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Carey L. Averill
Star of the Sea Catholic School

Janet M. Herrelko
University of Dayton

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EDUCATION IN PRACTICE

STREAMing with Butterflies: A Whole School STREAM Project

Carey L. Averill[1] *and Janet M. Herrelko*[2]

Abstract: This study explores the commitment of a school faculty to use the pedagogical practices needed to employ a project-based unit of science, technology, religion, engineering, arts, and mathematics (STREAM). The unit of study concentrated on environmental sustainability of butterflies through project-based learning (PBL). Teacher interviews were analyzed to reveal the similarities and differences, strengths, and weaknesses in the teachers' reactions to implementing a cross-curricula content unit designed for a pre-kindergarten (PK) to eighth grade school. Analysis of teacher data and classroom artifacts provided evidence of content mastery at the student levels, implementation of scaffolding for developmental levels, and the need for flexibility in scheduling. As a result of the study, the school leadership gained new perspectives regarding how the faculty understood and implemented STREAM programming. This study contributed to the knowledge base by informing teachers and educational leaders about the level of effectiveness STREAM can have within a K–8 school.

Keywords: STREAM, STEM, science, technology, religion, engineering, arts, mathematics, sustainability, environment, butterflies

Because knowledge is available on every Internet-connected device, what you need to know matters far less than what you can do with what you know. The capacity to innovate–the ability to solve problems creatively or bring new possibilities to life–and skills like critical thinking, communication, and collaboration is far more important than academic knowledge (Wagner, 2012).

1 Star of the Sea Catholic School
2 University of Dayton

Preparing the students of today for productive lives in their chosen vocations, citizenship, and personal lives is a challenge felt by educators at all levels of schooling. From acquainting children with career choices in the elementary grades, progressing to experiences with a wide variety of occupations in the middle years (Rathburn, 2022) are the joint goals of a Science, Technology, Religion, Engineering, Arts, and Mathematics school (STREAM). This report details a case study in an urban school in the mid-Atlantic region of the United States and examines the commitment of the school faculty to engage in STREAM pedagogy. This study contributes to the knowledge base by informing teachers and leaders about the current level of effectiveness and areas of weakness of STREAM implementation at one school when using a project-based focus. As a result of the study, this school's leadership gained the perspective of how teachers became investigators when implementing a new STREAM project.

STREAM schools foster creativity and innovation within a curriculum that is student-centered, inquiry-based, and challenging. To accomplish these highly demanding educational elements, educators create learning experiences that are cross-disciplinary in nature and relevant to the real world. The STREAM curriculum in this study follows the instructional model detailed by Bybee (2019) as the 5Es. The 5Es represent having students engage, explore, explain, extend, and evaluate a hands-on project which integrates academic subjects to emphasize connections across disciplines. This pedagogical approach develops analytical and creative skills through investigations.

For students in the United States to remain globally competitive in the 21st workforce, contemporary research suggests educators must shift from teaching subjects in isolation to integrating science, technology, engineering, and mathematics (STEM). Catholic education adds quality of life goals by including the arts and religion into STEM, creating the abbreviation STREAM. Incorporating academic core subjects helps students make connections through content areas while engaging in hands-on activities and real-world projects (Moore et al., 2014). Although STREAM curriculum represents six academic areas, it allows instructors to dictate how specific interdisciplinary connections are made between them and to emphasize the connection itself. The hands-on project design by the school community for this STREAM investigation is the study of butterflies, their life cycle and sustainability in the present world. This study examines how the faculty used Bybee's (2019) 5Es to create project experiences for students. If the faculty is successful in the generation of engaging, exploring, explaining, extending, and evaluating hands-on activities for their students, then STREAM proficient students are able to apply the rigor of content knowledge to solve complex questions while investigating global issues and developing new solutions. The butterfly project is this school's first school-wide STREAM project. This study examines the involvement of how each faculty member interprets the STREAM pedagogy and follows through with their implementation.

When students do the work required for project-based learning, they use multiple content areas for one project, employ physical learning, use the process of mental storage using the five senses, apply and observe the interconnection of concepts, and create and augment their mental schema (Boss et al., 2011). This approach moves the lesson goals into broader territory of conceptual learning and knowledge products as evidence of learning. There is a need for STREAM projects to begin at the elementary level because this pedagogical approach encourages the youngest of learners to explore, experiment, question, and discuss findings. According to Discovery Education (2018), STEM education is an interdisciplinary approach that supports critical thinking and the exploration of STEM practices. This study contributes to the knowledge base by informing teachers and leaders about the current level of effectiveness and areas of weakness of STREAM implementation at one school when using a project-based focus and how teachers became investigators in this case-study.

Project-Based Learning

Historically, Aristotle and Confucius were two of the first proponents of students doing the learning work in order to grasp concepts. Socrates added that the questioning of students draws out their innate knowledge and encouraged critical self-evaluation of that knowledge. Dewey noted that students learn by doing, where students' interests drive the selection of experiences. Piaget believed that students learn by applying inquiry steps, examining issues, collaborating with others, and reflecting on their experiences to understand new concepts (Boss et al., 2011). These were major educational theorists whose research supported the use of project-based learning (Kokotsaki & Wiggins, 2016). When the teachers created project objectives, they incorporated the eight Mathematical Practices of the Common Core (National Governors Association, 2010) and the National Council of Teachers of Mathematics (NCTM) Teaching Practices (Leinwand, 2014) and the processes of the Next Generation Science Standards (National Research Council, 2013) along with the art, technology, and language arts objectives of the local diocese (Diocese of Richmond, 2014). The butterfly project objectives for STREAM are listed and aligned in Table 1.

Project-based learning (PBL) in this study was a form of situated learning based on constructivist research (Lave & Wenger, 1991) where students and teachers are immersed in real, meaningful problems that allowed them to engage, investigate, discuss, and share new ideas and knowledge (Buck Institute for Education, 2008; Krajcik & Shin, 2014). The school community included students, teachers, staff, and parents working together to investigate the sustainability of butterflies.

Table 1

School-Wide Butterfly Project Lesson Objectives

Science	Technology	Religion	Engineering	Art	Mathematics
Ask questions	Become aware of the web of technological systems on which society depends	Sacred Scripture: Develop a relationship with God and learn about his gifts	Define problems	Generate artistic ideas and work	Make sense of problems persevere in solving them
Develop and use models		Church History: Awareness of church as the family of God	Develop and use models	Develop artistic ideas	Model with mathematics
Plan and carry out investigations	Learn how to use new technologies as they become available	Doctrine: Recognize the importance of prayer and God's Word in one's life	Plan and carry out investigations	Complete art work	Use appropriate tools strategically
Analyze and interpret data		Develop a sense of right and wrong behavior	Analyze and interpret data	Analyze and interpret work	Attend to precision
Use mathematics and computational thinking	Recognize the role that technology plays in the advancement of science and engineering	Liturgy	Use mathematics and computational thinking	Convey meaning through the presentation	Reason abstractly and quantitatively
Construct explanations		Sacraments	Design solutions	Perceive and analyze artistic work	Look for and make use of structure
Engage in argument from evidence	Make decisions about technology, given its relationship to society and the environment	Dignity of the human person-Family life, human dignity, community, morality	Engage in argument from evidence	Apply criteria to evaluate artistic work	Construct viable arguments and critique the reasoning of others
Obtain, evaluate, and communicate information		Learn by heart: Service/ social justice/servant leadership	Obtain, evaluate, and communicate information	Relate ideas with deeper context and understanding	Look for and express regularity in repeated reasoning

Science & Engineering adapted from NRC, 2013; Art & Religion adapted from Diocese of Richmond, 2014; Mathematics. adapted from Leinwand, 2014

Methodology

Having researched the effectiveness of using STEM procedures in classrooms, it was the desire of this research to learn how cooperative teachers would be to implement a teaching method that was different from the standard manner of content presentation and how the teachers responded to implementing thematic course content through the PK–8 classes. The principal and faculty jointly decided to use a STREAM methodological approach to teach climate sustainability by studying the life cycle of butterflies.

To examine how the faculty implemented and taught using STREAM within a school-wide curriculum, a case study approach provided the methodology to reveal positive and negative attributes of the process. To identify the effective elements of this school-wide project that Bogdan and Biklen (1992/2003) recognized as "Historical Organizational Case Study," the researchers developed interview questions for the faculty members. Bogdan and Biklen (1992/2003) stated that substantive theoretical questions provide the basis for generating formal theory.

The research question for this study was: How did elementary and middle school teachers vary in their implementation of one STREAM project? This main research question guided the document review and interviews with key informants. The interview questionnaires elicited perceptions of the key informants as they described their implementation of the butterflies STREAM unit. A key informant was defined as an individual who taught the STREAM unit by adapting it appropriately for the grade-level the key informant was teaching. Interview questions were created from the faculty meetings where the STREAM project was reviewed. Qualitative research best captured the voices of the key informants as they emerged during this implementation process. In this study, the authors' knowledge of relevant research, experiences with professional development served as sensitizing concepts and influenced our data analysis. Sensitizing concepts have been regarded by researchers as being useful for providing focus to guide this qualitative method (Blumer, 1970; Denzin, 1989; Patton, 1990). Data in the form of written responses noted how individual teachers varied in their implementation of this STREAM project.

Participants

The sample in this study was derived from a religion-based elementary and middle school in an urban location in the mid-Atlantic region of the United States with grades pre-kindergarten to grade eight (PK–8). During the study period, enrollment consisted of 251 students. The school employed 23 teachers, three teacher assistants and eight support staff. Of the 23 teachers: 13 had a bachelor's degree, eight had a master's degree, and two had doctoral degrees. The class sizes during the measurement period varied from 11 to 36 students (See Table 2). Within this Title I school population, one-third of the families received tuition assistance where the annual tuition was $7,376.00 per student.

Table 2

School Student Population 2022–2023

Grade	Number of Students
PreK - A	11
PreK - B	19
Kindergarten	36
1	23
2	36
3	24
4	24
5	24
6	17
7	19
8	18

In addition to faculty and staff participating in this project, members of the Home and School Board contributed to the purchasing and installation of butterfly gardens that were constructed throughout school property. Volunteers helped the students create a flight of the butterfly migration display inside the school building.

Procedure

The challenge presented to the faculty was to create a learning ecosystem with butterflies that was grade appropriate. The learning opportunities were to be accessible to all age groups by the interweaving of activities between at least two content subject areas. These STREAM methods deepened the learning experience and interest for the students. Local and global issues were examined using a multi-disciplinary lens; the teachers had to create enticing challenges that can be sustained over time.

In faculty meetings, teachers discussed their comfort level and expertise regarding how to successfully cultivate a learning ecosystem with butterflies. Working in small groups, they created webs of learning ideas to integrate more than one subject area and presented the pedagogical webs to the school faculty as a whole. The teachers' engagement remained active as they continually worked together sharing ideas and information. Effective professional development was identified as active when teachers were engaged physically, cognitively, and emotionally through various activities such as sharing and discussions (Knowles, 1983; Lieberman & Pointer Mace, 2008). In tandem with lessons happening inside the building, the faculty worked with students and parents to build a sustainable outdoor garden.

One key element to this project that promoted student discourse was the prayer partners program. The prayer partner program paired students from grades PK to grade 3 with older grade students in grades 4-8. The teachers collaborated to ensure that the matches would work well. Depending on class size, some students had more than one prayer partner. The partners helped guide the younger students at weekly religious services, to participate in classroom activities and events, and to celebrate holidays throughout the school year. Building relationships, serving as role models, and providing mentorship were goals of the prayer partner program which helped strengthen the Catholic school community and built students' knowledge by explaining their work. During the STREAM project, prayer partners routinely met to compare the stages of their butterflies and shared in the release. When the completed butterfly projects were displayed throughout school, the prayer partners participated in gallery walks to view projects and to discuss the variations done by each class.

Faith is integrated into all subject areas in a Catholic school education. Therefore, sharing STREAM experiences with students' prayer partners was important. The McMorris (2016) study discussed the relationship between religious practice and academic engagement. McMorris (2016) noted that higher levels of student involvement were associated with positive academic dividends and improvements in overall schooling. When using a STREAM-based pedagogy, science answered the "How" (Billingsley et al., 2013; Billingsley et al., 2014), art made science beautiful and enhanced the aesthetic of technology (Root-Bernstein, 2011), and religion answered the "Why" (Billingsley et al., 2013; Billingsley et al., 2014). When prayer partners explained what they were learning at their grade level, the project linked multiple areas of STREAM.

Materials

In early spring, the school purchased butterfly kits along with larvae for every classroom. Chart paper, drawing paper, and graph paper were provided through school funds. Chromebooks and desktop computers were used for student research to include butterfly migration patterns, life span, and species native to the Mid-Atlantic region. Classroom projects were created from school resources to include learning about symmetry through wing design, building butterflies using Legos, and comparing butterflies to moths and frogs. Planter boxes, soil and flowers were purchased through funds raised by the Home and School Association. Parent volunteers donated over 100 Sharpies and their time by cutting out over 250 butterflies out of clear plastic sheets for the students to design their own butterflies.

Sustainability

The World Commission on Environment and Development (1987) defined sustainability as, "meeting the needs of the present without compromising the ability of future generations to meet their needs" which encourages every human being to acquire the knowledge, skills, attitudes, and

values necessary to shape a sustainable future. Through research on habitats, students learned about, established, and maintained a small ecosystem on school grounds. Within the four pillars of sustainability (human, social, economic and environmental), this project focused on social and environmental (Simon, 2023).

Building Butterfly Gardens

Activities that went beyond the school campus included participation from friends and family who donated to Random Acts of Kindness, a fund that focused on the social interaction of our students. One goal of this fundraiser was to create an outdoor learning environment where parents purchased materials for raised-bed butterfly gardens. Enough materials were purchased for every classroom, including art, music, and library departments to have a butterfly garden. The students planned continual maintenance of the gardens in preparation for the next crop of butterflies and to help reinforce the impact individuals have on the environment. Other school activities were age and grade appropriate including: field trips to the Norfolk Botanical Gardens; examinations of butterfly migration patterns; the study of life cycles of butterflies; comparisons of other species to butterflies; and finding scripture on spiritual conversion, the resurrection and the transfiguration.

Data Collection

The school principal engaged with the faculty during their small group meetings listening to the issues of successes and problems that existed during the implementation of the STREAM butterfly project. From these sessions, the principal developed seven questions for the faculty that would provide evidence of keywords regarding what they observed and their commitment to integrating content and implementing a STREAM project (Afshari, 2023):

1. What did you do to create curriculum for your class butterfly project?
2. How did you determine the interconnecting content projects?
3. What did you create to determine the connections with scripture?
4. How did you align the prayer partners with this project or how can you implement it for this school year?
5. What are two take-aways for your teaching from the butterfly project?
6. What are two ways to enhance or improve upon, add or do differently moving forward?
7. How did you grow in learning?

The use of interviews and written documents (Patton, 1990) as reliable sources of data collection served the methodology for this qualitative study. The data collection began in the fall

of 2022 when the school faculty were asked to respond to questions focused on the teachers' work and the student knowledge products from the project-based work of the previous 2021–2022 school year.

Data Analysis

The teacher responses were inspected by a reviewer who was not part of the school system. The responses were searched for common terms using a manual word sort that produced content variables. Two recent studies delineated how specific words were used by study participants to demonstrate a commitment to professional development (Afshari et al., 2020; Afshari, 2023). The present study identified specific vocabulary words that teachers used as links to their commitment to using STREAM. Once the words were identified, the teacher responses were reviewed again, and a count was recorded for each teacher's comments. The faculty responses were grouped into three grade groups for the purpose of reporting data trends from teachers: grades PK–5; grades 6–8; and specialty topics such as technology and foreign language.

Results

The goal of this study was to learn how teachers implemented a school-wide STREAM project. The teachers participated in a STREAM project because research noted that project-based learning helped students become active learners; at this school, students discovered they can have a profound impact on their environment. In this project, the level of difficulty and complexity increased as the grade levels rose. Knowledge, discussion, and action regarding habitats and climate were heard in every classroom. Hallways were decorated with projects from each class. There were mathematical measurements of wings, literary analyzes of book characters that transformed throughout novels, graphs of butterfly growth charts, poetry, and biblical passages regarding resurrection. The STREAM project culminated with a school-wide creation of a butterfly migration pattern modeled with over 250 plastic butterflies. Every student, teacher, and staff member designed their own unique butterfly that was added to the model of butterfly migration.

This project-based learning cultivated students' curiosity and built an understanding of core scientific ideas. Student understandings were displayed in their verbal observations and questions and with prayer partners. At the project's conclusion, the students and faculty were curious about the success rate each class has with their butterfly eggs developing into butterflies and how to calculate that percentage. Artifacts exhibited what students learned (Krajcik & Blumenfeld, 2006; Krajcik & Shin, 2014), and teachers used classroom artifacts to demonstrate how students' understanding developed across various unit elements in PBL (Krajcik & Shin, 2014). As classroom projects were completed, they were displayed in a variety of ways including: the school

hallways, the school's social media sites, and the teachers' faculty meetings. Gallery walks frequently occurred when classes examined and discussed the displayed project work of other students.

Weekly discussions were shared at faculty meetings along with charts to help teachers share how STREAM was promoted in the different grades as well as school-wide special courses. These charts were hung in the faculty lounge as reminders of ideas generated and goals discussed by the group. "Butterfly Bits" were weekly memos sent to faculty and staff that pertained to butterfly information that the faculty discovered. Some memo examples included: butterflies are found on every continent except Antarctica; butterflies taste with their feet; 48 U.S. states have designated state insects or state butterflies. Butterfly facts, class projects, and "Butterfly Bits" provided a unifying experience for the whole faculty. Vibrant discussions took place between faculty members as they shared pedagogical ideas, methods, and experiments.

In the elementary classes, reading times included *The Very Hungry Caterpillar* (Carle, 1981) and *Fancy Nancy: Bonjour, Butterfly* (O'Connor, 2012) that detailed the metamorphosis process. In middle school, students completed character analysis from novel studies that demonstrated transformation, rebirth and resurrection. Novels included *The Diary of Anne Frank* (Frank, 1989), *Torn Thread* (Isaacs, 2000), *Escape: Children of the Holocaust* (Zullo, 2011), *Number the Stars* (Lowry, 2011), and *Night* (Wiesel, 2004). The students identified parallels in literature and faith leading to discussions of transformation, hope, rebirth and resurrection. All students designed butterflies and wrote biblical verses on their designs. Using literature was a differentiating point between elementary grades and middle school grades.

The special topic teachers were involved in the faculty professional development activities and created lessons or games based on their area of expertise rather than the 5Es. The art teacher incorporated many projects throughout the grade levels including watercolors with flowers, butterflies, and bees. The plastic butterflies colored by the students were not biologically accurate in color nor design. Symmetry was stressed in the coloring by the students. In physical education, all grades played a game called "Bees and Butterflies" (Boulton, n.d.). In Spanish class, students learned vocabulary words related to butterflies and their various stages. The music teacher was not able to create any lessons for the project.

Challenges shared by some teachers were in reference to timing the release of the butterflies as some experienced cold, rainy weather during the week of their release. Additionally, two teachers shared that their students witnessed birds eating their butterflies upon the release. While the butterflies becoming food for birds was alarming to some, it prompted meaningful discussions regarding the cycle of life, predators, camouflage, and food chains.

Of the 23 teachers, seven responded to the questionnaire with a return rate of 30%. The reviewer noted 15 key pedagogical terms used by the respondents. (See Table 3).

Table 3

Teacher Responses to Questionnaire

Content Variables	Grade Groups		
	Pre–K	6–8	Specials
Art	1	1	
Collaboration	2	1	
Cross Curricula	4	1	
Hands-on	2		
History	1	2	
Academic Interactions	2	1	
Personal Interactions	1	1	
Language Arts	5	2	2
Mathematics	7	2	
Prayer Partners	2	1	
Religion	6		1
Research		1	1
Science	10	3	
Technology	2		2

In the interview questions commentary, the faculty respondents stated they would like to schedule more time for the students to work with their prayer partners. Several faculty noted meaningful discussions had occurred between the older students and younger students. Teachers asked if there could be increased sharing and teaching by the older students with the younger students and prayer partners. The faculty saw prayer partners in an expanded view that would interlace academics with religious elements. The respondents shared they would like more preparation time to complete research and ways to integrate STREAM. Future topics of research were discussed both with students and amongst the faculty.

Teachers stated they all felt safe about teaching the stages of butterflies, but it was a new area of learning and teaching beyond the basics. Through ongoing dialogue at faculty meetings, gallery walks, and shared artifacts, risk-taking was encouraged, and therefore, pedagogical practices of STREAM implementation were promoted. According to Bybee (2019), STEM instructional strategies required a different set of skills and knowledge than traditional lecture and text-based approaches. Therefore, even veteran teachers needed additional learning opportunities that included ongoing professional development. Providing professional learning communities allowed time for reflection, planning, and collaboration. Projects that the teachers integrated from STREAM consisted of cooperative learning classroom environments and design-based learning with a student-centered approach. Both teachers and students engaged in inquiry, lesson planning and matching material to learning outcomes; these and the participation in cooperative learning

centers, both within the class and across grade levels, all led to building a stronger understanding of our environment through sustainability.

Discussion

The teacher engagement in the STREAM pedagogy was exciting for the school leadership to observe. Many of the teachers asked to continue doing the butterfly project the following school year because they noted how they could improve their teaching and include more integration of content.

Challenges

Some challenges included the continuity of care for the butterfly gardens once summer arrived as there were not enough volunteers to tend to the gardens. Moving forward, suggestions include creating a rotation schedule as a way to earn volunteer hours for both parents and students. Another suggestion is to ask families to take the raised garden home with them over the holidays and summer for better care.

While creating a school-wide ecosystem of learning, another challenge arose: How to ensure that each class dedicated time to this project to deepen students' learning experience as well as collaborate with partners throughout the school campus? During this study, classes had STREAM hours built into their weekly schedule to enhance their love of inquiry and scientific exploration.

Another obstacle was the time constraint to offer consistent, ongoing professional development for teachers within the PreK–8th grade setting. Sufficient time for professional development was necessary to engage all faculty in the STREAM process, specifically those unfamiliar with integration pedagogy STREAM. Additionally, the faculty desired more dedicated time to research, learn, and collaborate. Finding time needed more discussion with the faculty.

Research has shown that effective professional development increased motivation and commitment to the learning process (e.g., Fullan, 1995) and addressed specific learning needs of each school, class, grade level and teacher (Quick et al., 2009). With ongoing professional development, teachers became better educated on student misconceptions and learned various ways in which to engage their students through varying instructional strategies and content areas (King & Newmann, 2004).

As the school leadership prepares for the next season of butterflies, teachers and students are engaged in discussions on what they know and how they want to adapt this project next year. As older classes join with their younger prayer partners throughout the year, teachers want to intentionally plan learning activities together to include more journaling and the releasing of butterflies in tandem. The faculty want to increase the opportunities for the students to share and teach what they have learned to their prayer partners.

Suggestions for future research include examining how school faculty teach with genetically modified butterflies, how middle grade students can research the topics of: how butterflies are being raised for sustainability in rainforests; what climate-induced migration means; and what the impact of climate change has on species within the school geographic location. While teachers continue their discussions and planning using a STREAM approach, they continue to contribute a focus and connection on humans, our environment, and relationships with God.

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