

# **A Case Study: Partnership with Parklands-Turner branch of the DC Public Library**

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# 1. Introduction

## 1.1. Program Introduction

In response to the rapid changes in the industrial structure, the government has provided STEAM education to more children nationwide to help them develop future science and technology skills. However, there is a significant disparity in the availability of STEAM education among different socio-economic groups.

To address this inequality, our nonprofit organization is committed to providing STEAM programs at no cost in underprivileged communities. We aim to enhance access to STEAM education for children and raise awareness about its importance. This initiative aligns with our vision of reducing inequality in STEAM education.

More specifically, the organization provides community-based, informal STEAM programs at the DC Public Libraries and school-based STEAM afterschool programs in partnership with DC Public Schools, making STEAM education more accessible and demand-driven to meet the needs of students. Additionally we provided math tutoring program at a DC public school and organized field trips to places such as the National Children's Museum, where children can engage in various STEAM activities.

Our programs serve students in grades K-5 because introducing STEAM concepts at an early age helps to ignite children's natural curiosity and interest in these subjects. The STEAM programs are delivered via hands-on activities utilizing various STEAM kits.

The programs are conducted through project-based work with group members, resulting in the production of final projects as outcomes. During the group activities, instructors closely engage with children and evaluate their performances.

## 1.2. DC Public Library Partnership Background and Purpose

In today's society, STEAM education is crucial for preparing individuals for the future; however, there are still significant limitations in providing STEAM education opportunities in underserved communities. This is primarily due to high education costs, which serve as barriers that make it even more challenging for underserved populations to access these opportunities.

For example, according to the report, *"America After 3PM STEM: STEM Learning Is Growing, but Barriers and Gaps Persist,"* it states that "the financial burden of STEM programs is significantly higher than that of non-STEM programs. After-school programs offering STEM learning cost an average of \$107 per week (annual cost of \$3,852), which is significantly higher than the average cost of \$74 per week (annual cost of \$2,664) for non-STEM programs. Programs offering STEM activities two or more times per week cost an average of \$116 per week (\$4,176 annually), and this cost burden is a major contributor to educational inequality."

Our organization is addressing this high costs associated with the STEAM program by offering two key initiatives: (1) free after-school programs during the school year at DC public schools and the Parklands-Turner branch of DC public libraries, and (2) a free summer program at the Anacostia branch of DC public libraries. In partnership with DC Public Schools (DCPS) and the DC Public Library (DCPL), we offer STEAM educational content, resources, and highly qualified instructors, while our partners provide the facilities.

Notably, the Parklands-Turner branch not only provides a dedicated children's library space but also has the support of committed library staff members, including a children's librarian. Working with a

children's librarian and having a secure learning space at the Parklands-Turner branch is essential to achieving our common goals of reducing STEAM disparities in underserved communities.

### 1.3. Research Scope and Methodology

This case study aims to analyze the effectiveness of the STEAM after-school program operated at the DC Public Library Parklands-Turner branch from various perspectives and identify the factors contributing to its success and areas for improvement. To this end, we set out to explore the following key research questions.

#### Research Questions:

- Did the STEAM after-school program have a significant positive impact on the STEAM learning abilities, problem-solving skills, and collaboration abilities of participating students?
- How do the subjective learning experiences and satisfaction levels of program participants differ from the objective skill assessments of instructors? What insights do these differences provide regarding the program's specific strengths and areas for future improvement?

#### Research Scope and Approach:

This study focused on two main aspects to evaluate the effectiveness of the program. The first is the overall participation status of the participants, and the second is the participants' subjective perceptions and objective evaluation of their collaborative and problem-solving skills.

To analyze participants' participation, attendance records for each session were examined to identify overall participation trends. An analysis of the participants' satisfaction and their collaborative and problem-solving skills was conducted using two different data sources. (Please refer to Appendix 1 for the survey results and Appendix 2 for the evaluation items.)

- **Participant Survey** (Subjective Perception): A survey was conducted for 19 participants at the end of the program, and responses were collected on a scale of 1 (very negative) to 5 (very positive). This survey aimed to understand children's subjective perceptions, including their perceived improvement in problem-solving skills resulting from program participation. This data provides essential information for understanding internal changes in children, such as learning satisfaction, confidence, and initiative. For example, questions such as an increase in STEAM knowledge (Q10), an increase in confidence in STEAM learning (Q11), and an increase in problem-solving ability (Q12) were used to evaluate subjective perceptions of overall improvement.
- **Instructor Evaluation** (Objective Instructor Evaluation): To complement the subjective perceptions of the participant survey, an instructor evaluated 13 students' performance on a scale of 1 (poor) to 5 (excellent). This evaluation provides an objective assessment of collaborative and problem-solving skills. Instructor assessed specific behaviors and outcomes, such as how students approached problems, presented creative solutions, applied step-by-step procedures, analyzed results, and made suggestions for improvement. These evaluations help identify specific strengths and weaknesses in students' current problem-solving abilities, providing practical directions for improvement. For example, problem-solving ability was broken down into sub-components such as "problem approach," "creative solutions," "step-by-step approach," and "result analysis and reflection," enhancing the diagnostic value.

By integrating and analyzing data from two distinct measurement perspectives—the instructor's objective evaluations and children's subjective surveys—we gained a more precise and comprehensive understanding of both the program's successful aspects and the areas for

improvement. This thorough understanding will inform future improvements and ensure the program's continued success.

**Table 1 perspectives on comparing evaluation data to survey data**

| Classification            | Evaluation data                                                                  | Survey data                                                                 |
|---------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>What is measured</b>   | Individual students' problem-solving and collaboration skills (observer ratings) | Participants' program experience and perceptions (self-assessment)          |
| <b>How it is measured</b> | 1-5 scale scores (per student, per item)                                         | Percentage of responses on 1-5 scale (for all participants)                 |
| <b>Key categories:</b>    | Problem-solving skills and participation in collaborative activities             | Involvement in team projects, learning outcomes, and problem-solving skills |
| <b>Characteristics</b>    | Objective measures of performance                                                | Subjective measures of satisfaction and perception                          |

## 2. STEAM Program and Partnership Operations

### 2.1. Demographic Characteristics of the Community

The Parklands-Turner branch is in the Southeast DC (Ward 8) region. According to DC data, this region is “a predominantly African American community, and approximately 39% of the Ward 8 population is comprised of children and youth. Compared to other District wards, residents of Ward 8 are about 11% less likely to work in the city's labor force. The median income is 38% lower in Ward 8, as compared to other District wards. The percentage of families in poverty is almost twice as high in Ward 8 as compared to the district overall.” (Profile of Health and Socio-Economic Indicators DISTRICT OF COLUMBIA DEPARTMENT OF HEALTH Center for Policy, Planning and Epidemiology State Center for Health Statistics).

### 2.2. Partnership Operations and Program Progress

#### 2.2.1. Partnership establishment and collaboration model

Our organization has formed a strategic partnership with the DCPL central office, a collaboration that has been instrumental in the success of our program. We have also signed a building agreement with Parklands-Turner Branch, which has provided us with the use of their children's library. In addition to the children's library, they have also provided staff members, including a children's librarian. Our organization has, in turn, provided the program content, resources, and instructors.

Unlike other DC public library branches, Parklands-Turner has made a unique and invaluable contribution to our program. The library not only reserves the children's library from 3:30 to 4:30 but also enables a children's librarian to work closely with our organization. This collaboration is a key factor in the program's success as (1) it ensures the students' full engagement for the entire 50 minutes (3:30 to 4:30) and (2) a children's librarian's instruction has contributed to high-quality instruction, which reassures us of its long-term success. At the same time, our program has enhanced the children's library program by providing STEAM subjects.

#### 2.2.2. Program curriculum and content

During the 2024-2025 school year, 27 registered children participated in the program at the Parklands-Turner Branch Library. Participants learned about the five core areas of the curriculum outlined below:

## Science

Our science activities, conducted through hands-on experiences with various learning kits, are designed to enhance children's problem-solving skills, teamwork, and creativity. For instance, the students engage in electronic experiments, building circuits, programming simple robots, and experimenting with different electronic components. The instructor guides them through the concepts and, by asking questions, sparks children's curiosity and encourages them to think creatively, analyze problems, and find solutions. These are not just skills for the classroom, but valuable tools that can be applied to various aspects of life, ensuring that the time and effort invested in these activities are truly worthwhile.



## Technology

- **Coding:**

Coding programs offer many benefits, enhancing problem-solving, logical thinking, and creativity while preparing children for STEAM careers. Learning to code builds confidence and resilience and improves performance in subjects like math and science. It teaches children to break down complex problems into manageable steps and introduces computational thinking. Through coding, children can express their creativity by designing games and apps, and many projects require teamwork, fostering collaboration and communication. For example, we use Sphero robots and apps to teach coding concepts in a fun and engaging way through hands-on learning. We also utilized a Botley coding robot to teach children basic coding concepts in a fun and engaging way through hands-on learning. The instructor not only introduces coding concepts such as object detection, looping, and line following, but also teaches fundamental concepts like logic and sequencing.



- **Virtual reality (V.R.):**

We use virtual reality (V.R.) to improve science education and for virtual field trips, as it is an invaluable tool for teaching STEAM subjects. V.R. helps children visualize complex concepts, processes, and environments, making it easier for them to comprehend and remember what they've learned. In addition, V.R. allows children to take virtual field trips to museums, natural environments, historical sites, and outer space. These simulations enable children to visualize and interact with concepts that may be difficult to observe in the physical world. These activities can lead to improved learning outcomes, increased student engagement.



## Engineering

Early exposure to engineering education promotes children to think critically and tackle challenges systematically by identifying problems and developing solutions. Furthermore, early engineering education ignites curiosity and helps children see how science and math are applied in real life. This foundation supports future STEAM learning and equips children with a solid understanding of STEAM. Engaging in hands-on projects encourages teamwork, effective communication, and perseverance through setbacks, fostering resilience. For instance, robotics education equips children with vital skills that are increasingly relevant in today's technology-driven world, potentially guiding them toward successful careers in STEAM. Ensuring access to robotics and LEGO, especially for underrepresented groups, is imperative to closing the equity gap in STEAM fields. Through robotics and LEGO activities, children learn sequencing, pattern recognition, and basic engineering principles. As they explore mechanics, electronics, and programming, they grasp essential skills for the future. Children take pride in building their robots and LEGO models. These activities reinforce computational thinking by breaking tasks into logical steps and overcoming challenges, which helps develop resilience and self-confidence.



## Arts and Engineering

Introducing children to 3D concepts is a vital investment in their future, enhancing skills in spatial reasoning, problem-solving, and creativity, which are essential for success in STEAM fields like animation, game design, and architecture. Using 3D pens, we teach three-dimensional thinking, allowing children to design and construct simple structures while understanding the engineering design process. 3D modeling helps children visualize and manipulate objects, fostering critical thinking about structure, size, and materials. Also, through teamwork, children share ideas and refine their designs to produce a team project as an outcome product.



## Math

By using various hands-on educational resources, we support children's better grasp of mathematical concepts and number senses. We help children build confidence in their mathematical abilities and motivate them to tackle more complex ideas.

- **Math games for number senses:**  
To improve the students' math skills, we utilize interactive electronic math game toys specifically designed to help children practice essential math skills such as addition, subtraction, multiplication, division, and understanding greater and lesser values in a fun and engaging way.
- **Money games:**  
We use fake money to teach mathematical concepts in a practical context. The money game is entertaining and compelling for developing essential financial skills for real-life situations. The game format generates interest and boosts participation, fostering a positive attitude toward learning math through hands-on experiences, such as handling real money.
- **Geometric shapes:**  
We use Pattern Blocks Puzzle Shapes to teach geometric shapes, promote problem-solving skills, and enhance creativity, spatial reasoning, and an understanding of basic math concepts like symmetry and fractions. Through group activities, children describe shapes and colors, expand their vocabulary, and develop communication skills.
- **Logic games:**  
Logic games are excellent for enhancing reasoning and problem-solving skills. Our program utilizes STEM logic road-building toys to encourage children to think critically, plan strategically, and apply logical reasoning to complete various challenges. The students improve their spatial reasoning and learn about cause and effect by building tracks and navigating vehicles. Some of these toys involve multiple steps, fostering strategic thinking as the students evaluate solutions to overcome obstacles. Engaging with these puzzles also enhances hand-eye coordination, concentration, and creativity.

### 2.2.3. How it is delivered

Our STEAM programs are designed and managed by Dr. Lan Joo, the Founder and CEO of the organization. Dr. Joo is responsible for developing the content and curriculum, preparing STEAM learning resources, securing instructors, and ensuring the quality and effectiveness of the programs. Additionally, she writes the program's impact evaluations and establishes partnerships with individual schools and institutions. Dr. Joo focuses on developing STEAM programs specifically for children, recognizing the importance of introducing these concepts at an early age. These experiences help shape children's cognitive and reasoning abilities, fostering their creativity and innovation for the future.

The program is delivered through hands-on group projects led by instructors, emphasizing both theoretical concepts and their practical applications. The modalities of the program include:

First, the STEAM program emphasizes **hands-on projects** that encourage groups to apply concepts to real-world situation. This approach helps children see the connections between ideas and their everyday lives. Additionally, facing and overcoming challenges during a project teaches valuable lessons in perseverance, resilience, and problem-solving. Completing these hands-on projects provides children with a sense of accomplishment, boosting their self-esteem and confidence in their abilities. When children are actively

engaged and take ownership of their learning, their motivation increases, making the learning process more enjoyable and effective.

Second, we use **team-based group activities** that provide children with valuable experiences in collaborative problem-solving process. This approach encourages discussion and teamwork, allowing children to share their ideas, listen to one another, and work together to find the best solutions. Through these activities, children learn to collaborate effectively by leveraging each other's strengths and compensating for weaknesses. Engaging in group work also teaches children how to cooperate with different individuals and teams as they strive to achieve a common goal.

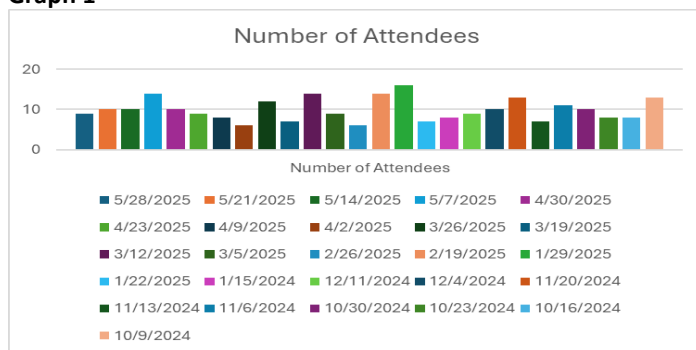
Third, our instructors present students with realistic and complex problem situations, along with **guided questions** to enhance problem-solving skills. This approach encourages children to actively find solutions. Our instructors ask open-ended questions such as, "How could you approach this differently?", "What do you think will happen?", "Why do you think this has occurred?", and "Are there alternative solutions you can consider?" These questions stimulate students' thinking processes and encourage them to explore various problem-solving options.

### 3. Data-driven Performance Analysis

#### 3.1. Attendance Data Analysis

The average number of attendees per session was approximately 9.92, indicating consistent attendance of around 10 students. The day with the most attendees was January 29, 2025, with 16 attendees, while the days with the fewest attendees were April 2, 2025, and February 26, 2025, each with six attendees. The graph is shown below.

Graph 1



The number of participants varies significantly, ranging from 6 to 16. This suggests that several factors influence attendance rates, such as specific days of the week (e.g., immediately after the holidays and during testing periods) and the external environment.

The attendance data also indicates that six participants maintained a high attendance rate of above 66% during the school year 2024-2025, as shown in the table below.

Table 2 Core participants' attendance rates

| Individual    | Attendance Count | Total Count | Attendance Rate (%) |
|---------------|------------------|-------------|---------------------|
| Participant 1 | 23               | 27          | 85.2                |
| Participant 2 | 23               | 27          | 85.2                |

|               |    |    |      |
|---------------|----|----|------|
| Participant 3 | 21 | 27 | 77.8 |
| Participant 4 | 21 | 27 | 77.8 |
| Participant 5 | 18 | 27 | 66.7 |
| Participant 6 | 18 | 27 | 66.7 |

The above attendance data demonstrates that some core students are satisfied and engaged in the program, which increases the likelihood of their continued voluntary participation. One of the factors that contributes to the high attendance rates among these students is our successful engagement with their parents, who are responsible for dropping off and picking up their children. Parental involvement plays a crucial role in achieving high attendance rates. Additionally, motivating these six students to return to the program encourages them to ask their parents to bring them back. Their high attendance ensures that these students do not miss out on the educational content offered, allowing them to learn consistently and build on their experiences. This is crucial for long-term learning and skill acquisition.

Although the program has core members with high attendance rates, there remains an opportunity to enhance attendance rates for other students by increasing engagement with their interests and actively involving parents in the program.

## 3.2. Survey Data Analysis

### 3.2.1. Findings from survey data

Based on the analysis of the survey data, we found that participants' satisfaction and positive experience with the program were very high. A detailed breakdown of each question category is shown below:

- (1) Activity Engagement:** This category measures how much participants were interested in and enjoyed the program, their willingness to participate again and recommend it, and their increased interest in STEAM fields.

Q1. Participants were interested in and enjoyed the program: 79% rated it 5 out of 5, and 21% rated it 4, indicating that all participants were delighted and excited.

Q2. Intent on participating in the program again: 84% gave a 5, 11% gave a 4, and 5% showed a 3, indicating that most participants strongly desire to participate again, which means the program is highly engaging.

Q3. Would recommend the activity to a friend: 74% gave it a 5, 15% gave it a 4, and 11% gave it a 3, showing that most participants would strongly recommend the program to others. This is a testament to the program's quality and the satisfaction it provides.

Q4. Increased interest in STEAM fields: 84% received a 5, 16% received a 4, and all participants reported a significant increase in interest in STEAM fields, indicating that the program was highly successful in achieving its STEAM education goals.

*Overall, the "Engagement with the activity" category received very high favorable ratings across all metrics, especially the increase in interest in STEAM fields, which was positive for all participants.*

- (2) Participation in team projects:** This category assesses collaboration, communication, problem-solving skills, and increased confidence in teamwork.

Q5. Collaboration with teammates: 73% received a 5, 18% received a 4, and 9% received a 3, indicating that most participants felt they worked well with their teammates.

Q6. Communication and cooperation among team members: 82% received a 5, 18% a 4, and 9% a 3, indicating that all participants rated communication and cooperation within the team as very good.

Q7. Team's problem-solving efforts: 73% received a 5, and 27% received a 4, with all participants indicating that the team worked well together to solve problems.

Q8. Increased confidence in teamwork: 36% gave a 5, 45% gave a 4, 18% gave a 3, and 5% gave a 2. While the percentage of 5s is relatively low compared to other statements, the combined 4 and 5 scores still show a high favorable rating of 81%. This indicates an overall increase in confidence in teamwork but also suggests that some participants may have expected greater improvement.

*Overall, "Participating in team projects" also received favorable ratings across most metrics, particularly satisfaction with team members' communication, cooperation, and problem-solving efforts.*

- (3) Learning outcomes and problem-solving skills:** This category assesses an increase in STEAM-related knowledge, an increase in STEAM learning confidence, and an increase in problem-solving skills.

Q10. Increased STEAM knowledge: All participants rated their STEAM knowledge as significantly increased, with 79% giving a rating of 5 and 21% showing a rating of 4.

Q11. Increased confidence in STEAM learning: 86% received a 5, and 14% received a 4. All participants reported a very significant increase in confidence in STEAM learning, which is one of the program's most notable outcomes.

Q12. Increased problem-solving skills: 57% gave a 5, 29% gave a 4, and 14% gave a 3. While the percentage of 5s is slightly lower than that of other learning outcome statements, the combined 4s and 5s still yield a high favorable rating of 86%. This indicates an overall improvement in problem-solving skills.

*Overall, the results for Learning Outcomes and Problem-Solving Skills were also very positive. Increased Confidence in STEAM Learning received the highest score from almost all participants, indicating that the program was very educationally effective.*

### 3.2.2. Implications drawn from the findings

The participants expressed a high level of satisfaction with the program. A significant percentage of responses rated the questions on the survey with scores of 4 and 5, indicating that participants generally had a positive overall experience. This strong level of satisfaction reveals the program's effectiveness and its potential for future success.

One of the program's greatest strengths is its ability to inspire interest in STEAM fields. This aligns perfectly with the program's goals of providing educational experiences through team projects and hands-on activities. Participants also demonstrated significant improvement in their collaboration and communication skills, as evidenced by their high scores on survey questions related to participating in team projects. This underscores the program's effectiveness in developing these essential skills.

However, there is room for improvement in areas such as problem-solving skills and self-confidence. The data reveal that the percentage of participants scoring a 5 for the statements regarding "increased problem-solving skills" and "increased confidence in teamwork" was relatively low compared to other statements. This suggests that, for some participants, the program's impact on these two areas may not have been as significant.

To address this, we should consider providing additional enrichment activities or personalized feedback to participants who need more support in developing problem-solving skills and

confidence. For example, we can facilitate discussion about challenges students faced during the problem-solving process, encouraging them to reflect on how they could improve next time.

### 3.3. Evaluation Data Analysis

#### 3.3.1. Average scores and standard deviations

We analyzed the average score for each item of evaluation data along with the standard deviation. Standard deviation is an indicator of how much the data is spread around the average, making it beneficial for understanding the differences in performance among students. The average score and standard deviation for each item, calculated based on the scores of 13 students, are shown in Appendix 5.3.

The program has achieved **high average scores, ranging from 4.27 to 4.58**, across all evaluation items. This underscores the program's success in providing a positive and practical learning experience for the majority of students, effectively developing the core competencies targeted by the program.

The **standard deviation for each item was between 0.62 and 0.76**, indicating that there was slight variation in scores among students. This is strong evidence that the program had a consistently positive impact on most students. Although there are some low-scoring groups, the overall standard deviation is not extremely high, leading us to conclude that the program's effects are relatively consistent. The low standard deviation means that most students are clustered around the average score, which can be interpreted as the program having a consistent effect in teaching and learning a specific skill. Conversely, a high standard deviation indicates significant performance differences among students, suggesting that individualized instruction or additional support is needed.

*These high average scores with low standard deviations indicate that the majority of students performed well across all evaluation items, with slight variation in scores among students.*

#### 3.3.2. Learning outcomes

##### (1) Problem-solving skills

The program has excelled in strengthening students' basic competencies, particularly in problem-solving. The participants have demonstrated overwhelming strengths, scoring an average of 4.58 in all basic and structured problem-solving processes.

##### (2) Collaborative Activities

The participants achieved an average score of 4.46 in all items related to collaborative activities, including 'Role Distribution,' 'Degree of Cooperation,' 'Collaborative Problem-Solving Approach,' 'Solution - Collaborative,' and 'Feedback and Reflection,' demonstrating very high performance. This means that the students have developed effective collaboration skills, including "improved role distribution within the team".

##### (3) Creative problem-solving skills

The "Creative Solution" item received an average score of 4.27, which is relatively low compared to other items. Although a score of 4 or above is still considered high, it is noteworthy that most students scored 5 in various categories. This indicates that additional guidance and encouragement are necessary to help students move beyond conventional thinking and propose unique and innovative solutions.

*In summary, the program has proven to be an excellent educational program that successfully cultivates problem-solving and collaboration skills in most participating students. At the same time, the program's effectiveness could be maximized by further developing "creative problem-solving" abilities and providing more attentive and customized interventions for some students.*

### **3.4. Analysis of Evaluation Data in Connection with Survey Data**

Evaluation data shows objective scores from external observers on how well students performed on specific competencies (problem-solving, collaboration). In contrast, survey data represent the subjective perceptions of program participants regarding their feelings and level of satisfaction with the experience and performance. By analyzing these two types of data together, we can understand how the actual effectiveness of our program matches or diverges from the perceptions of participants.

Based on our analysis of the evaluation data in connection with survey data, most participants believe that their collaboration and problem-solving skills have improved. This perception of participants is consistent with the evaluation data, which indicates that the majority of students scored higher. However, there are both similarities and differences in the perceptions of instructors and students regarding problem-solving and collaboration skills.

#### **3.4.1. Comparing perceptions**

##### **(1) Problem-solving skills**

- **Similarities:**  
Both the instructor and the students agree that most students have improved their problem-solving skills as a result of participating in the program. In particular, the increase in STEAM knowledge and confidence shows that students themselves perceive their learning outcomes very positively.
- **Differences:**
  - Perceived specific weaknesses: The instructor noted that the students still have room for improvement in certain areas, such as "creative solutions," but these particular weaknesses are not evident in the students' surveys. It is possible that students responded by focusing on their overall "improvement" in their abilities.
  - Individual struggles: The instructor identified the students who struggled with problem-solving on an individual basis; however, the survey does not capture these individual deviations in detail, as it shows trends across the class. The students would have been more focused on their own "incremental experiences".

##### **(2) Collaboration skills**

##### **(3)**

- **Similarities:**  
Both the instructor and the students agree that the program's team projects are successful and that the majority of students have good or improved collaboration skills. Most notably, there is a high level of satisfaction with the communication and cooperation among team members, as well as the problem-solving efforts of the team.
- **Differences**

- Individual issues identified by the instructor: The instructor identified the students who struggled with collaboration; however, the high group average in the student survey conceals these challenges.
- Gap in 'confidence': While students were satisfied with the overall collaboration process, it is interesting to note the relatively low percentage of 5s for 'increased confidence in teamwork'. This suggests that there may be some disconnect between feeling that "we worked well together" and feeling that "my collaboration skills have improved noticeably, and I feel more confident." In other words, while they contributed to the team's success, they may have had higher expectations for personal growth, or they may have lacked the opportunity to assess their collaboration skills objectively.

### 3.4.2. Implications

By comparing evaluation data and student surveys, we can gain deeper insight into the program's successes and challenges.

**Overall success:** The program has had a positive impact on improving problem-solving and collaboration skills for most students as evidenced by the students themselves. This is particularly evident in achieving the core educational goal of increasing interest and confidence in STEAM.

**Attention to individual students:** Evaluations have identified certain students who individually require additional support in specific competencies (problem solving or collaboration). It is essential to offer them personalized coaching or additional practice opportunities.

**Enhancing 'creativity' and 'confidence':** While the students report that their overall problem-solving skills have improved, the instructor observed a decrease in the number of perfect scores for 'creative solutions'. In addition, student satisfaction regarding their 'increased confidence' is lower compared to other collaboration-related questions. This suggests that future programs should explore activities that further stimulate creative thinking. Moreover, these programs should provide opportunities for students to recognize their collaborative abilities and boost their confidence through personal contributions.

## 4. Conclusion

### 4.1. Summary of the Program's Successes

Through your partnership with the DC Public Library Parklands-Turner Branch, we have achieved significant success in increasing access to and demand for STEAM education and supporting student growth. Key successes include:

**Contribution to closing the STEAM education gap:** By providing free STEAM after-school programs to children in underserved communities, we have effectively reduced the access gap to STEAM education. This is a significant achievement that aligns with our organization's vision and values.

**Enhancement of participant satisfaction and willingness to reparticipate:** One of the most critical indicators of success was the high level of satisfaction expressed by students regarding the program, as well as their strong desire to participate again. This is clear evidence that the program provided students with enjoyable and meaningful experiences, which will positively impact its long-term sustainability.

**Effectiveness of hands-on, team-based project learning:** With hands-on educational kits and materials, students engage in team projects. These activities not only increase student interest but also contribute to improving collaboration and problem-solving skills. Our findings confirmed that interest and engagement are key factors in maximizing learning effectiveness.

**Importance of team-based collaborative learning:** The team activities in our program greatly enhanced students' communication and collaboration skills. Through problem-solving processes that required teamwork, children acquired knowledge and naturally learned various social and collaborative problem-solving skills. This was evident in the positive evaluations received in both instructor assessments and student surveys.

**Establishment of a unique collaboration model:** We successfully formed a strategic partnership with the DCPL Central Office, and our collaboration with the Parklands-Turner Branch has been instrumental in the program's success. The library not only provided space for the children's program but also ensured that staff members, including the children's librarian, worked closely with our organization. This unique collaboration model ensured full participation of students for the entire 50 minutes and guaranteed high quality of the program.

**Enhancement of the value of the library's programs:** Our STEAM program contributed to expanding the educational offerings and enriching the value of the children's library programs by incorporating STEAM subjects.

**Maintenance of high participation and learning engagement:** With the active involvement and close cooperation of parents, we successfully maintained high attendance rates among a core group of students.

## 4.2. Lessons Learned and Success Factors

The partnership with the DC Public Library serves as a model of delivering high-quality STEAM education to underserved communities. Several key factors contributed significantly to the success of this partnership are as follows:

**Strategic partnership and effective communication:** Establishing a strategic partnership with the library was essential to the program's success. This collaboration enabled us to solidify the program's foundation and secure the necessary support.

**Leveraging complementary strengths:** Our organization provided STEAM education content, resources, and instructors, while the library provided a safe learning space and experienced staff, leveraging each other's strengths. This complementary division of roles effectively enhanced the program's quality by utilizing the expertise of both parties.

**Shared common goals:** Both partnerships aimed to reduce the STEAM education gap and increase access to STEAM opportunities in the underserved community by providing sustainable, high-quality after-school programs. This shared sense of purpose was a key driver of the partnership's success.

**Flexible and adaptive program operations:** The program was designed to address the gaps in STEAM education during after-school hours, adopting a demand-driven approach tailored to the needs of students.

## 4.3. Future Directions and Suggestions

The successful partnership experience with the DC Public Library Parklands-Turner branch provides valuable insights for the future development of the program and the establishment of cooperation models for our community-based STEAM program.

**Enhancing creativity and confidence in students:** Although students have reported an overall improvement in their problem-solving skills, the percentage of students achieving perfect scores for "creative solutions" remains low. Additionally, satisfaction regarding "increased confidence in teamwork" is relatively lower compared to other questions related to collaboration. In future programs, we will design activities that stimulate creative thinking and increase confidence. These activities will provide students with more opportunities to recognize their collaborative abilities and build self-assurance through individual contributions.

**Sharing the best practices and partnership models:** We will document and share the successful collaborative model from the Parklands-Turner Library. This model includes the active participation of a children's librarian and library staff, as well as a dedicated space for activities. This best practice can be shared with other library branches and local institutions to offer a high-quality, free STEAM program jointly to children in underserved communities.

**Maintaining flexibility and adaptability:** It is essential to remain open to adjusting and adapting program content to meet the unique characteristics and needs of local communities.

**Conducting pre- and post-data collection:** Beginning from the next school year, we will conduct pre- and post-data collection to assess the program's actual impact and facilitate continuous improvement.

## 5. Appendices

### Appendix 5.1. Survey questionnaire and results

|                                                  | Questions                                                                                                                                            | Ratings |     |     |    |   |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-----|-----|----|---|
|                                                  |                                                                                                                                                      | 5       | 4   | 3   | 2  | 1 |
| <b>Interest in activities</b>                    | 1. How much interest and fun did you have while participating in the program? 1 (not at all likely to participate) to 5 (very likely to participate) | 79%     | 21% | 0%  | 0  | 0 |
|                                                  | 2. Would you like to participate in the program again? 1 (not at all likely to participate) to 5 (very likely to participate)                        | 84%     | 11% | 5%  | 0  | 0 |
|                                                  | 3. How likely would you recommend this activity to a friend? 1 (not at all likely to recommend) to 5 (very likely to recommend)                      | 74%     | 15% | 11% | 0  | 0 |
|                                                  | 4. How much has your interest in STEM increased? 1 (not at all increased) to 5 (significantly increased)                                             | 84%     | 16% | 0%  | 0  | 0 |
| <b>Team Project Engagement</b>                   | 5. How well did you work with your teammates? 1 (not at all well) to 5 (very well)                                                                   | 73%     | 18% | 9%  | 0  | 0 |
|                                                  | 6. How well did the team members communicate and collaborate? 1 (not at all well) to 5 (very well)                                                   | 82%     | 18% | 0%  | 0  | 0 |
|                                                  | 7. How well did the team work together to solve the problem? 1 (not at all well) to 5 (very well)                                                    | 73%     | 27% | 0%  | 0  | 0 |
|                                                  | 8. How much has your confidence in working in a team increased? 1 (not at all increased) to 5 (significantly increased)                              | 36%     | 45% | 18% | 5% | 0 |
| <b>Learning Outcomes/ Problem-Solving Skills</b> | 10. How much do you think your STEAM-related knowledge increased during this program? 1 (not at all increased) to 5 (significantly increased)        | 79%     | 21% | 0%  | 0  | 0 |
|                                                  | 11. How much do you think your confidence in learning STEAM subjects has increased? 1 (not at all increased) to 5 (significantly increased)          | 86%     | 14% | 0%  | 0% | 0 |
|                                                  | 12. How much do you think your ability to solve problems increased? 1 (not at all increased) to 5 (significantly increased)                          | 57%     | 29% | 14% | 0% | 0 |

|                                                      |         |      |             |      |
|------------------------------------------------------|---------|------|-------------|------|
| 9. In which topics do you feel the most improvement? | Science | Tech | Engineering | Math |
|                                                      | 4       | 4    | 5           | 4    |

## Appendix 5.2. Evaluation results

|                                           | Questions                                                                                                     | Participant Number |   |   |     |    |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------|---|---|-----|----|
|                                           |                                                                                                               | 7                  | 8 | 9 | 6   | 10 |
| <b>Problem-Solving Skills</b>             |                                                                                                               |                    |   |   |     |    |
| <b>Problem Approach</b>                   | How effectively did the student define the problem and gather the necessary information? (1-5 scale)          | 5                  | 5 | 5 | 3.5 | 5  |
| <b>Creative Solution</b>                  | How original was the proposed solution compared to existing alternatives? (1-5 scale)                         | 4                  | 5 | 4 | 3.5 | 5  |
| <b>Evaluate the step-by-step approach</b> | How effectively did the student apply a structured approach to solving the problem? (1-5 scale)               | 5                  | 5 | 5 | 3.5 | 5  |
| <b>Analysis of Results and Reflection</b> | How effectively was the student analyzing the project results and suggesting future improvements? (1-5 scale) | 5                  | 5 | 5 | 3.5 | 5  |
| <b>Collaborative Work</b>                 |                                                                                                               |                    |   |   |     |    |
| <b>Role distribution</b>                  | How well did each team member fulfill their designated role? (1-5 scale)                                      | 5                  | 5 | 5 | 3   | 5  |
| <b>Degree of cooperation</b>              | How effectively did team members communicate with one another? (1-5 scale)                                    | 5                  | 5 | 5 | 3   | 5  |
| <b>Problem-Solving Approach</b>           | How well did the team work together to address the problem? (1-5 scale)                                       | 5                  | 5 | 5 | 3   | 5  |
| <b>Solution</b>                           | How well did the team work together to find the solution? (1-5 scale)                                         | 5                  | 5 | 5 | 3   | 5  |
| <b>Feedback and Reflection</b>            | How effectively did team members provide feedback to one another? (1-5 scale)                                 | 5                  | 5 | 5 | 3   | 5  |

|                                           | Questions                                                                                                     | Participant Number |    |   |   |   |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------|----|---|---|---|
|                                           |                                                                                                               | 1                  | 12 | 3 | 4 | 1 |
| <b>Problem-Solving Skills</b>             |                                                                                                               |                    |    |   |   |   |
| <b>Problem Approach</b>                   | How effectively did the student define the problem and gather the necessary information? (1-5 scale)          | 5                  | 4  | 5 | 5 | 5 |
| <b>Creative Solution</b>                  | How original was the proposed solution compared to existing alternatives? (1-5 scale)                         | 5                  | 3  | 5 | 5 | 5 |
| <b>Evaluate the step-by-step approach</b> | How effectively did the student apply a structured approach to solving the problem? (1-5 scale)               | 5                  | 4  | 5 | 5 | 5 |
| <b>Analysis of Results and Reflection</b> | How effectively was the student analyzing the project results and suggesting future improvements? (1-5 scale) | 5                  | 4  | 5 | 5 | 5 |
| <b>Collaborative Work</b>                 |                                                                                                               |                    |    |   |   |   |
| <b>Role distribution</b>                  | How well did each team member fulfill their designated role? (1-5 scale)                                      | 5                  | 3  | 5 | 5 | 5 |
| <b>Degree of cooperation</b>              | How effectively did team members communicate with one another? (1-5 scale)                                    | 5                  | 3  | 5 | 5 | 5 |
| <b>Problem-Solving Approach</b>           | How well did the team work together to address the problem? (1-5 scale)                                       | 5                  | 3  | 5 | 5 | 5 |
| <b>Solution</b>                           | How well did the team work together to find the solution? (1-5 scale)                                         | 5                  | 3  | 5 | 5 | 5 |
| <b>Feedback and Reflection</b>            | How effectively did team members provide feedback to one another? (1-5 scale)                                 | 5                  | 3  | 5 | 5 | 5 |

|                                           | Questions                                                                                                     | Participant Number |    |   |  |  |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------|----|---|--|--|
|                                           |                                                                                                               | 2                  | 13 | 5 |  |  |
| <b>Problem-Solving Skills</b>             |                                                                                                               |                    |    |   |  |  |
| <b>Problem Approach</b>                   | How effectively did the student define the problem and gather the necessary information? (1-5 scale)          | 4                  | 5  | 3 |  |  |
| <b>Creative Solution</b>                  | How original was the proposed solution compared to existing alternatives? (1-5 scale)                         | 4                  | 4  | 3 |  |  |
| <b>Evaluate the step-by-step approach</b> | How effectively did the student apply a structured approach to solving the problem? (1-5 scale)               | 4                  | 4  | 3 |  |  |
| <b>Analysis of Results and Reflection</b> | How effectively was the student analyzing the project results and suggesting future improvements? (1-5 scale) | 4                  | 5  | 3 |  |  |
| <b>Collaborative Work</b>                 |                                                                                                               |                    |    |   |  |  |
| <b>Role distribution</b>                  | How well did each team member fulfill their designated role? (1-5 scale)                                      | 4                  | 4  | 4 |  |  |
| <b>Degree of cooperation</b>              | How effectively did team members communicate with one another? (1-5 scale)                                    | 4                  | 4  | 4 |  |  |
| <b>Problem-Solving Approach</b>           | How well did the team work together to address the problem? (1-5 scale)                                       | 4                  | 4  | 4 |  |  |
| <b>Solution</b>                           | How well did the team work together to find the solution? (1-5 scale)                                         | 4                  | 4  | 4 |  |  |
| <b>Feedback and Reflection</b>            | How effectively did team members provide feedback to one another? (1-5 scale)                                 | 4                  | 4  | 4 |  |  |

**Appendix 5.3. The average score and standard deviation for each item of Evaluation, calculated based on the scores of 13 students (out of 5 points)**

| Evaluation Area                 | Item Name                              | Average Score | Standard Deviation |
|---------------------------------|----------------------------------------|---------------|--------------------|
| <b>Problem-Solving Ability</b>  | Problem Approach                       | 4.58          | 0.63               |
|                                 | Creative Solution                      | 4.27          | 0.62               |
|                                 | Step-by-Step Approach                  | 4.58          | 0.63               |
|                                 | Analysis of Results and Reflection     | 4.58          | 0.63               |
| <b>Collaborative Activities</b> | Role Distribution                      | 4.46          | 0.76               |
|                                 | Degree of Cooperation                  | 4.46          | 0.76               |
|                                 | Collaborative Problem-Solving Approach | 4.46          | 0.76               |
|                                 | Solution - Collaborative               | 4.46          | 0.76               |
|                                 | Feedback and Reflection                | 4.46          | 0.76               |