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Success Framework for a STEAM x S-L Partnership

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Success Framework for a STEAM x S-L Partnership (Evaluation)

Abstract

It is widely recognized that there is a need for a diverse workforce of STEM (science, technology, engineering, and mathematics) professionals, leaders, and innovators to co-create successful solutions for global problems. The inclusion of art into STEM activities (making STEAM the new acronym) has the potential to encourage a more diverse population of learners to become engaged in this workforce. While these needs are great, there is not widespread access to STEAM activities; teachers in many districts face multiple constraints in developing new rigorous activities. Partnerships between K-12 and universities can ease this burden through service learning (S-L).

At an urban elementary school in the northeast, an afterschool STEAM club has been partnering with a S-L engineering course from a local university to develop and facilitate activities. We call this partnership STEAM x S-L. This partnership seeks to be mutually beneficial and work towards a common goal developed by the community partner and university, to achieve a transformative relationship. Our partnership specifically focuses on engaging and growing K-12 STEAM education in a manner that does not place the burden solely on K-12 teachers.

Utilizing a design-based implementation research approach, the school and university teams created numerous collaborative activities for upper elementary-aged students. The process of improving activities occurred through iterative interviews, student work samples, and feedback from the K-12 students and undergraduate team leaders. The results from this iterative process were then used to develop an initial framework for what makes successful activities for the STEAM x S-L partnership. The framework was then mapped to current literature around developmentally appropriate teaching practices, STEAM, and S-L and further refined through comparison to student feedback on various activities.

This framework has implications for both researchers studying S-L and STEAM education and also practitioners seeking to set up their programs for success. While elementary teachers are overworked and over-asked, developing S-L relationships with local university programs can be one solution to addressing STEAM workforce development at both K-12 and university levels.

Introduction

In a most recent effort to strengthen Science, Technology, Engineering and Mathematics (STEM) education nationwide, the goal of the *Raise the Bar: STEM Excellence for All Students* initiative is to ensure their 21st-century career readiness and global competitiveness for all - regardless of background [1]. With a projected increase in STEM jobs of 8 percent by 2029 (a higher rate than non-STEM jobs [2]) there is a need to address the equitable cultivation of a STEM workforce that is diverse and culturally relevant.

In order to broaden the interest of young learners in STEM, many educators are including art in their STEM activities (making STEAM the new acronym.) This inclusionary practice has the potential to encourage a more diverse population of learners to become engaged in STEM practices [3]. With arts-inclusive STEM programming, we prepare students to be interdisciplinary collaborators who can add new perspectives to the increasing demand for innovation.

Even with governmental initiatives and inclusive practices to increase STEAM efforts, teachers, especially at the elementary level, face constraints in creating and keeping up with the increasing need to create STEAM lessons to engage students [4].

To address some of the issues in creating a STEAM curriculum, an afterschool STEAM club was created in partnership with a local university through a Service Learning (S-L) program. This program pairs a college engineering design class (32 students) with a STEAM club (28 students) where college students lead weekly STEAM activities with elementary students (4th and 5th graders) under the supervision of the STEAM club advisor (an elementary science teacher). A selection of approximately 6 university students attend STEAM club on a rotating schedule. University students learn how to work with diverse groups of children to better their work in the classroom while elementary students gain exposure to STEAM activities under the mentorship of engineering students. We call this relationship a STEAM x S-L Partnership.

This evaluation paper describes the DBIR-based process for developing the STEAM x S-L framework. It also presents the STEAM x S-L framework which addresses the communication needed to sustain the collaboration, the best practices for club facilitation, and the guidelines for the creation of successful materials for the partnership.

Study Context

What is the burden?

It is widely noted that there will be a significant increase in the number of STEM jobs over at least the next decade. Yet according to the U.S. Bureau of Labor and Statistics, “over 99 percent of STEM employment was in occupations that typically require some type of postsecondary education for entry, compared with 36 percent of overall employment” [5]. In order to fulfill our future STEM needs, we need to increase the quantity and diversity of postsecondary students going into STEM fields of study. This starts in K-12 education.

The educational goals associated with STEM curriculum require students to think critically, apply knowledge in creative ways, and problem solve. Multiple spaces and opportunities need to be created and fostered to cement these techniques into the students’ skill sets. However, teachers contend with a multitude of factors that can inhibit them from providing the creative time and space needed to fully develop this 21st-century skill set.   According to Rotherham and Willingham, “teaching that promotes creative thinking as the foundation of instruction is often hit or miss and is rarely institutionalized in curricular or instructional practices in school systems [6].”

Since *No Child Left Behind* was signed into law in 2002, public schools and therefore public-school teachers have been evaluated largely by student performance on standardized achievement tests. As Hardiman states, public school teachers are under significant constraints preventing innovation. Teachers can inadvertently stifle creativity simply due to the demands of the education system on both teachers and students. To foster creativity, students need space for divergent thinking, dissent, and solving problems that don't have just one solution [7]. While the future of the STEM pipeline starts in K12 education, the burden simply cannot be shouldered solely by public schools.

STEAM clubs are one solution to help

Attention to the broader STEM education ecosystem outside of regular school curriculum may be particularly important for broadening and diversifying the pool of STEM talent [8]. Outside the constraints of the general education classroom, teachers do not have to worry about testing in a STEAM club. This encourages diverse styles of learning and eases the pressure of grading/studying/viewing learning as a "chore." STEAM clubs adopt and adapt learning materials and activities with the aim of creating an interest in STEAM by connecting participants with positive learning experiences [9] and meaningful social interactions [10].

As far as intervention goes, one early study suggests that college-going students who participated in a college-run STEM club during high school had 1.49 times the odds of expressing STEM career aspirations relative to students who did not participate in a STEM club [8]. In comparison, the following other interventions provided comparative results: Summer bridge - 2 times more likely [11]; campus visits with a STEM college professor 1.3 times [12]; and STEM dual enrollment - 1.3 times [13].

S-L relationships can ease this burden on teachers

S-L encourages engagement in the community by involving participants to meet needs in the community, especially the needs of those who are under-served. It is reciprocal, values partnership, and recognizes the expertise brought by the community partner. It also includes reflection, which has been shown to enhance learning across academic subjects [14]. S-L is integrated by educators in a way designed to meet needs and goals identified by the community while being intricately linked with learning objectives and outcomes. Before, during, and after their service, students also engage in structured reflection to help them gain further insight into course or program content, a broader appreciation of their academic disciplines, and a greater sense of civic responsibility.

S-L relationships are mutually beneficial

When properly implemented, service-learning provides benefits for all stakeholders involved. Effective service-learning partnerships are founded on mutual benefit and mutually agreed upon vision, mission, goals, and evaluation. Such partnerships allow for democratic decision-making, process improvement, and resource sharing [11]. This resource sharing eases the financial burden on elementary schools, which are not typically equipped to fund additional STEAM activities [4].

In terms of student benefit, national evaluations have demonstrated that S-L programs in higher education institutions are effective in enhancing college students' sense of civic responsibility, academic achievement, and life skills. One study measuring 35 different outcomes showed that all were favorably influenced by service-learning engagement [15]. For engineering students engaged in the STEAM x S-L framework, this community engagement also allows for engagement in human-centered design. Human-centered design processes have been shown to increase productivity, improve quality, reduce errors, reduce training and support costs, improve people's acceptance of new products, enhance companies' reputations, increase user satisfaction and reduce development costs [16], [17].

When developing a S-L relationship, it is critical to ask 1) What does the faculty member want or need their students to learn? And 2) What are the goals or needs of our community partners? The intersection of these answers is the foundation of an S-L partnership [18]. This is important to ensure that S-L relationships are mutually beneficial, with the ultimate goal being a transformational partnership. Transformational relationships are characterized by closeness, equity, and integrity, and grounded in lenses of collaboration, reciprocity, and diversity [14]. Distinctions among S-L relationships depend on factors such as goal integration, resource sharing, planning, coordination, and communication [14]. The Transformational Relationship Evaluation Scale (TRES) gives a quantitative rating of a given relationship, based on 9 key attributes: outcomes, common goals, decision-making, resources, conflict management, identity formation, power, significance, and satisfaction and change for the better [15]. This scale offers a guideline for S-L implementation and a rubric for partnership evaluation. The university in this study used TRES to develop all partnerships the university engages in and guide service-learning training modules for all university faculty, undergraduate service-learning teaching assistants (S-L TAs), and community partners. The university also used TRES to evaluate all partnerships, via surveys completed by university faculty, S-L TAs, and community partners at the midpoint and conclusion of each semester.

Methods

Authors' Role

We, the authors, include a full-time non-Tenure track teaching faculty in the College of Engineering, an elementary school teacher and STEAM club leader in a nearby urban public school, and an undergraduate service-learning teaching assistant (S-L TA) who coordinates logistics and communication for the STEAM club partnership. All authors are partners in co-designing the STEAM club activities and maintain a shared drive where materials are kept and worked on collaboratively. The resultant STEAM x S-L partnership examined in this paper is a collaboration between the authors and is the result of efforts since 2017.

S-L TA role

For service-learning courses, each S-L TA broadly acts as a liaison between community partners, university students, teaching faculty, and a Community-Engaged Teaching and Research team at the local university. In the STEAM x S-L framework, the S-L TA maintains a feedback system between stakeholders. This includes regular communication via email with the community partner, in order to guide the direction of developing activities and lesson plans, finalize time and resource decisions, and evaluate both existing lessons and university student participation. The elementary teacher's expertise is instrumental in determining logistics, creating engaging activities, and identifying areas for growth. The S-L TA alters activities accordingly as feedback is received. A log of lessons learned and feedback from each activity is maintained throughout each semester and used to improve existing activities.

Approach

To create our STEAM x S-L framework, we utilized a design-based implementation research (DBIR) approach. This research design approach aims to improve education through an iterative process that democratizes innovation among multiple stakeholders [19]. DBIR includes four principles: (1) deciding on a focus for joint work, (2) doing research, (3) organizing the design process, and (4) developing a capacity for continuous improvement [20].

In the spirit of DBIR, the focus of the STEAM x S-L effort is to create a positive learning environment for both college and elementary students where they are free to explore and grow their skills in STEAM topics. The research undertaken is to support the success of the effort by creating a framework that maps our best practices for STEAM x S-L. A summary of how our work maps to DBIR is presented below in Table 1.

Table 1. Map of STEAM x S-L to DBIR Principles

DBIR Principle	STEAM x S-L
Focus for joint work	Create a positive learning environment for both college and elementary students where they are free to explore and grow their skills in STEAM topics.
Doing research	Literature review of current S-L and STEAM club successes and web searches to find activity ideas
Organizing the design process	STEAM x S-L Framework for best practices based on feedback from all stakeholders
Developing capacity for continuous improvement	A clearly defined communication structure that has a consistent check-in frequency

Data Collection and Analysis Cycle

Figure 1 provides a visual representation of the data collection process that we used in our DBIR for informing our STEAM x S-L framework. Its contents are detailed in this section.

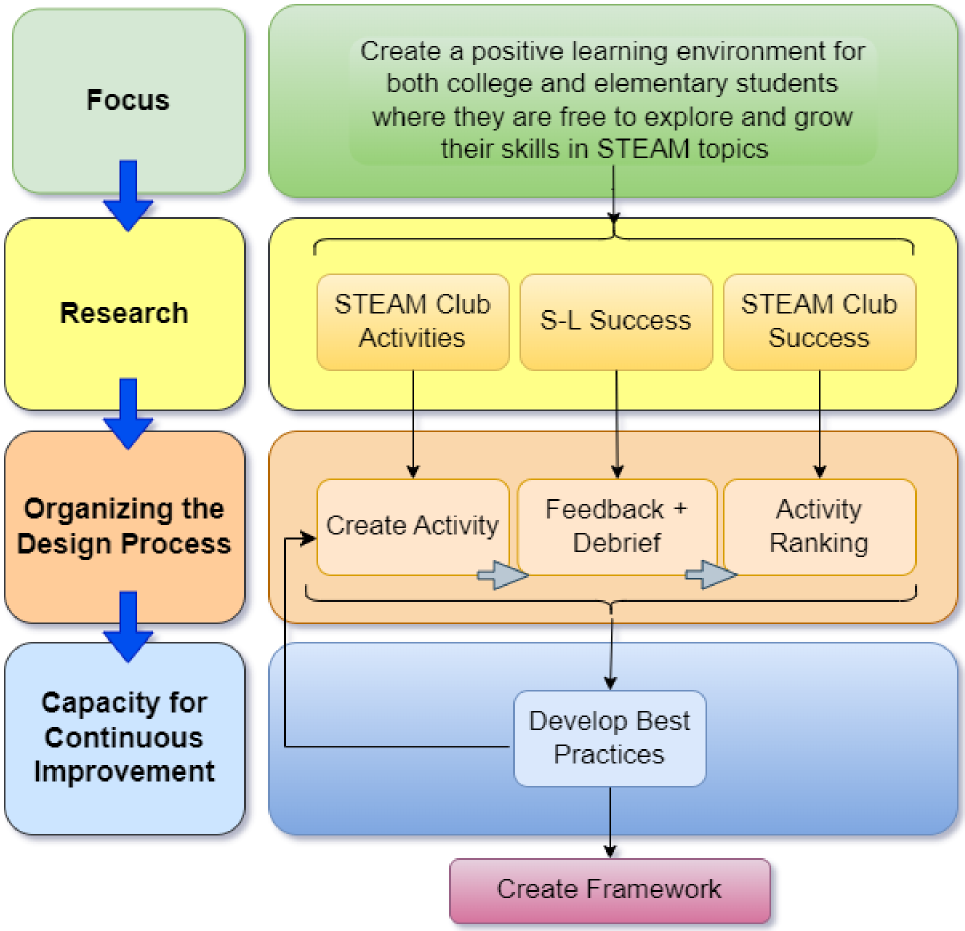

Figure 1. Data Collection Process Used in DBIR to inform STEAM x S-L Framework

Initial Research

The goal of this stage was not to conduct an exhaustive systematic literature review, but instead was to sensitize ourselves to the landscape of existing programs and scholarship that might inform our iterative efforts. We began our work by studying other successful S-L programs in literature. Some notable engineering S-L practitioners include Purdue University's EPICS/Science Bound, with Indianapolis Public Schools [21], Louisiana State University's Community Playground Project [22], and Cooper Union's STEM Saturday Program [23]. While these programs were helpful in setting up some scaffolds for the S-L side of our partnership, they tended to be much larger and well-funded programs. This larger scale did not have the exact focus on STEAM clubs like our partnership and further encouraged us to create our framework to fill this gap.

Other research investigated how to create STEM/STEAM clubs and the components required for success. Topics such as commitment, planning, and logistics were common themes and noted in our process. One paper we found particularly encouraging in our research mentioned that inviting STEM professionals was critical to a good club and that "students respond well to college students and young speakers [24]."

Lastly, the planning of activities for the STEAM x S-L required many hours of internet searching for what we thought would be "fun ideas" and speaking with other teachers and faculty about the activities they had successfully tried. Finding appropriate matches in our "goldilocks zone" seemed a sticking point as many tasks were too long, not rigorous enough, or vaguely described, again encouraging the development of our framework.

Cycle of Implementation and Feedback

Activity Implementation

Once an activity had been created around a scientific or engineering concept, the elementary teacher reviewed the student directions and follow-along worksheets to ensure clarity and appropriateness for the developmental level of the students. During the activity, the elementary teacher continued to monitor student progress and make alterations as needed. Sometimes these changes took the form of increased scaffolding for small groups, sometimes they reflected a challenge with materials, and sometimes they were in response to either the content or the activity being outside the zone of proximal development of the students [25].

Feedback and Debrief

After the activity was completed, the elementary teacher and the undergraduate students debriefed on the successes and challenges of both the lesson and working with young children. Then a similar debrief was conducted between the elementary teacher, the S-L teaching assistant, and the teaching faculty via emails before the following lesson. Any changes made during the lesson were discussed and added to the lesson notes for subsequent years. Additionally, the undergraduate students conduct weekly reflections on their own work.

STEAM club activity ranking by elementary students.

At the end of the semester, the STEAM Club students ranked their favorite and least favorite activities with explanations as to why they enjoyed or disliked the lessons. The elementary teacher, S-L TA, and teaching faculty then looked for trends with these activities to inform future lessons. The ranking results showed (1) what academic content was successful and (2) what types of activities were successful. We used this information to change unsuccessful lessons and used the "favorites" as exemplars when developing new lessons. Figure 2 shows an example of one of the visual feedback maps collected at the end of a semester and used for evaluation of a lesson.

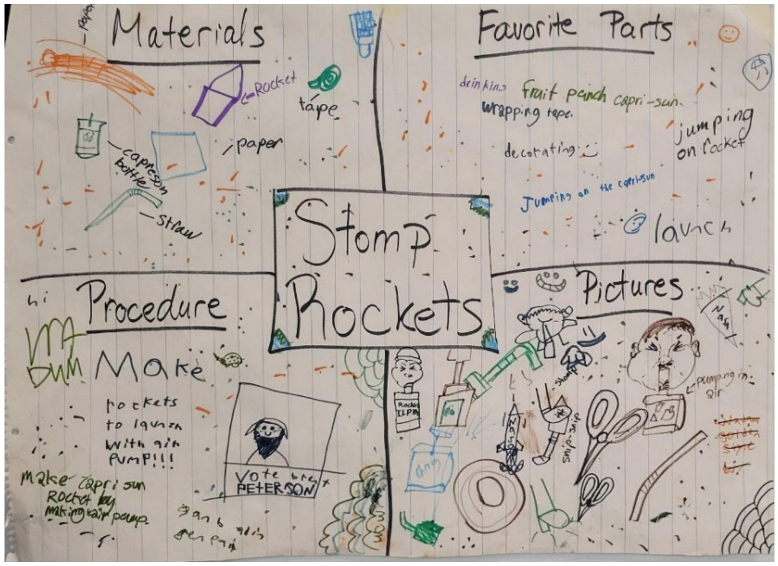

Figure 2. Example of a Visual Feedback Map Created by STEAM Club Participants

Resultant Framework

Our framework introduces S-L as a means to implement STEAM education without demanding that elementary teachers contribute all of the necessary time and resources themselves. We present this framework through the results of our DBIR as a guide to a successful STEAM x S-L relationship. Our framework is presented in graphical form in Figure 3 and its contents are detailed in the section.

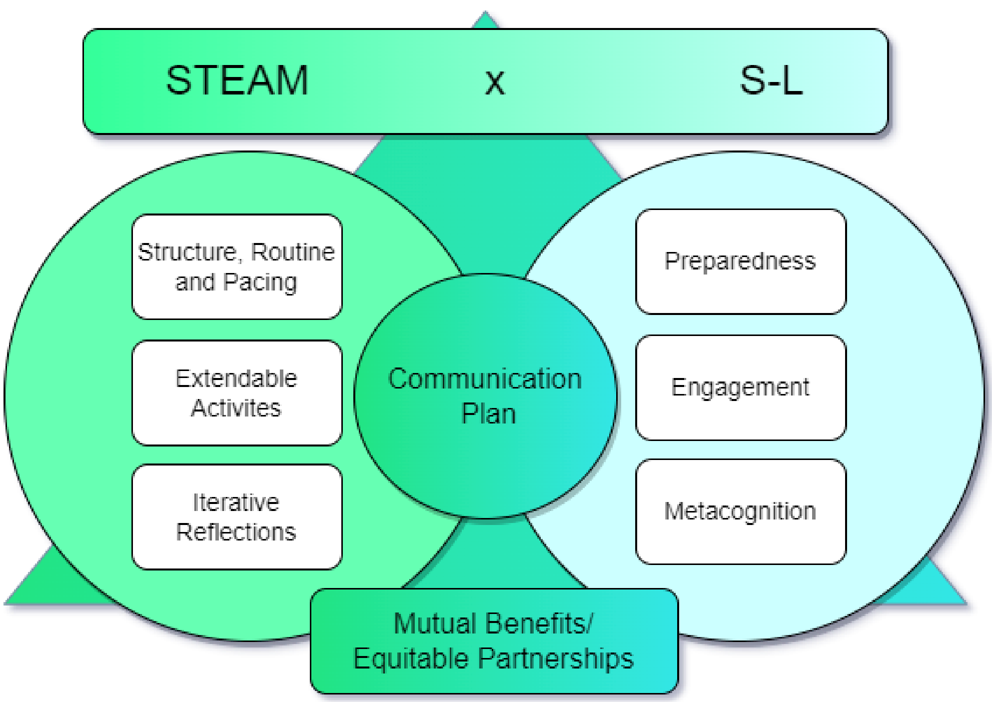

Figure 3. STEAM x S-L Framework

Mutual Benefits/Equitable Partnerships

At its foundation, the STEAM x S-L framework is built upon an equitable service-learning relationship. The university and community partner establish a mutually agreed upon vision for this relationship, such that the partnership responds to recognized community and university goals, and yields benefits for all stakeholders. Our STEAM x S-L framework recognizes the community's need for expanded elementary STEAM education, and the university's need to educate successful, civically minded students in human-centered design. It accordingly responds to community and classroom goals by providing elementary STEAM clubs with support and providing university students with service-learning opportunities, which are proven to have numerous personal and academic benefits [15]. Even though the elementary students are self-selecting to be a member of STEAM Club, they still reap the benefits in comparison to their peers. Consequently, all participants have a vested interest in the process and outcomes of the relationship.

Collaboration and pooling of intellectual and material resources benefits learning on all sides. Utilizing university funds and equipment eases the financial burden on elementary teachers, and makes available a wide variety of STEAM lessons and activities. In collaboratively creating lessons, university faculty can both take advantage of elementary teachers' training and expertise and also take on the majority of the time commitment required to prepare presentations, activities, and materials.

For both college and elementary students, STEAM club presents a low-pressure learning environment outside of the typical classroom structure, which emphasizes enjoyment, creativity, and active engagement. This environment encourages positive emotions in learning, which are associated with an increased scope of attention, global thinking, and a repertoire of skills to create, explore, and integrate content knowledge [26].

Communication Plan

Communication, trust, and respect - all foundational aspects of a transformational S-L partnership - also define the STEAM x S-L framework. The teaching faculty, community partner, and S-L TA employ democratic decision-making in all facets of STEAM club development. University faculty and students recognize the elementary teacher's expertise, which is essential in understanding and implementing developmentally appropriate teaching practices.

The framework's constant feedback loop ensures that shared goals are being met, and provides ample opportunities to adjust practices accordingly. At the beginning of each semester, the community partner, teaching faculty, and S-L TA meet to reflect on the previous semester and plan for the following semester. Founded on the initial mutually agreed upon vision, this meeting:

1. Addresses any changes to the central community and classroom goals.
2. Addresses any changes to the partnership objectives, which are targeted towards the mutual vision.
3. Evaluates practices employed in the previous semester in terms of fulfilling objectives and working towards community and classroom goals.

4. Evaluates communication, logistics, and any processes which may help the partnership function more effectively.
5. Fosters brainstorming and discussions for new developments to improve the STEAM x S-L framework.

Throughout the semester, feedback occurs primarily via emails between the S-L TA and community partner. After each activity, the S-L TA requests feedback regarding

1. General STEAM Club reception, enjoyment, and comprehension
2. University student behavior and preparation
3. Timing and material concerns
4. Any other questions, difficulties, successes, or recommendations for future lessons

The S-L TA also solicits feedback from the university students in the form of reflections. Beyond prompting students to actively reflect on their experiences and develop connections to the course content, these reflections also serve as means to collect an additional perception of general STEAM Club reception, student takeaways from S-L, and any additional questions, difficulties, successes, or recommendations for future lessons.

Ultimately, all feedback collected throughout the semester is directly implemented or stored in a feedback log to be reviewed the following semester by faculty, S-L TAs, and the community partner. This practice enables constant process improvement and growth of the STEAM x S-L framework.

University Student Preparedness

Orientation within the STEAM x S-L framework is aimed at preparing university students to effectively facilitate lessons for elementary-aged children. For the S-L TA, training consists of discussions, reflections, and assignments concerning Anti-Racism, Asset-Based Community Development, privilege, and power dynamics. S-L TAs strive to apply and remain mindful of this training in their interactions with community partners and students, and in preparing students for community engagement.

Teaching faculty and S-L TAs select lead mentors for each section of S-L university students; the lead mentor handles materials, manages the group's transportation to the partner site, and is the point person for questions and concerns while at the S-L session. Lead mentors submit applications, and are selected based on leadership, service, and childcare experience. Students with similar experience as tutors or camp counselors are typically well equipped to successfully engage with STEAM club kids and lead their peers. S-L TAs meet individually with the lead mentors to brief them on their responsibilities at the beginning of the semester. S-L TAs also attend the first service-learning session with the lead mentors, to show them the proper travel logistics, give an overview of STEAM Club procedures, introduce them to the community partner, and ensure everything goes smoothly. At least one lead mentor attends every subsequent S-L session and guides the other university students participating in S-L. With this process, there is always an experienced student present at STEAM Club to guide other student mentors.

All university students engaging in S-L are provided a guide to basic “Do’s and Don’ts” of service-learning, specifically working with kids, at the beginning of the semester. This list, compiled by the community partner, teaching faculty, and S-L TA, is based on developmentally appropriate teaching practices and previous STEAM Club experience. A one-pager template including school-specific information, sample student-created expectations, and our general guidelines for working with kids is provided in the Appendix of this paper.

The S-L TA additionally meets with student mentors before each S-L session, reviews the general guidelines of working with kids, and answers any questions. Working with an elementary teacher offers an additional opportunity for the students to learn and improve their facilitation skills.

In terms of STEAM topic preparation, the S-L TA provides students with all relevant materials a week in advance of engagement so that they can review and understand the lesson and activity. Students are given opportunities to ask questions in class or via weekly S-L Teams chats in the week leading up to the activity, and also meet with the S-L TA as a group prior to their departure to the partner site. As engineering students, the university students engaging in S-L typically have an understanding of the topics to be covered in STEAM Club. Regardless, the meetings with the full S-L group and a week of preparation allow for all students to sufficiently understand the topics and learn from each other, especially those students who may have a greater understanding of any given lesson. Out training structure is presented in graphical form in Figure 4.

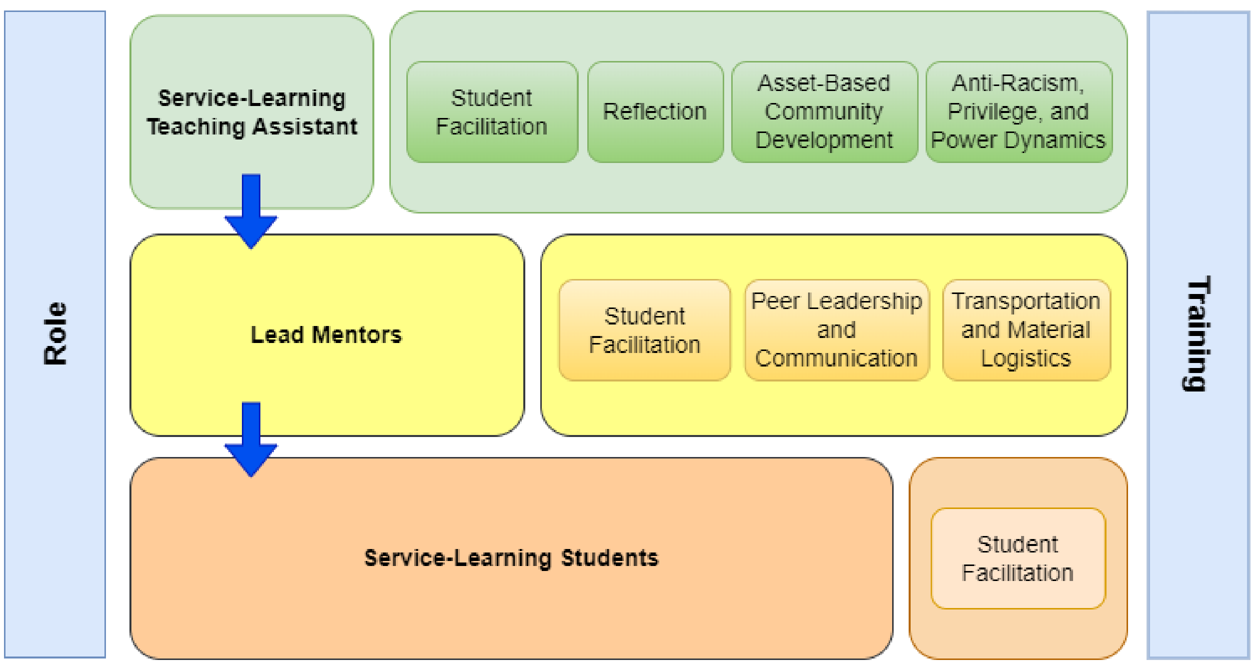

Figure 4. STEAM x S-L Training Structure

University Student Engagement

An essential component of the STEAM x S-L framework is college student engagement, both with the STEAM Club and in their own classroom. At the partner site, students' motivation to be engaged stems from, among other factors, their own academic interests. For our partnership, the university students' final project requires them to create a traveling museum exhibit targeted to children. Thus, S-L is essential for them to understand their target audience. By understanding how to successfully engage and teach kids in STEAM Club, university students can learn how to successfully engage and teach the same kids via their museum exhibit final project. Engagement enhances their ability to be academically successful. Through S-L participation, we are teaching engineers to engage and effectively communicate in an active learning scenario.

Metacognition

S-L remains an integral aspect back in the classroom. Reflections after each S-L session establish a connection between direct service and the academic curriculum. Studies have demonstrated the value of reflection to enhance comprehension, performance, and self-regulated learning [27]. Research also shows that the majority of students require external support to engage in reflection [28]. Thus, students are required to complete a reflection after each S-L experience. Students are asked to reflect on observations, discrepancies between their expectations and experiences, and potential applications to their coursework. These reflections are completed individually and in a written format, which allows students to process their own experiences and to access their responses at any point in the semester.

This metacognition distinguishes service and S-L. In actively recalling and analyzing their service experience, the students can examine and alter their thought processes and revise their teaching and design strategies accordingly. In this way, students' service experiences inform subsequent practice and real-world application.

Structure, Routine, and Pacing

Literature acknowledges that designing for a STE(A)M lesson can be difficult [29]. Conditions such as student levels, timing, and technology are just a few of the challenges teachers face in developing new curricula.

Our STEAM x S-L partnership lessons must fit within a 90-minute block of time, work in small groups led by engineering undergraduates, be relevant and attainable conceptually and procedurally to upper elementary students, and of course be engaging. In order to achieve this, we develop each lesson using an inquiry-based approach to learning and a predictable lesson structure. With inquiry or problem-based learning, the students are active participants in constructing meaning from the problems or puzzles presented to them. Social interactions are crucial in true constructivist models [7], which we facilitate by pairing an undergraduate student with small groups of two to five elementary students.

We also use consistent routines during the students' time together to help them transition from the regular school day to this after-school S-L partnership. With this consistency we can minimize downtime, maximize learning and engagement, and provide a sense of security

[30]. One of our most important routines is establishing and revisiting our group expectations or norms. We spend a significant amount of time at the beginning of each semester constructing a list of shared expectations for how all members of STEAM Club want to treat each other and be treated; then we revisit this list at the beginning of each session with our undergraduate students present. This acts as a social contract to hold everyone accountable for their behavior, which in turn maximizes opportunities for exploration and learning [30].

Our most successful lessons follow a consistent format based on the engineering design process. After a brief mini-lesson (10 minutes or less) in the underlying scientific concepts necessary for understanding, students then work in small groups to imagine, design, plan, create, test, improve, and collaborate. Depending on the lesson, students might also make predictions, ask questions, record data, and draw conclusions from their results. While the content does not need to align with state curriculum frameworks, the skills involved do align with the NGSS science and engineering practices [31]. With a predictable format of each lesson and consistent expectations students can focus on *what* to learn rather than *how* to learn. Additionally, consistency of format lets the content be novel, thereby increasing motivation and the ability to shoulder the cognitive load of the academics.

Third, our successful lessons need to fit our given time and have appropriate pacing. When students do not get to finish an activity, they feel disappointed and do not associate as many positive memories with that scientific concept. Engaging in a healthy struggle does not just apply to the rigor of academic content; the pacing of an activity also needs to match the developmental level of the students. Considerations such as attention span, complexity of materials, and the level of messiness to clean up at the end all play a role in determining time allotments for each stage of the activity. We have had the most success with setting visual timers for each stage of the activity to help keep students on track and motivated.

Iterative discussions

Through multiple years of iterative discussions through the debrief and reflection process described under *Methodology,* we have found a few recurring themes in successful lesson execution. First, all stakeholders need to be prepared. The university teaching faculty, S-L TA, lead mentors, undergraduate students, and elementary teacher all need to be familiar with the lesson, materials, and methods of instruction to maximize learning time and engagement. Second, the lesson activities need to have variables and multiple possible outcomes. We have found that students enjoy criteria, constraints, and creativity far more than experimenting for a specific outcome. For example, a lesson on building a device to fulfill a need (i.e. a bridge to carry x weight) consistently performs better than a lesson to answer a question (i.e. how much glue to make slime).

Extendable Activities for students who need more/less

Finally, our lessons benefit from being modifiable. In school, teachers need to modify and differentiate lessons every day [30]. STEAM x S-L lessons work best when they are accessible and challenging for every single student. This often means that we need to plan an extension/bonus activity for the groups who successfully finish early. Depending on the lesson, we may have a task list of activities where the complexity increases as students progress through the list. Oftentimes, the extension activity involves moving from the application of a skill to analysis to evaluation, thereby moving up the Bloom's taxonomy pyramid [7]. The malleable nature of the lessons means that all students are engaged and learning at their own pace.

Conclusion

The development of STEAM educational activities to support engagement and build a diverse workforce has placed the burden on K-12 teachers, who face multiple constraints in meeting ever-changing demands. Partnerships between K-12 and universities can ease this burden through service learning (S-L). S-L partnerships provide university students opportunities to engage in human-centered design, contextualize their education, and develop proven academic benefits and communication skills.

A team of an elementary school teacher, a university teaching faculty, and an undergraduate teaching assistant utilized a DBIR approach to create a STEAM x S-L framework. This framework was created to document their efforts, solidify their current organizational system, and create an institutional structure to share with the K-12 and engineering education community. This framework serves as an adaptable template for K-12 practitioners looking to set up successful STEAM programs and begin partnering with university S-L efforts. By increasing the number of students at all levels participating in STEAM education, we can encourage a more diverse population of learners to become engaged in this growing workforce.

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Appendix – Guide for University Students to Prepare for S-L

STEAM Club Orientation

SCHOOL INFORMATION

Address:
Commute Information:
Main Office Number:
Room Number/Location:
Teacher Name and Contact Information:

SCHOOL FACTS

- Grades Served:
  - i.e. preK-5, K-8
- School Size:
- School Type and Structure:
  - i.e. departmentalized, dual language
- Pertinent School Rules or Principles:
  - i.e. PBIS

SCHOOL DEMOGRAPHICS

	School	District	State
Total Count			
Race/Ethnicity (%)			
African American or Black			
Asian			
Hispanic or Latino			
Multi-race, Non-Hispanic			
Native American			
Native Hawaiian or Pacific Islander			
White			
Gender (%)			
Male			
Female			
Selected Populations (%)			
English Language Learner			
Economically Disadvantaged			
Students w/Disabilities			
First Language Not English			

STEAM CLUB FACTS

Number of Students:
Ages:
STEAM Club Days and Times:
Expectations (created by the STEAM Club kids):

- Treat others with respect
- Share and take turns
- Be safe - don't eat science!
- Take care of materials
- Clean up after ourselves
- Use common sense
- Stay on task
- Be creative and have fun!

SCIENCE CONCEPTS

Fourth Grade:

- Engineering design process
- Rock cycle and types of rocks
- Tectonic plates and natural disasters
- Renewable and non-renewable energy sources
- Types of energy and energy transfer
- Light waves
- Sound waves
- Animal and plant adaptations

Fifth grade:

- Water cycle
- States of matter and properties of matter
- Gravity and relationships between Earth, sun, and moon
- Water filtration and pollution
- Photosynthesis
- Decomposition
- Matter in ecosystems
- Energy pyramid and food chains

GENERAL NOTES ABOUT WORKING WITH KIDS

- They are still learning social skills, so explicit modeling about how we talk to people when frustrated, trying to be heard, needing to compromise, etc. is a good strategy.
- They can be somewhat shy around strangers, so make sure to introduce yourself and get to know their names.
- They know so much more that adults give them credit for! Ask them questions, and let them explain their thinking.
- Do:
  - guide students to solve problems by themselves
  - be engaged and respectful
  - review all the relevant materials and lesson plan before service-learning
  - approach service learning with an Asset-based Community Development (ABCD) perspective
- Don't:
  - complete the activities for students or tell them what to do
  - be on your phone while you're supposed be engaging with the STEAM club kids
  - come to service-learning unprepared
  - approach service with a savior complex