FUSE Studios Evaluation Report 2015-2016

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Executive Summary of the 2015-2016 FUSE Evaluation Report

This evaluation report describes results of the second year of analysis of survey, challenge, and interview data collected as part of the external evaluation of the *FUSE Studios* project. The FUSE Studios project has designed a series of learning challenges for youth that are offered in both schools and community settings to youth. The evaluation used data collected during the course of youth participation in FUSE Studios activities to analyze youths' FUSE Studio experience and the opportunities FUSE Studio challenges presented them to develop persistence in collaborative problem solving, to discover interests, and to make positive connections to school.

In the second year, the evaluation relied primarily on survey data and log data relating to youth engagement with challenges. Semi-structured over-the-phone interviews with studio facilitators were included to help interpret quantitative findings and to develop understanding of variations different sites' implementation models of FUSE.

Key Findings

FUSE Studios provide high levels of peer support and help youth discover new interests, two key principles of "connected learning" (Ito et al., 2013).

Over 97% of students located themselves at the two highest levels of 'peer support' and 'interest discovery' during their experience at FUSE, as evidenced by their responses to the survey items related to these connected learning principles.

FUSE's support for interest discovery was associated with better attitudes toward engineering- and science.

When we analyzed students' attitudes toward STEAM-related fields toward their end of the experience at FUSE, we found that those students who reported higher support for interest discovery in FUSE also reported more positive attitudes toward science and engineering. The positive association held up even when students' baseline attitudes are accounted for. This analysis provides some preliminary evidence that those who experience the FUSE environment as supportive of interest discovery develop more positive attitudes over time toward science and engineering.

Facilitators implementing FUSE in a wide variety of contexts valued the program as a site for youth to explore with others and to try and fail at things in a safe environment.

Facilitators report positive experiences with using FUSE in their classrooms, whether they chose to fully adopt FUSE as their course curriculum or integrate FUSE into their existing curriculum. Articulated benefits of using FUSE in their classroom were reported as providing students with a relaxed and fun space in a school setting to try things out, explore, learn that failure is okay, and authentically rely on peer-support in the learning process.

Facilitators implementing FUSE in a wide variety of contexts expressed two central concerns: diminishing student engagement over time and materials management

The most common and substantive response to 'challenges' experienced by FUSE studio facilitators were centered around the following:

- **Keeping track of materials to ensure ready and sustained access to all available challenges for students**
- **Diminishing student engagement over time due to students feeling as if they already completed the challenges and weren't sure what to do next, both in the case of students who had completed all available challenges and students who took FUSE for more than one term**

The present evaluation is not able to link variability in local studio adaptations to student-centered outcomes. However, this is the explicit goal of future evaluations.

Recommendations for Program Improvement:

To address reported challenges to implementing FUSE, we recommend the following: 1) consider designing detailed support guides for the material kits, as well as potential ways to pre-order materials so that facilitators don't have to worry as much as delaying student progress; and 2) design and disseminate strategies for extending/expanding/remixing existing FUSE challenges and continued to develop and disseminate new challenges.

Additionally, we recommend creating an online platform that allows site facilitators to more readily and accessibly see and exchange ideas with other site facilitators across schools, districts, and states. In particular, we heard facilitators tell us that they would appreciate support in troubleshooting classroom-based-challenges around:

- **Keeping track of materials**
- **Saving work online, given rotating laptops and lab settings**
- **Diminishing student engagement over time with repeat challenges**
- **Strategies for 'extending/expanding/re-mixing' FUSE challenges**
- **Strategies for classrooms that have returning FUSE students from year to year**
- **Strategies for how to encourage collaboration and sharing across peer groups**

Given that the majority of students in FUSE are spending time exploring different challenges rather than leveling up through a challenge sequence, we recommend considering how to also encourage FUSE facilitators to support students in exploring how to 'level' up within a challenge sequence.

Context for the Evaluation

This evaluation report describes results of the second year of analysis of survey and challenge data collected as part of the external evaluation of the *FUSE Studios* project. The FUSE Studios project has designed a series of learning challenges for youth, which are offered in both schools and community settings to youth. Youth choose what challenges they take on, as well as the levels of challenge they pursue. A team at the University of Colorado Boulder charged with the task of conducting an evaluation completed the analyses presented here, using data collected during the course of youth participation in FUSE Studios activities. Funding for the overall project and the evaluation comes from the National Science Foundation (DRL 1348800 and DRL-1433724).

The FUSE Studios project is one of a number of efforts now underway nationwide aimed at broadening access to interest-related learning activities in Science, Technology, Engineering, Arts, and Mathematics (STEAM). STEAM projects embrace a notion that learning inheres in the process making or production (Bevan, Gutwill, Petrich, & Wilkinson, 2015; Kafai & Peppler, 2011; Soep, 2006). Art and design (the "A" in STEAM) are hypothesized to be valuable elements for engaging youth from underrepresented groups, but they are also understood to be integral components of the practices of science, engineering, and mathematics (Ingold, 2013; Sinclair, 2004).

This evaluation speaks directly to three aspects of the FUSE Studios approach. First is the commitment to youth choice and agency in selecting challenges. As the developers of FUSE Studios do, we view learning as a "members" phenomenon" (Stevens, 2010), best studied and supported from the agent's point of view. Hence, our analyses focus in part on the experiences of youth in the FUSE Studios environment. We analyze their experiences from the standpoint of two key features of Connected Learning environments: the degree to which they are *interest-driven* and *peer supported* (see Ito et al., 2013, for more details on this model). We analyze variability in youth's experience of FUSE Studios as supporting and building upon their existing interests, as well as the degree of peer support for learning they experience.

A second aspect of FUSE Studios that the evaluation examined was the aim of the program to promote skills and dispositions that youth can apply productively in other contexts, including school. As a number of related initiatives do, FUSE Studios aim to promote persistence in the face of difficulties in learning, self-efficacy, as well support the development and sustainment of STEAM-related interests. Accordingly, we analyze youths' persistent engagement in FUSE studios over time as related to their self-reported responses to questions about self-efficacy, collaborative problem-solving, and STEAM interest.

Since the writing of our initial evaluation for the 2014-2015 school year, dozens of additional schools and community sites, domestically and internationally, have begun to use FUSE studios as part of their educational programming. A central tenet of the FUSE Studios design is to ensure the local adaptability of FUSE to a variety of diverse contexts. As such, this evaluation sought to better understand the ways in which FUSE studios was being adapted to meet the needs of particular contexts across the nation. To accomplish this aim, the CU Boulder team conducted semi-structured interviews with a subset of FUSE Studio facilitators that were representative of the diversity of FUSE host-sites (e.g., in-school v. after-school, district-supported v. independent, etc.). This evaluation uses this qualitative data to support a deeper understanding of strategies for local adaptation as they relate to youth experiences and patterns of participation with FUSE Studios.

The evaluation research is intended to complement the ongoing design-based research efforts of the development team at Northwestern University. Their research focuses on the iterative design of challenges, interaction patterns in FUSE Studios, and youth outcomes. This research reports on outcomes as well, using survey data and a longitudinal approach to analysis.

Evaluation Questions

In this evaluation study, we address three questions:

- How do youth participate in FUSE studios?
- How do youth experience the FUSE studio environment in relation to their lives and their skill development?
- How do youths' attitudes toward STEAM relate to their experiences of the FUSE Studios learning environment and their participation in the challenges?
- How does local adaptation relate to youths' experiences and patterns of participation within FUSE studios?

Approach to Evaluation

We relied on multiple sources of data for the evaluation. Sources for quantitative analyses were surveys and computer-generated data on youth attempts and completions of challenges. Sources of qualitative data included interviews with FUSE studio facilitators. These were used to help interpret patterns in the quantitative data.

Table 1.
Overview of data sources

Type	Description
Youth Surveys	Responses from T1, T2, and T3 at 59 FUSE studio sites
Interviews w/FUSE studio facilitators	During 2016 through consented and recorded phone calls with 9 focal FUSE studios
Digital records of 'challenge' starts & completes	Collected at 124 FUSE studio sites

Youth Survey Data

The youth surveys present items to young people intended to measure multiple near-term outcomes of participation in FUSE studio challenges and youths' experiences in FUSE studios. One set of outcomes include items that focus on aspects of self-regulation and were intended to elicit youth's *'self-efficacy' and 'collaborative problem-solving'*. Another set pertain to *expanded opportunities* that youth see as related to their participation in FUSE studios. Other scales developed to elicit youths' experience of the FUSE studio learning environment pertain to their perceptions of FUSE challenges and to experiences and principles of Connected Learning. Connected Learning is an emerging model for understanding youth's technology-supported interest-related pursuits (Ito et al., 2013).

During the 2015-2016 school year, survey administration was intended to prompt students (through their online FUSE profile) in all FUSE studios to take a survey at the beginning (Baseline), after 10 hours of FUSE (Time 2), after 20 hours of FUSE (Time 3), and after 50 hours of FUSE (Time 4). The baseline survey was predominantly STEAM-oriented items with a handful of self-efficacy items, whereas the Time 2, Time 3, and Time 4 surveys was a repeat of all items in T1 plus Connected Learning items (most of which were repeat survey items from those administered in the 2014-2015 school year). We received 1505 student responses to survey T1, 333 student responses to survey T2, and 313 student responses to survey T3. We did not receive any student responses to survey T4.

STEAM attitudes. These items are the most well represented on the surveys, as they were included in surveys T1, T2, and T3. Because student survey responses decreased over time, the majority of the student survey data comes from survey T1; most likely because it was the first survey students were asked to take, as well as the shortest of the three surveys. Item design for this subset of survey items is informed by research on best practices for soliciting students' positionality within STEAM fields (Kier, Blanchard, Osbourne & Albert, 2013).

Expanded Opportunities. These individual items ask young people to report on new interests discovered through participation and changed relationships with teachers and school.

Experiences of challenges. One set of items elicits whether youths' experience of FUSE Challenges was *enjoyable and doable*. Sample items include questions like "The beginning levels of FUSE challenges aren't too easy and they not too hard" and "It's fun to try challenges that I think are really hard."

Experience of Connected Learning Related to FUSE Activities. To elicit youths' experiences, we adapted scales from an earlier survey of principles of connected learning (Maul et al., 2016) for measuring the *interest powered* and *peer supported* principles. Sample items include questions like "The FUSE challenges I've tried are like things I want to do in the future" and "There are people my age who I like to do the challenge with." The item scales for each of these CL principles (interest powered and peer supported) achieved a scale reliability of the following: Interest Discovery at T3 was $\alpha=.80$; Peer Supported at T3 was $\alpha=.74$.

Survey Administration. At the 59 FUSE studios in which the youth took the survey(s), FUSE program staff asked site facilitators to encourage students to take the surveys at the various time points in which they popped up on the FUSE online program portal. T1 of the survey was to be administered after the youth had been at FUSE for thirty minutes, and T2 after the youth had experienced FUSE for ten hours, T3 at twenty hours, and T4 fifty hours. Of import, though, T2=T3=T4. In 'real-time,' this means that youth were asked to take T1 of the survey during their first day at FUSE, and T2/T3/T4 of the survey after about four to six weeks, five to thirteen weeks, and thirty weeks.

Survey data collection was organized to analyze change in youths' experiences and outcomes over time. Again, youth were to be given surveys on their first day at FUSE, and roughly three more times over the course of their experience in the FUSE Studio. Figure 1 illustrates the number of youth for whom we have survey data over time.

Figure 1. Survey Data Over Time

*T2 + T3 group includes both students that did and did not take T1

Data were also variable by constructs measured, due to variability across sites in data collection, as well as general survey fatigue as a result of the length of the surveys. We have nearly three times the amount of data on STEAM orientations (T1) than we have data on youths' responses to the Connected Learning measures. Additionally, as Figure 1 indicates, we have a relatively small number of youth that responded to the same items over time (recall that T1 only measures STEAM attitudes where as T2 and T3 measure STEAM + CL measures).

Survey Analysis Approach. We employed a variety of analytical approaches and tools to analyze survey data for this brief report, including producing descriptive statistics, using exploratory factor analysis, and then adapting a Rasch modeling approach to locate the student on a continuum for the connected learning experiences of peer support and interest discovery.

Facilitator Interviews

We conducted interviews with FUSE leaders at nine sites, including the Chicago area, as well as studios in California and Ohio. See the appendix of this report for the interview protocol we used. For the purposes of the present analysis, we sampled from sites where FUSE Studios was used in a school setting, whether during or after the regular school hours.

During interviews, we asked leaders about their perceptions of FUSE Studios and youth experience within them. We also asked them to report on how they adapted the program to fit into their particular organization. Our intent was to analyze how program developers and site leaders had adapted to one another's purposes and contexts (Downing-Wilson, Lecusay, & Cole, 2011; Nicolopoulou & Cole, 1993). In designing to meet this intent, we created a protocol that elicited facilitators' perspectives on topics like their perceived roles in the studio, the greatest benefits and challenges of implementing FUSE, as well as goals for having FUSE in their classrooms.

Interview Analysis Approach. We employed a thematic content analysis to get a sense of the patterns within and across the facilitator interview data. Using a deductive approach, we clustered the responses around the central constructs of interest to FUSE: free-choice, fun/relaxed, room for repair/failure, interest-driven, and peer-supported.

Challenge Data

About the challenge data:

We used a deductive approach to analyze to the 'challenge' data, which is the computer generated data that tracks student activity as indicated by their online FUSE student portal. This data tracks what, when, and how students engage in challenges, including counting their clicks to 'start,' 'complete,' 'save,' or 'quit' a challenge. Table 2, below, provides a short overview of this large data set.

As the reader will note in the sections that follow, we wanted to understand which challenges students most frequently tried and completed, and then how individuals participated in FUSE studio challenges. FUSE challenges have between two and five levels, though students are not necessarily encouraged to engage in challenges in a particular manner-- a central aspect of the FUSE 'free choice' studio environment. 'Completing a challenge,' for the purposes of this analysis, means that a student completed the entire challenge sequence.

For the purposes of the 2015-2016 evaluation report, we wanted to analyze how local adaptation influenced student participation with each other and on challenges. To achieve this aim, we put the focal studio challenge data, as well as the focal studio survey data, into conversation with the qualitative data (interviews with focal studio facilitators); and we present these findings in the section below that is focused on 'local adaptation'.

Table 2. Overview of challenge data

Type	Count
Users	6,922
Studios	124
Challenges	39

Limitations of The Various Types of Data Collected

As mentioned above, despite the fact that the survey administration was standardized to automatically prompt the youth to take the various surveys over the course of their experience with FUSE, the real-life conditions and dynamics within sites led to varying amounts of survey data actually collected.

Our data present a "remote view" on activities. Our qualitative data are limited and serve primarily to help us at the University of Colorado better interpret the quantitative data we have. The Northwestern team has substantially more expertise and data regarding the implementation of the program than we do on the evaluation team.

We did not link our dataset for the purposes of this evaluation to any background characteristics of youth, per our agreement with researchers at Northwestern University. Therefore, we cannot know whether our data are representative of the population of FUSE Studio participants, at least with respect to survey data and comparing survey and challenge data.

Findings

In this section, we present findings related to each of our evaluation questions.

1. How do youth participate in FUSE Studios?

We approached this broad question by employing a descriptive approach to analysis, relying primarily on the use of descriptive statistics. As the below paragraphs will illustrate, youth participate in a variety of ways in FUSE studios—they engage in challenges on their own and with their peers, they often try out multiple challenges without completing any particular sequence, and/or they prefer some challenges to others. In addressing the broad question of 'how do you participate in FUSE studios?', we organize our findings around the following three sub-questions:

- **Which challenges are completed the most?**
- **Which challenges are most engaged with among students?**
- **What are the different patterns with which students engage challenges?**

In regard to Question 1, our data reveal that of the 10 most popular challenges (listed in Table 3, blow), 80% of them are 'kit only' challenges (e.g. computer software is not required) and 60% of them involve Engineering. Additionally, we see that that for the most part, students are not completing the entire challenge sequence (see Table 3). Of the 39 available challenges, students did complete some challenges more than others, (e.g. 46% of students who started the 'Wind Commander challenge' also completed it), but there are not necessarily discernable characteristics of these challenges, other than the fact that again they are mostly 'kit only' and involve Engineering practices. It is important to note that in general, *82% of the challenges had a less than 25% completion rate among students in the 2015-2016 school year*.

Table 3. Top 10 Challenges by Completion Rate

Challenge	Start	Completion (Percent)	Type of Challenge
Wind Commander (V1)	962	444 (46%)	Kit only, Engineer., Aerodynamics, Physics
Coaster Boss	3,973	1,627 (41%)	Kit only, Engineer., Mat. Science, Aero., Physics
LED Color Lights	7,702	2,901 (38%)	Kit only, Engineering
How to Train Your Robot	441	2,636 (37%)	Kit + Software, Coding
Laser Defender	7,205	2,636 (37%)	Kit only, Material Science, Physics
Spaghetti Structures	7,483	2,369 (32%)	Kit only, Engineer., Mat. Science, Arch., Physics
Just Bead It!	4,933	1,398 (28%)	Kit only, Material Science
Party Lights	1,874	465 (25%)	Kit + Software, Engineering, Coding
Music Amplifier	2,886	688 (24%)	Kit only, Engineering, Music
Solar Roller	2,815	613 (22%)	Kit only, Aerodynamics, Physics

However, when we turn to Question 2: "Which challenges are most engaged with among students," we see a slightly different story. The 'Dream Home' challenge saw a total of 50,938 student 'actions' (e.g. starts, saves, quits, completes) in the 2015-2016 school year, followed by Keychain Customizer, Ringtones, and Print My Ride, all of which are 'software only' challenges (e.g. challenges that don't require use of FUSE physical kits). And with regard to content area, the most popular challenges students engaged in involved Art, Design and either 3D design or printing.

Table 4. Top 10 challenges according to student 'actions'

Challenge	Number of Actions	Type of Challenge
Dream Home	50,938	Software only, Art/Design, Architecture, 3D design
Keychain Customizer	37,850	Software only, Art/Design, 3D Design, 3D printing
Ringtones	22,443	Software only, Art/Design, Entertain. Tech/Music
Print My Ride	14,280	Software only, 3D design, 3D print, Engineer., Aerodyn
Game Designer	13,385	Software only, Entertain. Tech, Coding, Gaming
Eye Candy	12,624	Software only, Art/Design, 3D Design, 3D printing
Get in the Game	11,835	Kit only, Engineer., Art/Design, Mat. Sci., Gaming
LED Color Lights	11,606	Kit only, Engineering
Laser Defender	10,995	Kit only, Material Science, Physics
Spaghetti Structures	10,800	Kit only, Engineer., Mat. Science, Architecture, Physics

So while the Wind Commander challenge has the highest completion rate, it also has one of the lowest absolute number of starts (962)—suggesting that it likely not the most popular (or perhaps most available/accessible of challenges). What these data suggest, then, is that the challenges in which students most frequently engage (either by starting a level, completing a level, saving their work, or quitting a level) do not necessarily correspond to the challenges most frequently completed. And, that most 'popular' of challenges involve Art and/or Design and *do not* require physical materials—a finding that complements what some facilitators told us about their classroom-based challenges of materials management.

Alongside interpretation of this data, it is important to note that some facilitators engage in what we call a 'strategic challenge release' schedule, meaning that they only offer particular challenges at various times throughout the students' FUSE experience—such as in a CPS afterschool club, where the FUSE facilitator encourages all students to work on 'Dream Home' together as a whole class in the first two months of FUSE. Interview data like help in making sense of the challenge data representations like Tables 3 and 4.

With regard to the third sub-question of "What are the different patterns with which students engage challenges?", we attempted to categorize youths' patterns of activity from challenge data. We identified four broad patterns of participation from the data. For both descriptive and analytic purposes, we categorized the survey respondents by number and level of challenges completed. We have called these 'single challenge with leveling up', 'attempted challenge', 'two or more challenges with leveling up, and 'two or more challenge completions' (see definitions in Table 5) and counted the number of youth that fall into each category.

Table 5. Distribution of youth by participation

Category Definition	**Number of Youth** (Percent)
Two or More Challenge Completions Completed some level on at least 2 challenges.	2,836 (41.4%)
Two or More Challenges with Leveling Up Attempted at least 2 challenges. Completed level 2 or higher on at least 1 challenge.	595 (8.7%)
Attempted Challenge Attempted at least 1 challenge.	3,183 (46.5%)

Did not complete level 2 or higher on any challenge.	(40.5%)
Single Challenge with Leveling Up Attempted exactly 1 challenge. Completed level 2 or higher on that challenge.	232 (3.4%)

The data show that the majority of youth fit into either the 'two of more challenge completion' category or the 'attempted challenge' category. From one point of view, the large number of youth who attempted but did not 'level up' within challenges is disappointing, as these students did not appear persist in challenges. However, we caution against this interpretation, since what takes place "in room" may be a better indicator of persistence and interest discovery (Stevens, Satwicz, & McCarthy, 2008). And, it is encouraging that well over a third of the students completed some level on at least two challenges. Of import, FUSE facilitators encourage a wide range of engagement with the challenges to promote interest discovery, therefore, it's not surprising that nearly 88% of youth explored but did not complete a variety of challenges.

2. How do youth experience the FUSE Studio environment in relation to their lives and their perceived skill development?

Engaging in the FUSE studio experience constitutes only a small portion of students' lives. In some cases, students participate on a daily basis in the FUSE experience because it is a mandatory class for all 6th graders in their district. In other cases, students opt in to going to the FUSE afterschool club when their schedule allows, perhaps for just 60 minutes over the course of a week. Given the variety of exposure to FUSE that exists among students, we rely on the survey that was administered to students toward the end of their experience in FUSE (@ the T3 survey). With this data, we again employed a descriptive approach to analysis, categorizing the survey questions into 'indicators of the FUSE experience' and 'outcomes of the FUSE experience'—which allow us to get a sense of both how youth experience FUSE and how they perceive the skills they develop in FUSE in relation to the rest of their lives. Then, we honed in on two well-documented experiences of 'connected learning': 'interest discovery' and 'peer support'—and used students' responses from the T3 survey to get sense of how they experienced the FUSE studio environment especially in relation to these two constructs.

Indicators of the FUSE Experience

The items listed in Table 6 were designed to elicit youths' sense of the FUSE challenges as being either 'doable' and/or 'enjoyable,' with response options of strongly disagree to strongly agree. We analyzed the 'doable' and 'enjoyable' survey items as indicators of the FUSE experience, using descriptive statistics to characterize the youth's experiences of FUSE toward the end of their experience (at T3). As the mean scores reveal, in general students came in at a score average of 2.8 or higher on a four-point scale, suggesting that *students find the FUSE challenges both doable and enjoyable*. Two of the items with the highest average scores were "I can always find something fun to do when I come to the FUSE studio" and "I like the current FUSE challenges"—which we understand as two very straightforward indicators of students' highly positive relationship with FUSE studios.

Table 6. Mean survey scores for 'doable/enjoyable' items at T3

Item	Construct	N	Min	Max	Mean	SD
The beginning levels of FUSE challenges aren't too easy and they're not too hard.	Doable	279	1	4	3.11	0.71
There are some FUSE challenges that look so hard, I don't think I could ever try them (RC)	Doable	276	1	4	2.85	0.90
I often have a hard time understanding what I need to do to complete a FUSE challenge (RC)	Doable	276	1	4	2.79	0.86
I don't like the current FUSE challenge (RC)	Enjoyable	278	1	4	3.16	0.83
I like to repeat FUSE challenges I've already done	Enjoyable	279	1	4	2.87	0.90
I can always find something fun to do when I come to the FUSE studio	Enjoyable	278	1	4	3.31	0.68
I come back to challenges that I didn't finish the first time	Likeable	273	1	4	2.82	0.69

Outcomes of the FUSE Experience

For the 'expanded opportunity' and 'collaborative problem-solving' survey items, listed in Table 7 below, we understand these as 'outcomes' of the FUSE experience. The items we call 'collaborative problem-solving' are conceptualized as under the umbrella of '21st century skills'—that is, skills that are considered desirable for success in future work environments of the 21st century (Parker, Malyn-Smith, Reynolds-Alpert & Bredin, 2010). The data from T3 survey data suggest that FUSE environment is strongly encouraging youth to collaboratively problem solve amongst their peers before seeking the guidance of their teachers—an indicator that *the FUSE environment does well to promote 21st century skills.*

The 'expanded opportunity' items elicit youth's perspectives on their ability to transfer FUSE-related experiences, interests, knowledge, and skills to school settings separate from FUSE. Overall, most youth reported moderate levels of 'expanded opportunity' as a result of their participation in FUSE studios. From interviews with FUSE facilitators, we know that making the connections between FUSE learning and school learning more explicit for the youth is a shared goal across settings—and accordingly, we suggest that the FUSE design team consider how to support facilitators with this challenge.

Table 7. Outcomes of the FUSE Experience

Items	Construct	N	Min	Max	Mean	SD
I signed up for a new class or club at school because of something I did at FUSE.	Expanded Opportunity	276	0	1	0.26	0.44
In FUSE, I have developed new skills that have helped me to do better in school	Expanded Opportunity	277	0	1	0.68	0.47
Since starting FUSE, I have made new friends who share my interest	Expanded Opportunity	276	0	1	0.58	0.49
I have a better attitude about school since coming to FUSE	Expanded Opportunity	278	0	1	0.7	0.46
When I am asked to solve a problem in another class, I am more likely to ask a friend for help before asking a teacher for help.	Collaborative Problem Solving	277	0	1	0.69	0.47

When I am asked to solve a problem in another class, I am more likely to look it up myself before asking a teacher for help.	**Collaborative Problem Solving**	**277**	**0**	**1**	**0.67**	**0.47**
When I am working on a difficult homework assignment, I am more likely to look it up myself before asking an adult for help.	**Collaborative Problem Solving**	**278**	**0**	**1**	**0.68**	**0.47**
When I am working on a difficult homework assignment, I am more likely to ask a friend for help before asking an adult for help.	**Collaborative Problem Solving**	**274**	**0**	**1**	**0.52**	**0.5**
I like to work with other people when solving challenges	**Collaborative Problem Solving**	**277**	**1**	**4**	**3.15**	**0.83**
I only try hard challenges with my friends	**Collaborative Problem Solving**	**276**	**1**	**4**	**2.36**	**0.90**

Experiences of Connected Learning: Interest Discovery and Peer Support

Connected learning describes a form of learning in which individuals pursue interests with the support of others in ways that support academic or career development, civic engagement, or enjoyment of life. The word "connected" in learning refers to ways that pursuits link youth to peers and mentors and that interests are linked to academics and careers (see Penuel & DiGiacomo, 2016).

Support for Interest Discovery

Toward the end of the experience at FUSE (T3), 65.6% of the students reported that FUSE Studios supported their discovery of new interests. Notably, 24.8% of the reported that they discovered a new interest they saw as relevant for their future work and school lives. This is important because we know that connected learning is best supported through visible connections between in and out-of-school (or formal and informal) spaces—and that environments designed to support connected learning have the potential to sustain youth engagement over time (Ito et al., 2013). Because of the consistently high percentage of youth that locate themselves in levels 3 and 4 of the Interest Discovery Construct Map, our findings are similar to that of the 2014-2015 evaluation report: *The FUSE environment strongly supports youth in discovering interests.*

Table 8. Interest Discovery in FUSE

Level	Description	Number of Youth at T3 (Percent)
4	Youth discover a new interest they can see connections to for both future work and future school.	62 (24.8%)
3	Youth discover a new interest they can see connections to for work or school (but not both).	164 (65.6%)
2	Youth discover a new interest.	22 (8.8%)
1	No interest discovery.	2 (0.8%)

Peer Support

Nearly all (approximately 94%) of FUSE Studios participants who took the survey toward the end of their FUSE experience (at T3) experienced the learning environment as high in peer support Notably, there was also a substantive percentage (44%) of students who reported that peer *brokering* exists in FUSE Studios (seen at Level 4 of the below construct map). 'Brokering' in a connected learning environments refers to the activity of referring people to new activities to deepen their interests; it can be done by adults in a center or by peers (Ching, Santo, Hoadley, & Peppler, 2015).

Table 9. Peer Support by Level on Construct Map

Level	Description	Number of Youth at T3 (Percent)
4	Peers provide avenues to new opportunities and resources, with the chance to deepen and pursue interests through exchange of ideas during FUSE challenges.	112 (43.9%)
3	Peers provide support through teaching and helping within FUSE challenges.	128 (50.2%)
2	Peers provide modest to minimal support through teaching and helping within FUSE challenges; Student mostly keeps to her/himself while doing FUSE challenges.	14 (5.5%)
1	Peers provide limited or no peer support for participation within FUSE challenges and student reports to work alone while at FUSE.	1 (0.4%)

The percentage of youth located in the top two levels of the Peer Support Construct Map suggest that similar to the evaluation findings from 2014-2015, *the FUSE environment is an environment replete with peer support*.

3. How do youths' attitudes toward STEAM relate to their experiences of the FUSE studio learning environment and their participation in the challenges?

Student attitudes toward STEAM-fields: Relating studio experiences to connected learning principles

The largest survey data set from the 2015-2016 school year comes from the nearly 1500 student responses to the T1 survey, which was a survey comprised of items related to their attitudes toward the fields of Science, Technology, Engineering, Arts/Design, or Math, as well as a handful of items related to attitudes about collaboration and self-efficacy. To get a sense of if and how particular student responses were associated with particular factors, we ran an exploratory factor analysis on the STEAM-related items, and the initial scree plot indicated 5 factors. We proceeded to extract the 5 factors. Given the generally correlated nature of orientations toward Math, Science, and Engineering, we used a promax rotation which allows the factors to be correlated. The 5 factors we found were Science attitudes, Math attitudes, Engineering attitudes, Collaboration/Self Efficacy, and Career interests. For this analysis, we were interested in baseline (T1) Science, Math, and Engineering attitudes so we focused on the first three aforementioned factors. This is important because we wanted to get a sense of the potential differences or sample bias (if any) between students with multiple survey data points (e.g. who took the survey more than once over time) and those with one singular survey data point (those who only took one or less survey during their time at FUSE).

Next, we examined the reliability of those factors as scales. The Science attitudes scale had a Cronbach's alpha of .862, the Math attitudes scale had a Cronbach's alpha of .877, and the Engineering attitudes scale had a Cronbach's alpha of .905, indicating high reliabilities on all three scales. We then calculated a scale score for each student by calculating their mean score for each scale, which is illustrated in bolded bullet points below.

We chose this approach to creating scales because we didn't want to lose entire student cases because they did not answer one question on the scale.

- Science: Mean (2.88), N=1468
- Math: Mean (3.14), N=1456
- Engineering: Mean (2.98), N=1441

The group of students that took the T1 survey had a stronger positive attitude toward Math than they did toward Science or Engineering, but all three scales had means that leaned more toward the 'agree' (or positive) end of the scale than the 'disagree' end, suggesting an overall positive attitude toward these fields for nearly 1500 students that took the survey at Time 1.

The next step in our analysis was to compare the means of the separate scales (Science, Math, and Engineering) for those students that took both survey T1 and T3, to investigate any potential changes over time as related to their exposure to FUSE. As noted above, we received far less student responses to surveys T2 and T3 overall, and even fewer responses from students with multiple data points (again, those that took more than one survey over time). Cognizant and responsive to analyzing data with a small 'N', we created models (using the below bolded equation) that allowed us to see the relationship between students' experience of the FUSE environment (as indexed by their reported levels of interest discovery and peer support) and their final attitudes towards Engineering, Math, and/or Science.

- POST (e.g. T3) Math, Science, or Engineering STEAM Attitude = PRE Math, Science, or Engineering Attitude (e.g. T1) + T2 (Peer Support Level) + T3 (Interest Discovery Level) + error

Analysis of the data using the above equation suggest the following:

- More positive student attitudes toward the Science at T3 is predicted by high levels of student reported 'Interest Discovery' levels at Time 3 and by their TI Science attitude (the latter of which is neither surprising nor consequential)
- More positive student attitudes toward Engineering at T3 is predicted by higher levels of student reported 'Interest Discovery' levels at Time 3 and by their T1 Engineering attitude (the latter of which is neither surprising nor consequential)
- The only significant predictor of Math attitudes at T3 is Math attitudes at T1 (which is again neither surprising nor consequential)

Data reveal that those students who reported higher support for interest discovery in FUSE also reported more positive attitudes toward science and engineering. The positive association held up even when students' baseline attitudes are accounted for. This analysis provides some preliminary evidence that those who experience the FUSE environment as supportive of interest discovery develop more positive attitudes over time toward science and engineering. Simply put, FUSE's support for interest discovery was associated with better attitudes toward engineering and science.

Relating STEAM attitudes to challenge participation groups
We employed an ANOVA analysis to test the means for significant difference of STEAM attitudes among

challenge participation groups. With regard to math attitudes in relation to the challenge participation groups (two or more challenges with leveling up, two or more challenge completions, attempted challenge, and single challenge with leveling up) the mean math attitudes were essentially the same across the groups, with a slightly lower baseline math attitude for youth in the 'attempted challenge' category. Of all the three categories of STEAM attitudes, only math revealed a significant ANOVA result, illustrated in Figure 2 below.

Figure 2. Baseline Math Attitudes Across Challenge Groups

For science and engineering attitudes, there was no significant difference between participation groups. See Figure 3 and 4 in the appendix for baseline science and engineering attitudes across challenge groups.

4. How does local adaptation relate to youths' experiences and patterns of participation within FUSE studios?

To investigate the ways in which local adaptation influences student experiences and outcomes of FUSE, we interviewed nine teachers (aka facilitators) who used FUSE in their classrooms during the 2015-2016 school year. We chose teachers who use FUSE differently in their various contexts, attempting to garner a representative sample of local adaptation -- such as using it as a graded replacement for a previous 'Applied Tech' course, to offering FUSE as an afterschool credit-supplemental club, or as a voluntary in-school elective. We designed our interview protocol to elicit the teachers' goals of having FUSE at their site; to understand how those goals shaped the particular ways FUSE is implemented or adapted locally; and to get insight into the aspects of FUSE that supported larger school goals, as well as those that don't fit. With these questions, we aimed to get a practice-oriented perspective on the way teachers are making sense of the FUSE curricula in relation to the broader practices of teaching and learning in which they are engaged (Dreier, 2008, 2009). See Table 10 below for a brief overview of facilitator studio type, strategies, and goals, which reveals consistency and variance among the nine studio contexts.

Table 10. Focal studio characteristics

Facilitator	Studio	Facilitator Strategies	Facilitator Goals
Jen	Mandatory + voluntary; 5 days/week; single age; uses grades	Pre-FUSE challenges; one-on-one student conferences; challenge and/or level requirements; social norms around challenge engagement; strategic challenge release schedule; whole class check-in's	Cognitive + Non-cog. skills
Wes	Voluntary; 2-3 days/ week; non-graded	Informal student monitoring	Non-cognitive skills
Fred	Voluntary; single age; 4 days/week; uses grades	Extension strategies; one-on-one student conferences; challenge and/or level requirements; whole class presentations; guest speakers; informal student monitoring;	Cognitive + Non-cog. skills
John	Mandatory; multi-age; 2 day/week; non-graded	Strategic challenge release schedule; classroom progress poster; naming the class/content expert; extension strategies; informal student monitoring	Cognitive + Non-cog. skills
Cindy	Mandatory; multi-age; 2 day/week; non-graded	Classroom progress poster; making space for student presentations; informal student monitoring; strategic challenge release schedule; naming the class/content expert	Non-cognitive skills
Sean	Mandatory; multi-age; 2 days/week; non-graded	Strategic challenge release schedule; Whole class check-in's; naming the class/context expert; informal student monitoring; extension strategies; social norms of challenge engagement; materials monitoring	Non-cog. skills + Creativity
John	Voluntary (afterschool club); non-graded; daily	Extension strategies; field trips; informal student monitoring;	Cognitive + Non-cog. skills
Stephan	Voluntary; multi-age; daily; uses grades	Extension strategies; field trips; guest speakers; strategic challenge release schedule; whole group check-in's; whole group projects; informal student monitoring;	Cognitive + Non-cog. skills
Corey	Voluntary; multi-age; graded; 1 day/ week	Whole class check-in's, physical manipulation of space; informal student monitoring; naming the class/content expert	Cognitive + Non-cog. skills

Alongside broad, inductive and then thematic coding (Miles & Huberman, 1994) of the teacher interviews, we analyzed both the challenge data of the students in the focal studios as well as survey data from focal studios. The purpose of this approach to analysis was to relate organization-level variations in goals and supports to patterns of youth participation and to use teachers' perspectives across context to better understand the ways in which FUSE studios supports and/or constrains the productive adaptation of the FUSE program.

Table 11. Overview of focal studios data

Teacher/District/State	Studios	Student challenge data	Student survey data (@T3)
John/Schaumburg/IL	1		15
Cindy/Schaumburg/IL	1		25
Sean/Schaumburg/IL	1		20
Stephen/CPS/IL	1		11
Fred/California	3		0
Jen/Crystal Lake/ IL	5		0

Wes/Ohio	1		0
Corey/CPS/IL	1		0
John/CPS/IL	1		0

Student outcomes by focal studio

Experiences of connected learning by focal studio

As Table 11 illustrates above, there were four teachers whose students took the survey at T3 (toward the end of their experience with FUSE), providing a total of 60 focal students to analyze. We hone in on these data because we wanted to get a sense of how students in the focal studios were experiencing the FUSE learning environment, again with regard to the CL principles of interest discovery and peer support. In the following sub-section, we again draw upon this T3 data to get a sense of their attitudes about STEAM toward the end of their FUSE experience.

We employed an ANOVA analysis *between* the four teacher groups—and found no significant difference in construct map levels of CL experiences of interest discovery and peer support. This suggests that local adaptation practices among these four teachers is not significantly altering the connected learning experience that the FUSE environment is providing. However, when we ran an ANOVA analysis by comparing the pure means of interest discovery and peer support—there is a significant difference between groups in *peer support.* For example, John's Schaumburg studio reported the highest mean of peer support, while Sean's Schaumburg studio saw the lowest overall means, as illustrated in Table 12 below. With regard to the comparison of overall mean scores for interest discovery among studios, we find no significant difference among studios; but we do see that once again John (Schaumburg) and Stephen (CPS) had highest reported levels of interest discovery while Cindy and Sean had the lowest.

Table 12. Mean interest discovery and peer support by focal studio

Focal Teacher	Mean ID*	Mean PS*
John, Schaumburg	14.0	15.5
Cindy, Schaumburg	12.8	14.1
Sean, Schaumburg	12.7	12.0
Stephen, CPS	13.6	14.5

*Out of a possible ID score of 19 and PS score of 17

In sum, we do not find significant difference between the student-reported levels of connected experiences of interest discovery and peer support across teacher groups. While there is a difference in overall sum scores for these two CL experience among the four teacher groups, it is important to note that *all four focal studios experienced relatively high levels of interest discovery and peer support.*

STEAM attitudes by Focal Studio

When we employed an ANOVA analysis between the four teacher groups in relation to the students' attitudes toward STEAM toward the end of their experience with FUSE (@ T3)—we found a significant difference among teacher groups in *math* and *science* attitudes. This suggests that among the four focal teacher groups for which we have survey data at T3, some studios are doing better than others in supporting students' positive orientations toward Math and Science. With regard to engineering, there was no significant difference among groups. As Table 13 reveals, John's studio saw the highest math and science scores, which suggests that in his studio, he is doing especially well to support positive attitudes toward present and future participation in Math and Science related fields.

Table 13. Mean math and science attitudes by focal studio

Focal Teacher	Math*	Science*

John, Schaumburg	3.6	3.14
Cindy, Schaumburg	3.0	3.0
Sean, Schaumburg	3.0	2.6
Stephen, CPS	3.2	2.5

*Out of a possible score of 4 on both Math and Science

Student participation patterns by focal studio

We employed a handful of approaches to analyzing the participation patterns among students involved in the focal studios. As Table 11 above revealed, there are X amount of students for whom we have 'challenge' data on and for whom participated in a focal studio. Similar to the analyses conducted in the rest of this evaluation report, we analyzed student participation patterns in focal studio in relation to 1) how they participated in FUSE challenges (e.g. their participation challenge group) and 2) what challenges they participated in as well as overall studio 'activity.'

Challenge participation patterns by focal studio

# of kids in each group by focal teacher (table that KVH will produce) and analyze this.

Type of challenge participation by focal studio

When compared with overall participation rates in various types of challenges (kit only, software only, Engineering or Art/Design focused, participation patterns within the focal studios are similar in some ways and distinct in others. For example, 6 out of the 13 studios (that are led by the 9 focal teachers) participate in software-only challenges more than they participate in kit-only challenges. This is different than the overall pattern (among the 124 studios) which shows that the most 'popular' of student challenges, with regard to engagement, are the software only challenges. In overall studio pattern, the most popular challenges involved Art/Design, 3D design and/or 3D printing. Amongst the focal studios, the percentage of engagement in Art/Design was also notably higher than other content areas like material science, coding, music or physics; though the percentage engaged in challenges requiring 3D printing varied among focal studios. And, while percentage of students engaged in challenges that involved Engineering varied from 11.8% to 19.4% across focal studios, it is worthwhile to note that across all studios, Engineering-related challenges were those most frequently 'completed' (recall Table 3).

Table 5. By studio challenge-type engagement

	Engineering	Software Only	Kit Only	3D Printing	Art/Design	Material Science	Coding	Music	Physics
Studio	by %	by %	by %	by %	by %	by %	by %	by %	by %
Fred	15.1	13.2	17	7.5	18.9	13.2	3.8	3.8	7.5
Fred	14.5	14.5	16.4	7.3	20	12.7	3.6	3.6	7.3
Fred	15.1	13.2	17	7.5	18.9	13.2	3.8	3.8	7.5
Wes	14.8	14.8	18.5	3.7	18.5	11.1	3.7	7.4	7.4
Corey	13.7	15.7	15.7	9.8	17.6	11.8	5.9	3.9	5.9
John	15.1	13.2	17	7.5	18.9	13.2	3.8	3.8	7.5
Jen	19.4	16.1	12.9	12.9	22.6	6.5	3.2	3.2	3.2
Jen	17.5	17.5	12.5	12.5	22.5	7.5	5	2.5	2.5
Jen	15.4	17.9	15.4	7.7	12.8	10.3	12.8	0	7.7
Jen	11.8	17.6	11.8	5.9	29.4	11.8	0	5.9	5.9
John	16.1	14.5	14.5	8.1	19.4	9.7	4.8	4.8	8.1
Cindy	15.6	15.6	14.1	7.8	18.8	9.4	6.3	4.7	7.8
Sean	17.5	15	15	7.5	17.5	12.5	5	2.5	7.5

Nature of challenge participation by focal studio

To explore how challenge data related to our conjectures from qualitative data about the nature of 'co-participation' at FUSE studios, we analyzed challenge data to represent how often youth participated together in a challenge. Co-participation, then, as evidenced by students 'tagging' each other online during the completion phase of a challenge level. This analysis, as well as the overall counts student engagement in a challenge (as evidenced by the number of 'starts' and 'completes') is presented by focal studio in Table 16.

Table 16. Co-participation and activity counts in focal studios

Facilitator	Mean group size @ 'start'	# of challenge levels 'started'	Mean group size @ 'complete'	# of challenge levels 'completed'
Jen	1.12	1,097	1.36	164
Wes	1.11	1,863	1.19	442
John	1.06	832	1.29	233
Cindy	1.06	1,126	1.62	268
Sean	1.12	1,624	1.28	231
John-CPS	1.09	1,114	1.24	237
Corey	1.12	547	1.35	87

*At the present time we are unable to analyze these numbers for Stephen's classroom

Across focal studios, co-participation means rise when analyzed by 'completes' (aka students finish a challenge together) versus 'starts' (when they begin the same challenge together in the same room). Of note within the focal studios, Cindy's classroom has a markedly higher co-participation rate than the other focal studios, suggested that she is doing well to create a highly collaborative learning environment. Wes's studio, on the other hand, has a more average co-participation rate, yet a notably high number of challenge levels 'completed' as compared to other focal studios, suggesting that he is doing well to encourage students to 'level up' through particular challenge sequences.

Overview of focal studio analysis

Teachers employ a variety of strategies when using FUSE studios in their classrooms, including creating physical posters to highlight student collaboration and progress, instilling daily whole class check-in's and reflection/sharing time, strategically releases challenges over time, and/or requiring participation grades. In addition, all teachers report positive relationships to the 'choice'/youth-interest-driven nature of the FUSE studio. In particular, FUSE facilitators often told us that the best part of using FUSE in their classroom was getting to opportunity to provide a learning environment where youth choice, 'failure', and peer-supported problem-solving through collaboration were foregrounded—making visible the compatibility of central FUSE design principles even within school-based adaptations.

Across the nine FUSE school-based studio sites throughout the nation, students experience the FUSE environment as a robust space for learning, one replete with both 'peer support' and support for 'interest discovery' (Ito et al., 2013). Such findings remain consistent despite a high degree of variability in local program adaptation-- at the district, school, and classroom levels. We suggest that the FUSE studio learning environment is doing well to design and support for productive adaptation: "evidence-based curriculum adaptations that are responsive to the demands of a particular classroom context and still consistent with the core design principles and intentions of a curricular intervention" (DeBarger, Choppin, Beauvineau & Moorthy, 2013, p. 298).

Recommendations

Recommendation: Maintain commitments to student choice and culture of peer support.

We are confident that the FUSE studios environments are currently cultivating a strong culture of peer support and interest discovery. The majority of youth reported that the FUSE studios provide avenues to new opportunities and resources, with the chance to deepen and pursue interests through exchange of ideas during FUSE challenges. The program leaders should do their best to maintain these high levels of student choice and peer support, and even consider how to broaden the scope of challenges made available to students per site or by grade level, with the potential to diversify the range of experiences for all students.

Recommendation for Program Improvement: ***Design 'extension/mash-up' strategies for facilitators to encourage youth to 'go beyond' the completion of FUSE challenges and to ameliorate diminishing engagement over time.***

Recommendation for Program Improvement: ***Facilitate cross-site interaction and learning about local adaptation strategies and successes.***

Recommendation for Program Improvement: ***Encourage 'leveling up' as much as cross-challenge exploration….***

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Appendix

Facilitator Interview Protocol

- **Can you tell us what your current role is at the school?**
- **How did you come to have this role?**
- **How did you come to be involved with FUSE?**
- **What is your role within FUSE as a facilitator/leader?**
- **What do you see as your role in the FUSE research?**
- **What do you want your students to get out of participating in FUSE? (i.e., What do you hope they get out of it?)**
- **How would you describe FUSE to a colleague?**
- **Why do you think the district (or school leadership) chose to implement FUSE?**
- **Can you describe a typical week, in terms of how often and with whom you work with FUSE?**
- **How do you currently implement FUSE in your school? (Probe: Describe a typical day and week when FUSE is being implemented)**
- **Has it always been this way, or has this changed/evolved since you started? (Describe)**
- **How do you know if your students are getting something out of FUSE? What about from the point of view of students?**
- **Do you ever assign grades in FUSE? What do you base those grades on?**
- **In what ways (if any) do you organize student activity (?) when your students are doing FUSE (mandated groups, voluntary independent work, etc.?)**
- **What have you noticed about student engagement during FUSE?**
- **Do you notice this impacting classroom dynamics (in or outside of FUSE studios in other ways?**
- **Can you tell me a little about the way that FUSE is perceived in the broader context of your school? And the support you receive for FUSE from your peers/administrators?**
- **What are the greatest challenges you've experienced with using FUSE in your classroom? And the greatest benefits?**
- **In what ways do boys and girls engage FUSE challenges similarly? differently?**
- **Have you noticed new relationships between students forming in FUSE? Have any of these been surprising to you? If so, what about the FUSE environment might explain these new relationships?**

- **Are there some strengths of individual students that only come out in FUSE? If so, what are they? Are there some students that struggle in the FUSE environment? What makes them struggle?**

Figure 3. Baseline Science Attitudes Across Challenge Groups

Figure 4. Baseline Engineering Attitudes Across Challenge Groups