



# STEAM Framework Feasibility Study

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## Introduction

STEAM (Science, Technology, Engineering, Arts, and Math) is an educational philosophy designed to integrate five key disciplines that support children's natural curiosity and excitement for exploration, while also building a foundation for later academic achievement. STEAM curricula are currently gaining popularity in the United States, partly in response to the U.S.'s below-average achievement rankings in these disciplines; as of 2015, the U.S. was ranked 27th in science and 35th in mathematics among industrialized nations (DeSilver, 2017). This increased focus on science and math curricula corresponds with a predicted increase in STEAM jobs over the coming years (Bureau of Labor and Statistics, 2014). The United States depends on scientists and engineers to solve critical problems, ensure homeland security, and improve standards of living; understandably, shortcomings in math and science achievement in the United States (Organization for Economic Cooperation and Development, 2014) continue to raise concerns among educators, economists, and policy makers.

In response to these trends, preschool programs are often encouraged to take a proactive approach in preparing youth for the increasing demands of math and science core standards. However, the introduction of STEAM to preschool classrooms requires educators to be knowledgeable and competent in science and math domains. To support early childhood educators, LAUP has designed a STEAM Implementation Framework, which supports teachers' and parents' integration of science, technology, engineering, art, and math practices into their classrooms and homes, respectively.

Teachers' attitudes play an important role in the development of children's views toward science and mathematics. A teacher's positive attitude, especially at such a formative time as preschool, can set the stage for a child's future in STEAM education (Aslan, Tas, & Ogul, 2016; Geist, 2015). Teachers' levels of self-efficacy (beliefs about their own competency) in science and mathematics contribute to students' achievement outcomes in STEAM (Timur, 2012). Therefore, positive teacher attitudes toward science and math are critical to a successful STEAM program.

Exposure to STEAM curricula also increases children's concrete knowledge of scientific materials (e.g., scales, measuring cups, funnels), which in turn makes children more likely to explore science-based centers and play materials. Children prefer exploring areas in which they are familiar with the materials and where resources are readily available; in studies of STEAM in the classroom, children do not demonstrate a preference for "science centers" during free play if they are not formally taught science lessons (Tu, 2006). On the other hand, teachers who spend more time on STEAM areas (including physical and life sciences) have students who spend more time in "science centers" during free play (Nayfeld, Brenneman, & Gelman, 2011). If teachers feel confident in teaching STEAM lessons, interest and free play engagement may increase. Conversely, if teachers do not feel comfortable and avoid STEAM lessons, children will attend "science centers" with less frequency. In sum, teachers' self-efficacy and confidence in teaching STEAM curricula may predict free play decision-making as well as longer-term child outcomes. To study these effects, LAUP created an intervention that provided teachers with information on, and support for implementation of, a preschool-appropriate STEAM curriculum.

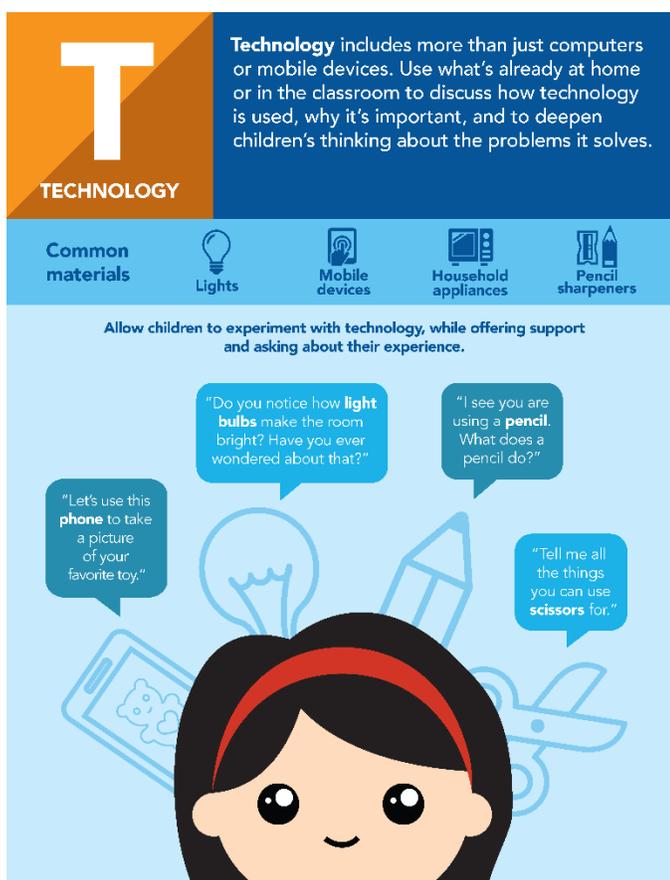
### **LAUP's STEAM Framework and STEAM Toolkit**

LAUP's STEAM Implementation Framework, which was used for this intervention, consists of step-by-step guidance for the implementation of STEAM in early education programs. The Framework is a multi-page guide developed specifically for teachers. As a supplement to the framework, LAUP also developed a hand-held STEAM Toolkit (Figure 1). The toolkit takes the form of an accordion pamphlet with colorful graphics, can be used in the classroom or at home, and contains tips and information for implementing STEAM with preschool children in a variety of settings. For example, it provides ideas for asking questions about numbers, animals, and typical household objects. This toolkit was used as a quick reference guide to the Implementation Framework.

Participating parents were given a STEAM Toolkit and access to the monthly blog ([www.steamcorner.wordpress.com](http://www.steamcorner.wordpress.com)). A large-scale meeting was held prior to the start of the program to explain to teachers and parents the expectations for their sites. Parents were told that any concerns or questions would be addressed by the LAUP researcher, and that their child could opt out at any time. The expectations communicated to parents were that parents would increase science and math talk outside of the classroom, in order to extend their children's learning at home. Parents were asked to utilize the resources provided (the Toolkit, blog access, and the LAUP researcher) to communicate about the concepts of STEAM with their children outside of the classroom.

In addition to providing parents with the STEAM Framework and blog access, LAUP distributed a hard copy of the toolkit to two early education program sites and 56 parents. It is also available free of charge at LAUP's website ([www.laup.net](http://www.laup.net)).

Figure 1. Sample Page of the LAUP Steam Toolkit



About three months into the school year, the STEAM Framework was distributed to directors, supervisors, and teaching staff at both participating sites. All staff were given the STEAM Framework and the STEAM Toolkit as part of their participation in the program, and were instructed to read the framework and ask questions as they arose, as well as to distribute the STEAM Toolkit to all parents. Preliminary meetings were held with all parents; these meetings introduced the STEAM implementation program and served as an opportunity to field questions and concerns. During the meeting, parents were given a survey to explore attitudes and beliefs about STEAM in early childhood education.

### Research Questions

The current study, which ran during the 2015-2016 academic school year, sought to understand how the LAUP STEAM Framework and toolkit were received in the classroom, and to highlight areas for improvement. The attitudes of parents and teachers were also explored as a part of this study, since they are crucial to the success of any new innovation.

The following research questions were addressed by this study:

1. What are the features of a STEAM curriculum as they are currently implemented in preschool classrooms? Is STEAM being taught? If so, to what extent?
2. How do teachers feel about STEAM in preschool?
3. What was the frequency of use and fidelity of implementation of LAUP's STEAM framework by teachers and parents through the 2015-2016 academic year?
4. What were the attitudes of parents to STEAM education outside of the classroom?

The primary purposes of this study were to uncover links between attitudes toward STEAM curricula and teaching behaviors; to generate and refine themes that would help to characterize experiences of individual participants; and to extract general insights from the data.

### **Finding: Teachers are not familiar with the acronym STEAM, nor do they have adequate access to STEAM materials in their classrooms.**

According to a teacher survey, none of the participants had ever heard of the acronym STEAM. This is likely due to the new inclusion of “A,” for “Arts,” in the STEM acronym. In addition, 80% of teachers reported that they did not have adequate access to science and math materials. An important aspect of encouraging teachers to implement STEAM in ECE was to help them acknowledge the opportunities that were already present in their classrooms. Once teachers were taught how to find and incorporate existing STEAM opportunities in their classrooms, they were confident in their ability to implement new ideas in their classrooms. Teachers were given instructions and support by the researchers, who demonstrated how to pay attention to the small details of their classrooms and how to pose scientific questions to students.

### **Finding: Teachers are mixed in their beliefs about how much science and math should be taught in the classroom.**

Teachers in the current study held varying beliefs about how much science and math should be taught in the classroom. Half of the teachers surveyed felt that 10 to 30 minutes per day was a sufficient amount of time to focus on math and science, which represents from 4% to 12% of a half-day class; the other half of the teachers felt that it was necessary to talk about math and science for 60 minutes or more per day. This indicates that, while a large number of teachers still do not believe science and math should be a priority in the ECE classroom, there are many teachers who already prioritize STEAM and might be willing to incorporate new techniques or tools.

### **Finding: Parents believe STEAM should be a priority in early education, and the vast majority would utilize resources if they were available.**

Parents play a critical role in their children’s early learning. The majority of learning takes place outside of the classroom, which makes parents’ role in implementing STEAM at home highly important. On a paper survey, parents were asked to reveal some of their feelings toward science and math in early education; their responses were positive. Of the parents surveyed, 96% felt that science and math should be taught in Pre-K classrooms. Similarly, 80% felt that STEAM should be a priority in Pre-K classrooms.

Parents were also asked to consider a list of possible resources on STEAM, and rate the items according to their perceived usefulness. Access to a quick reference guide was reported as being most useful (88%), followed by access to a trained coach for support (82%). Parents wanted to feel empowered in their children’s education by sharing in teachers’ resources, and by participating in direct communication with a trained professional.

Several in-person observations were conducted, and the end of many classroom observations allowed the observer the opportunity to speak with parents about their experience with the STEAM toolkit. During conversations with parents, it was noted that the toolkit was easy to use and user-friendly. Parents referenced the ease of opening up the pamphlet and quickly being able to utilize its content.

### **Finding: Despite having access to technology (computers, tablets, and smart phones), the majority of children are not learning about STEAM at home.**

A major barrier to developing skills in the use of technology is a lack of access. Without access to technological devices or the internet, it becomes difficult to learn about the nuances of utilizing technology. The vast majority of participants (84%) in the current study do have access to technology (computers, tablets, and smart phones); however, access to technology alone does not indicate a willingness to engage in STEAM activities in the home, which could be accomplished by visiting developmentally appropriate websites on STEAM, watching videos on science, or playing science-related interactive games. Of the parents surveyed, only 18% said their children engage in more than six activities related to STEAM outside of the classroom on a weekly basis. When asked about their implementation of STEAM at home, parents primarily stated reasons relating to a lack of knowledge – they did not know how to implement STEAM, did not know what it entailed, or did not know whether it was expensive.

**Finding: STEAM is rarely visible in Pre-K classrooms; however, implementing a STEAM framework appears to increase use of math language in normal teacher-child interactions.**

During the academic school year of 2015-2016, LAUP conducted multiple observations to determine the number of STEAM-focused opportunities that were presented during a normal school day. STEAM materials were prevalent in all participating sites (including fish tanks, science centers, and block areas), but math and science were rarely discussed or directly taught during a typical school day prior to the STEAM Framework implementation. Conversations with teachers and staff showed their lack of confidence in math and science, which made them reluctant to engage in teachable moments, due to a fear of presenting incorrect information. This feeling is common among the ECE workforce, who often feel less than prepared when it comes to teaching science and math to their students (Torquati, Cutler, Gilkerson, & Sarver, 2013). Teachers are more likely to teach and share in moments where they feel comfortable and knowledgeable.

Following the introduction of the STEAM Framework, researchers conducted monthly observations to determine whether science and math opportunities increased in participating classrooms. Teachers using the STEAM Framework tended to use more math language when interacting with children during free play. These teachers often asked open-ended questions about the toys and activities with which the children were engaged. For example, teachers asked, "Tell me about the block you are using. How many sides does it have?", or "Can you think of a few ways we can make the blocks into a line?" Math language increases children's critical thinking skills, while introducing them to basic mathematical concepts. Similarly, asking questions relating to shape, order, and linear relationships helps to lay the foundation for geometry. After using the framework and toolkit, teachers stated frequently that it became easier to talk to their students about STEAM, because they had a reference to rely on.

**Finding: Parents feel strongly that they are highly influential in their children's future career and educational path, but they also believe that going to a good college plays an important role.**

Parents were asked a series of questions related to the factors they perceived to be most consequential for their children's success. The purpose of these questions was to characterize parents' beliefs about the factors contributing to the success of their children. Overall, 86% of parents reported feeling that they would be extremely influential in their children's career. However, when parents were asked to rank a list of potential factors in their children's success, "going to a good college" was ranked highest, while "parental support" was ranked the lowest. These data indicate that parents see higher education as extremely important to their children's success. Despite parents' belief that they will influence their children's career pathways, parents evidently also place great value on education.

**Finding: LAUP's STEAM Framework was easy to use, and translated easily to parents using the STEAM Toolkit.**

Parents and staff were asked throughout the study to comment on the ease of use and readability of the STEAM Toolkit. During observations and conversations, multiple parents (N=3) noted how easy to read and "user-friendly" the STEAM Toolkit was, and noted that it made the topics appear simple to implement at home. Parents reported feeling more comfortable with STEAM once they had had a chance to read the Toolkit. Staff (N=3) agreed with parents, and stated that the Toolkit simplified seemingly complex domains into a quick reference guide. However, parents reported that they would like more direct assistance in implementing STEAM at home.

## Recommendations

The following recommendations are made for future implementations of STEAM, based on the findings of this first implementation study:

1. Parents and early education staff have favorable attitudes toward implementing STEAM in their programs and at home. It is recommended that more programs and parents be given the opportunity to use the STEAM Implementation Framework and STEAM Toolkit.
2. While attitudes were favorable, usage could have been higher with more direct support. It is important for future implementation programs to offer increased support. Parents and teachers could benefit from monthly check-ins and from more follow-up visits from LAUP support staff.
3. More outreach should be directed to parents, in order to encourage STEAM outside of the classroom. Staff should provide parents and teachers with opportunities to engage in STEAM outside school, through sharing of targeted resources. While initial group meetings were seen as beneficial, parents need more opportunities to interact with STEAM professionals.
4. Additional intervention materials would be useful for teachers and support staff. Teachers are constantly on the move inside the classroom, which makes it difficult to refer back to a framework for STEAM suggestions. Direct professional support with video technology may offer a unique insight into individualized STEAM opportunities in a given classroom. Development of such an intervention could be based on Harvard's FIND program (<http://developingchild.harvard.edu/innovation-application/innovation-in-action/find>) and used with select staff at participating sites. Harvard's FIND project was designed to provide detailed one-on-one coaching for healthy interactions with children using video technology and feedback software. For the purposes of STEAM, researchers could use this video technology and feedback software to record classroom observations, to provide detailed instruction on how to incorporate STEAM, and to note STEAM activities already taking place.
5. Advocates for STEAM and early education should reach out to parents and ECE staff about the resources available to support their STEAM efforts, and should promote these resources to staff and parents across the LAUP network and throughout Los Angeles County.

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## Appendix A. Methodology

### Participants

Two LAUP provider sites, containing three classrooms total, participated in this research study. Three lead teachers and two assistant teachers were each given access to the STEAM Framework, STEAM Toolkit, and monthly blog. Both parents (N=56) and teachers (N=5) participated in the study, with the parents receiving access to the STEAM Toolkit and monthly blog. All participants came from LAUP's preschool network in Los Angeles County. Participants were purposively sampled from three typical classrooms within a range of quality-tiered ratings (to enhance understanding of selected individuals' experiences that would provide the greatest insight into the research questions). Participants were not offered incentives to participate, and could end their participation at any time.

Participating teachers and staff were given a STEAM Implementation Framework, STEAM Toolkit, monthly blog access, and direct access to the researcher for the purposes of this study. In a small group meeting, teachers and staff were given a brief overview of the expectations of the study. Teachers and staff were asked to read and review the framework, and to ask any questions they had about its implementation.

### Data Collection

*Parent Survey.* At the beginning of the school year, parents were surveyed on their attitudes toward STEAM. They were asked a series of questions designed to capture their philosophy on teaching science and math to young children, and to identify the factors they believed were most important for future success. The survey took roughly ten minutes to complete.

*Teacher Survey.* At the beginning of the academic school year, teachers were given a survey to determine their attitudes toward STEAM in early education. The survey took roughly eight minutes to complete.

*Director Interview.* At the end of the academic school year, one director was interviewed to gauge their feelings toward implementing STEAM in their programs. The interview lasted roughly thirty minutes and was semi-structured. The director was asked a series of questions from a predetermined list. During the course of the interview, probing questions were asked in order to reveal the director's thoughts and ideas about implementing STEAM.

Table 1. Survey and Interview Data Collection Overview

Instrument	N	Response Rate	Time period
Parent Survey	56	100%	October 2015
Teacher Survey	5	100%	October 2015
Director Interview	1	100%	May 2016

*Pre-Intervention Observations.* A researcher from LAUP scheduled a time to observe each program site, accompanied by the program's director or supervisor. The observer was looking for items or environmental opportunities that might provide STEAM experiences to children (e.g., a fish tank, science materials, or blocks). Once the environment was observed, the observer took notes on the interactions between teacher and child for about two hours. The goal of these observations was to determine the number of STEAM-related interactions between teacher and child. Opportunities for interaction included teacher actions such as asking about quantity, asking leading questions about physical sciences, guiding an experiment, or asking children to use descriptive language for numbers or objects.

*Post-Intervention Observations.* Post-intervention observations were scheduled after the initial meeting, and after the discussion with director and staff that detailed the expectations for use of the LAUP STEAM Framework. The goal for these observations was to capture moments of STEAM implementation through guided opportunities and interactions. The observer looked for STEAM-specific language, STEAM activities, and moments of STEAM-focused teaching between teacher and child. In total, eight observations, comprising a total of 18 hours, were completed.

Table 2. Observation Data Collection Overview

Location	# Pre-intervention Observation	# Post-intervention Observation	Time period
Site A	1	3	September 2015 to June 2016
Site B	1	3	September 2015 to June 2016

## Appendix B. Teacher Survey

Thank you for participating in LAUP's STEAM (Science, Technology, Engineering, Arts, and Math) framework implementation study! This brief survey will help us learn about your attitudes and understanding of STEAM in ECE classrooms. Your responses are confidential and your identity or that of your classroom will not be disclosed.

1. Have you ever heard of STEAM (or STEM) in early education? (Circle one) **Y N**
2. Have you ever been trained in STEAM (or STEM) education? **Y N**
3. Have you ever attended a professional development workshop and/or conference that addressed STEAM (or STEM) concepts? **Y N**

4. Do you feel science and math should be taught in the preschool classroom?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Why or why not?
5. Do you use a published curriculum that addresses science and math?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	If Yes, what is its name?

6. On average, about how many science or math activities do you do each week with the children in your class?
- 0 to 1 activity       2 to 3 activities       4 to 5 activities       6 or more activities

7. Do you experience the following problems at your site? Please circle Yes or No.

Inadequate materials for individualized science instruction	<b>Yes</b>	<b>No</b>
Inadequate materials for individualized math instruction	<b>Yes</b>	<b>No</b>
Inadequate access to other resources on STEAM concepts	<b>Yes</b>	<b>No</b>
Lack of confidence teaching math and sciences subjects	<b>Yes</b>	<b>No</b>
Lack of time to attend STEAM professional development opportunities	<b>Yes</b>	<b>No</b>
Inadequate technology support	<b>Yes</b>	<b>No</b>
Lack of time to plan and prepare STEAM activities	<b>Yes</b>	<b>No</b>

8. Would you find the following resources helpful at your site? Please circle Yes or No.

Access to a bi-weekly YouTube channel explaining STEAM concepts	<b>Yes</b>	<b>No</b>
Access to a weekly blog that discusses STEAM and early education	<b>Yes</b>	<b>No</b>
List of online resources for STEAM publications and journals	<b>Yes</b>	<b>No</b>
A quick reference guide that can be displayed in the classroom	<b>Yes</b>	<b>No</b>
Direct support from a trained coach regarding STEAM education	<b>Yes</b>	<b>No</b>

9. How many minutes per week do children use desktop or laptop computers in your classroom?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more
10. How many minutes per week do children engage in science-related activities?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more
11. How many minutes per <b>day</b> do you think STEAM should be taught in a preschool classroom?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more

12. Please describe, if applicable, your biggest concern about incorporating STEAM into your preschool program?

13. As a technology user, do you classify yourself as:

- Not yet familiar
- Beginner with support
- Confident on my own
- Capable of teaching others

14. Please check the box that represents your feelings toward the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
I am aware of professional development opportunities that are centered around STEAM	<input type="checkbox"/>				
Parents should play a major role in their children's science and math learning	<input type="checkbox"/>				
Most people believe math and science should be a priority in preschool education	<input type="checkbox"/>				
The children will not understand STEAM concepts	<input type="checkbox"/>				
I don't have enough support to effectively teach STEAM to my students	<input type="checkbox"/>				

15. Is there anything else you would like to add? (Questions, concerns, etc.)

**Thank you for your time.**

If you have any questions about this study, please contact Drew Barrett at (213) 416-1287 or [dbarrett@laup.net](mailto:dbarrett@laup.net).

## Appendix C. Parent Survey

Thank you for participating in LAUP's STEAM (Science, Technology, Engineering, Arts, and Math) framework implementation study! This brief survey will help us learn about your attitudes and understanding about STEAM in the classroom, and at home. Your responses are confidential and your identity will not be disclosed.

1. Have you ever heard of STEAM in early education? (Circle one) **Y** **N**
2. Do you feel that science and math are appropriate for preschool classrooms? **Y** **N**
3. Do you believe that talking about science and math is important for young children? **Y** **N**
  
4. STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. How important do you believe these subjects are for students?
  - Other subjects are more important
  - Somewhat important
  - Important
  - Very important
  
5. How confident are you talking with your child about math and science at home?
  - Not confident at all
  - Somewhat confident
  - Very confident
  - Extremely confident
  
6. How willing would you be to spend extra time to help your child be successful in math and science?
  - Extremely willing
  - Very willing
  - Somewhat willing
  - Not at all willing
  
7. If you had extra money to spend each month on your child, how would you be most likely to spend it?
  - Music, art, or dance lessons
  - Enrichment program in math or science
  - Sports team expenses
  - Clothing
  - Entertainment
  - Enrichment program in reading or language
  - Some other way
  
8. How influential do you think you will be to your child's future career path?
  - Extremely influential
  - Somewhat influential
  - Not influential at all

9. What factors are most important to your child's success? Please rank the following factors in order from 1, being most important, to 7, being least important:

- \_\_\_ Studying hard
- \_\_\_ Good Pre-K-12 education
- \_\_\_ Having a role model
- \_\_\_ Parental support
- \_\_\_ Going to a good college
- \_\_\_ Support from teachers
- \_\_\_ A passion for learning

Please circle Y for Yes, or N for No.

- 10. Do you think STEAM should be a priority in Pre-K classrooms? **Y N**
- 11. Would you like to see your child pursue a career in STEAM? **Y N**
- 12. Do you believe STEAM should be a priority in education overall? **Y N**

13. If you were given resources describing how to incorporate STEAM into your household, would you use them?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	If No, why?
14. Do you have any concerns about your child learning STEAM in his/her preschool classroom?	<input type="checkbox"/> Yes	<input type="checkbox"/> No	If Yes, explain:

15. On average, how often does your child engage in science or math activities (building blocks, sorting, counting, and investigating) per week?

- 0 to 1 activity       2 to 3 activities       4 to 5 activities       6 or more activities

16. Do you find the following statements to be true at your home? Please circle Yes or No

- |   |     |    |
|---|-----|----|
| Access to the internet                                  | Yes | No |
| Time to focus on science and math at home               | Yes | No |
| Limited access to resources on STEAM concepts           | Yes | No |
| General understanding of science and math               | Yes | No |
| Access to community resources centered on STEAM         | Yes | No |
| Availability of technology (computer, smartphone, etc.) | Yes | No |

17. Would you find the following resources helpful? Please circle Yes or No

- |  |     |    |
|--|-----|----|
| Access to a bi-weekly YouTube channel explaining STEAM concepts    | Yes | No |
| Access to a weekly blog that discusses STEAM and early education   | Yes | No |
| List of online resources for STEAM publications and journals       | Yes | No |
| A quick STEAM reference guide that can be displayed on your fridge | Yes | No |
| Direct support from a trained coach regarding science and math     | Yes | No |

18. How many minutes per day does your child use a computer at home?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more
19. How many minutes per week does your child engage in science related activities?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more
20. How many minutes per day does your child have access to games and/or content on a smart phone?	<input type="checkbox"/> None	<input type="checkbox"/> 10-30	<input type="checkbox"/> 30-45	<input type="checkbox"/> 60 or more

21. Is there anything else you would like to add? Questions, concerns, etc.

**Thank you for your time.**

If you have any questions about this study, please contact Drew Barrett at (213) 416-1287 or [dbarrett@laup.net](mailto:dbarrett@laup.net).

## Appendix D. Director Interview Protocol

The purpose of the director interview was to gain deeper insights into the big picture of STEAM in ECE programs. The director was told that all information was confidential, and no names would be disclosed. The director was also told that at any point in the interview the director could leave. The interview took roughly thirty minutes, and was semi-structured. The interviewer asked the following questions of the director, and noted the director's answers:

1. Tell me about your experience with LAUP's STEAM Framework tool.
2. Do you believe the program was beneficial to your program? Why or why not?
3. Tell me your overall beliefs about STEAM in early education.
4. What changes would you make to the program?