stakeholders were asked to review the researchers collected data in the form of 1) project descriptions (qualitative) and student participation (quantitative), 2) the determination process for coding, and 3) the coding results for each project. If in disagreement, they were able to provide a written explanation for the researchers' to review and update as needed. Stakeholders were also given an opportunity to provide anecdotal information for any section.

A group of five stakeholders, two teachers, one parent, one coordinator, and one administrator, completed the full initial review process. Stakeholders confirmed the accuracy of the data provided, agreed with the primary/secondary codes created, and accepted the researchers alignment of projects to applicable codes. Only five project code alignments were questioned by stakeholders. The recommendations were reviewed, considered, and where applicable, changes were made. Based upon feedback from stakeholders, minor changes were made to tables and formatting of information to be easier for future review and interpretation.

A secondary review was completed in the spring of 2024 by electronically providing a draft copy of the full manuscript to the FCCPS central office staff and the division's legal counsel for review/revision, acceptance of results, and approval. This further establishes the study's validity and reliability. As with the initial review, all recommendations were reviewed, considered, and where applicable, changes made to the report. The full manuscript will be submitted for publication after the results have been shared with experts at an international STEM education conference during the summer of 2024.

Findings

A program effects case study is an effective way to do research for completing a detailed look at how a program affects the people it was designed for. This kind of case study can be used to determine if changes are necessary and how to make programs that work better. This practice oriented research study provides information of the contribution and implication of study by practitioners. The case study found that students in the FCCPS sustainability program are developing deeper

understandings of urban agriculture and environmental science each subsequent year through multiple, intentional experiences that combine their classroom instruction with project-based activities in the schools aquatic education facility, the vivarium (indoor greenhouse) facility, the school gardens (pollinator, native plants, food production), and living labs (water retention area designed ecosystems).

Limitations

Despite case studies being "one of the most frequently used qualitative research methodologies in educational research, the methodologists do not have a full consensus on the design and implementation of the case study, which hampers its full evolution" (Yazan, 2015). Another limitation of this case study is that it may not be generalizable to other populations or contexts. In this case study, the research focuses on a singular program and a particular population, so the findings may not be applicable to other programs or populations in different settings.

Conclusions

This case study details high school students' experiences of participating in an AgroLab framework-based sustainability program. The research question for this case study is: How effective is the AgroLab framework in supporting the hands-on, project-based experiences of a secondary (6–12) campus's sustainability program? The research question in this case study focused specifically on the experiences of secondary school students after actively participating in various sustainability projects of the program through the student's experiences, attainment of educational standards, and community perceptions of the program.

The model serves in streamlining efforts of new and existing environmental science, energy, and design programs under the umbrella of an urban agriculture program focused on sustainability within the city's public schools and the adjoining community. The study confirms the AgroLab model and the framework used at Meridian High School supports the hands-on, project-based experiences of a secondary (6–12) campus's sustainability program through student's experiences, the attainment of multiple educational standards, and the positive perceptions of the program by the community.

References

Dul, J., & Hak, T. (2008). *Case study methodology in business research*. Amsterdam: Elsevier.

Ebneyamini, S., & Sadeghi Moghadam, M. R. (2018). Toward Developing a Framework for Conducting Case Study Research. *International Journal of Qualitative Methods, 17*(1). Retrieved January 12, 2024, from https://doi.org/10.1177/1609406918817954

EvalCommunity (2023). *Case Study Evaluation Approach*. Retrieved January 12, 2024, from https://www.evalcommunity.com/career-center/case-study-evaluation-approach/#:~:text=A%20program%20effects%20case%20study,impact%20on%20the%20target%20population

Hancock, D.R., Algozzine, B. and Lim, J.H. (2022) Doing Case Study Research: A Practical Guide for Beginning Researchers. Teachers College Press. New York.

Kirk J., Miller M. (1986). *Reliability and validity in qualitative research*. Thousand Oaks, CA: Sage.

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research*, 34, 1189.

Wu-Rorrer, B. R., Mecca, P., Pollack, C., George, K., Knight, S., Hardy, V. (2021). Part 3: The History of Sustainability: Education in Action. *Technology and Engineering Teacher, March 2022.*

United Nations (2016). About the Sustainable Development Goals. United Nations, New York. https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Yazan, B. (2015). Three approaches to case study methods in education: Yin, Merriam, and Stake. *The qualitative report*, *20*(2), 134-152.

Yin, R. K. (1989). *Case study research*. Beverly Hills, CA: Sage.

Yin, R. K. (1994). *Case study research: Design and methods (2nd Edition)*. Beverly Hills, CA: Sage.

Yin, R. K. (2018). *Case study research: Design and methods (5th Edition)*. Los Angeles, CA: Sage.

Zapata, F., Barbieri, G., Ardila, Y., Adame, Y.A.A., Akle, V., Johann, Alvarez, V., and Osma, J.F., (2019). AgroLab: a living lab in Colombia for research and education in urban agriculture. The Cumulus Bogota 2019 Conference, *The Design After*.