Best Practices for Facilitation in a Choice-based, Peer Learning Environment: Lessons From the Field

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Abstract: Teaching is one of the most extensively studied topics in education research. However, most studies of teaching assume a standard learning arrangement, in which the teacher is the content expert and directs student learning. What happens when this is not the case, when the resources for learning lie elsewhere (online, other students) and the expertise that the teacher brings is in how to facilitate learning rather than convey content? How do teachers navigate the role of 'facilitator', and what are the pedagogical best practices for doing so. Here, we address these questions by examining facilitation in one set of in- and after-school making and learning environments, called FUSE. Drawing on student and teacher interviews, classroom observations, and video, we analyze the needs experienced by facilitators and the tools and practices they implemented to address those needs.

Teaching is one of most extensively studied topics in education research, with handbooks going back over 50 years (Darling-Hammond & Bransford, 2005; Gage, 1963; Lanier & Little, 1986; Travers, 1974). However, this literature shows an implicit, but significant, bias toward teaching and learning conducted within the standard arrangement of classroom instruction – in which the teacher is the content expert and directs and evaluates student activity.

Studies of informal learning provide small glimpses into alternative approaches to teaching and learning. For example, Paradise and Rogoff (2009) described a *learning arrangement* (Stevens, Satwicz, and McCarthy, 2008) they termed *learning by observing and pitching in*, in which learning occurs by watching an adult within the context of everyday activity. At first, learners might help out and ask questions. Then as they gain expertise, they can become a fuller participant, eventually becoming able to do it on their own. Rogoff and colleagues have documented this form of learning extensively in out-of-school contexts, particularly in home-based interactions between children and parents, and they've explicitly contrasted it with the ways in which learning is typically arranged in schools. A similar contrast was made by Becker (1972), in comparing the apprenticeship model of learning that takes place in many workplace environments to learning in schools. In this model, learning occurs similarly to the model documented by Paradise and Rogoff. An added element made explicit by Becker, however, is that in on-the-job situations, newcomers guide their own learning, deciding what they want to learn, when, how, and from whom. They may also get to decide when they feel proficient enough to demonstrate competence by taking a certification test or taking on a particular task without assistance. This contrasts with school, where the teacher dictates what is being learned, how, and from whom, and assessment happens at a time and in a format of the teacher's choosing.

However, in the learning arrangements described by both Paradise and Rogoff (2009) and Becker (1972), the adult is still more knowledgeable about content matter and is ultimately the resource from which learners are learning, in whatever format. What happens when this not the case, when the resources for content learning lie elsewhere (e.g., online, other students) and the expertise that the teacher brings is in how to facilitate the learning process rather than how to convey content?

FUSE (the learning environment we examine here) represents such an alternative infrastructure (Stevens, et al., 2016) for learning in- and after-school. It was designed based on research on informal learning (e.g., Becker, 1972; Cole, 1996; Stevens, et al., 2008) and involves 29 STEAM challenge sequences, housed on the FUSE website, which are designed around the video-game model of 'leveling up' to unlock higher levels of increasing difficulty and complexity (Salen & Zimmerman, 2005). Challenges are done using both open-source software and physical tools and materials (e.g., 3D printers, breadboards). FUSE differs from a traditional classroom environment in that students choose what challenges to do, at what pace, when to leave challenges, and whether to work alone or with others, based on their individual interests and learning preferences. In FUSE, the teacher also plays a different role than in a traditional classroom, serving as facilitator rather than instructor and being only one of many resources on which students can draw (others include peers and both written instructions and help videos on the FUSE website). Teachers do little pre-prepared, whole-class presentation, but rather, circulate around the room working with different individuals and groups. There is typically little or no formal assessment or grading but a great deal of informal evaluation and feedback on the process and products of students' work. As a result, running a program like FUSE not only requires new materials and modes of work but also new ways of guiding learning and new demands on teachers' capacity to support learners (Wardrip & Brahms, 2016).

FUSE bears some resemblance to makerspaces, in that the primary mode of activity and means of learning is the design and construction of personally meaningful physical and digital objects, using both high-tech and low-tech tools. However, there are also important differences between FUSE and makerspaces. Some makerspaces are built on a workshop model, where an instructor leads learners in doing a specific project with particular materials, while others simply let participants loose to learn with minimal facilitation, expecting them to teach themselves or each other (Blikstein & Worsley, 2016). Both these models have been critiqued for either over-constraining (workshop model) or under-supporting (open-ended makerspace) learner activity (Blikstein & Worsley, 2016). In contrast, FUSE takes a middle path. It provides more structure and support than open-ended makerspaces – in the form of leveled challenges with written instructions and help videos. However, it also provides more freedom than a making workshop – by allowing participants to choose what challenge to do, from a gallery of 29 options. Finally, while some makerspaces are built on a mentor model, where experts are available as resources in a space (Honey & Kanter, 2013), FUSE neither expects nor positions the adult in the room to be a content expert. This is important, because FUSE facilitators are largely K-12 teachers, who don't necessarily have prior experience in making or STEAM.

Therefore, insights from FUSE on best practices for facilitation may be particularly informative for school-based educators looking to implement and facilitate making activities or spaces at their schools. This addresses a gap in the current literature, as the majority of the literature on makerspaces focuses on learners and learning rather than on the role of teachers or facilitators, and what research has been done has focused on out-of-school contexts, such as museums (e.g., Brahms & Crowley, 2016) where a facilitator is supporting both youth and parents in learning together, creating a different learning arrangement. As makerspaces and other hands-on, project-based activities grow in popularity and, increasingly, make their way into schools (e.g., Honey & Kanter, 2013; Martinez & Stager, 2013), it is important that we address this gap in the literature, not only for researchers and designers, but also for teachers, who increasingly find themselves thrust into these roles without much guidance on how to navigate them.

Method

Since its inception in 2012, FUSE has grown from two afterschool implementations to roughly 200 in-and after-school programs across 26 U.S. States and in Helsinki, Finland. Over the last seven years, we have studied a number of these different implementations, in different ways. However, to date, our analyses have primarily focused on student interest development and learning or the spread of educational innovations.

Here we draw on two sets of previously collected data to instead examine facilitator practices and adaptations. The first of these is a year-long ethnographic study of student interest development and learning in seven FUSE studios at three elementary schools in one large, diverse, Midwestern school district, which took place during the 2015-16 school year. Data collected included observations, field notes, and video recording, using both stationary and wearable cameras, during every FUSE session (twice per week for 90 minutes total, for the entire school year). We also conducted end-of-year semi-structured interviews (Charmaz, 2006) with 57 fifth and sixth grade students and eight facilitators. The second data source came from a project aimed at understanding how educational innovations spread and involved the study of 57 schools implementing FUSE as a new program during the 2017-18 school year. From this diverse set of 57 schools, we selected 17 focal cases for close analysis, which were representative of the larger dataset in terms of student and school characteristics and proposed ways of implementing the program. We studied FUSE at these schools over two school years, each year conducting both beginning and end-of-year interviews with facilitators and administrators, end-of-year interviews with students, and observations of classroom activity, accompanied by video and field notes.

Drawing on grounded (Glaser & Strauss, 1967), distributed (Hutchins, 1995; Latour, 2005), and interaction analysis (Hall & Stevens, 2015; Jordan & Henderson, 1995; Stevens & Hall, 1998) approaches, we analyzed these data, in order to understand the needs experienced by facilitators and the tools and practices that they implemented to address those needs. We also analyzed the outcomes of particular tools and practices to understand their relative efficacy.

Findings

Our analysis of the needs experienced by facilitators yielded seven main categories, including: (1) guiding students toward relevant resources; (2) encouraging or rewarding desirable skills and practices; (3) assessing student performance or growth; (4) encouraging students to reflect on learning; (5) maintaining materials; (6) maintaining student engagement; and (7) making connections between challenge activity and STEAM careers.

Tools and practices created to address these needs fell into three categories: (1) classroom routines, (2) interactional practices, and (3) teacher-created artifacts. In the sections that follow, we describe each of the seven needs and provide examples and analysis of efficacy of the tools and practices created to address each.

Guiding students toward relevant resources

One of the biggest things that facilitators reported that young people learned in FUSE was the ability to find resources to solve their own problems. However, this required both facilitators and students to make a shift from a traditional school-based model of learning, where the teacher is the primary content expert and resource in the room, to the FUSE model, where students are expected to find information themselves. As a result, facilitators articulated the need to help learners find resources to problem-solve independently, saying, for example, "Some of [the students] have a difficult time finding information on their own, conducting searches, or remembering to go up to the help menu, or how to find resources that help them solve their problems on their own."

Some facilitators have addressed this need by employing specific interactional practices, such as redirecting a young person who comes to them for help by saying "Did you read the directions on the website?" or "I think [classmate's name] just had that same problem, why don't you go ask them?" Others have created physical artifacts to assist students in finding information resources (specifically peers with relevant expertise). For example, we've seen a variety of different variations on the idea of an expert board – a whiteboard or bulletin board posted somewhere in the room where participants' names are listed next to challenges where they have expertise (and therefore can be a resource for their peers). Figure 1 shows three examples.

Figure 1. Three versions of expert boards: spreadsheet (left), star board (middle), and boss board (right).

Important to notice about the different versions of the expert board is that some serve their function better than others. For example, on the spreadsheet (left) each student participant was represented by their own row, and students filled in the box next to every challenge level they'd completed. This was not particularly effective as a resource guide, as it highlighted individual student progress more than who might have expertise on a particular challenge. In contrast, for the star board (middle), after a student finished a level of a challenge, they would put up a star next to that challenge, indicating that they had challenge expertise. This worked well, in that it foregrounded the challenges on which another student might need help and then clearly displayed names of peers with relevant expertise. However, it had the disadvantage of failing to distinguish the class period of a particular student. As, in this particular FUSE studio, multiple classes rotated through the space every week, a peer with relevant expertise could easily be from another class and therefore not be accessible. The Boss Board (right) does the best job of directing students to relevant resources, as it not only highlights challenges first and then explicitly names students with expertise on those challenges, but it distinguishes between student experts in different classes, so that students in any particular class know who to seek out in their specific class.

Encouraging or rewarding desirable skills and practices

The expert board, in all of its variations, also addressed a second need, articulated by facilitators, the desire to encourage or reward desirable skills and practices. However, there were many other practices, routines, and artifacts that facilitators implemented to serve this same function. Informal practices included words of encouragement from facilitators when students eventually figured out something they'd been struggling with, helped another student solve a problem, or created a sophisticated artifact. However, facilitators also implemented more formalized practices to address this need. For example, in one class, a facilitator created a travelling "Engineer Award" (a 3D-printed golden wrench). When the facilitator first created the wrench, he had the whole class sit down and collectively brainstorm a list of characteristics or practices that might earn a student the wrench (e.g., persevering, helping, creating new things, being on-task, working hard, leveling up, and problem-solving). Then, each week, the student who had won the wrench the previous week would nominate a new student to be awarded the wrench. This required the student to identify the reason for the nomination and to get the nomination “seconded” by either another student or the facilitator. In explaining the reasoning behind the creation of the Engineer Award, the facilitator who’d created it told us a story about a group who had worked really hard on a challenge and persisted in spite of problems, then said, “I think it was so cool that they had that problem, they worked through it, they tried different things. Then it worked, and they were so excited about it. How do we recognize that as a class? That led to the creating of the wrench.” In a second classroom, another teacher imitated this practice (after hearing about it at our two-day professional development workshop for new teachers). However, in that classroom, the facilitator determined the criteria for receiving the award and did the awarding himself, removing the critical piece of getting students to think about what characteristics were desirable in the FUSE space and giving them agency over how and when to reward those characteristics.

A related practice, which originated from the same facilitator as the “Engineer Award”, was the routine of giving “woots” at the end of each class period. During the last five minutes of each FUSE class this facilitator would direct the class’s attention to an overhead projection of the studio activity feed on the FUSE website (which shows all challenge level completions, by username, for a given FUSE studio). He would then read down the list and announce which students in the room had leveled up on which challenges that day and lead the class in saying “Woot woot!” for each of them. This routine not only rewarded a specific desirable practice (completing a challenge level and leveling up), but it also encouraged a classroom culture of supporting the success of others. It had a secondary benefit of letting students know who might be expert in particular challenges, but because it was transitory and took place at the end of the class period, it was likely not as effective for this purpose as the expert boards. We also saw different variations on this routine, such as facilitators leading whole-class reflections at the end of class or using a learning management system to digitally award points to students who had leveled up or exhibited desirable behaviors, such as helping others.

A final way in which facilitators used artifacts to encourage desirable skills and practices was related specifically to 3D-printed artifacts. The 3D printers and accompanying 3D design challenges are some of the biggest draws for student interest in FUSE. However, 3D printing is also complex and often fails to achieve desired results for a variety of reasons. As a result, facilitators have used 3D printed artifacts in two different ways to encourage desirable skills and practices. Some display successful 3D printed artifacts for others to see, as a way to celebrate student success. Others have created a table or wall of failed 3D prints, in order to encourage students to accept and learn from failure. Both types of artifacts seem to be effective at achieving their desired goals, but the table or wall of failed prints seems to have a particular impact on students’ acceptance of difficulty and ability to persist through failure. For example, when we asked one student from a class with a table of failure what they had learned in FUSE, they said, “I learned that 3D printing is a lot harder than you'd think. There could be some difficulties and then you'll definitely make mistakes, because it's really hard at points, but you'll get the hang of it, and it's really fun.”

Assessing student performance or growth

Although many facilitators organized FUSE as a completely ungraded experience, some facilitators felt either a personal need or external pressure to assess student performance or growth in FUSE. For example, some facilitators wanted to have a sense, for themselves and their students, of what learning was taking place and what growth was occurring over time. Often, in these studios, assessment was fairly informal. For example, when asked whether and how they were assessing learning, one facilitator said, “I'm not assessing learning, like it's pretty much informal assessment. I'm watching, I really watch the children. I watch, you know, ‘Are they engaged?’ That's a huge telltale sign if they're working with other people, if they're problem solving.”

However, other facilitators faced pressure to assess student learning from administrators or school and district policies that required some form of assessment. For example, one facilitator explained that because FUSE was being used as part of the school’s science curriculum, it needed to be assessed in relation to the Next Generation Science Standards, saying, “Um, so we, right now, we're looking at how to align what they're doing to the practice standards for science so that they can be formally assessed for FUSE, because…we're only going to FUSE one day a week, but that one day a week is taking a science period. So that’s ultimately an assessment that’s being lost.”

In practice, assessment took a number of different forms, including observation rubrics, capstone projects, presentations of student work, and written reflections. Some assessment, such as observations rubrics, were relatively unobtrusive for students and lightweight for facilitators to implement. For example, at one school, facilitators developed a 21st century skills rubric. Each week they picked a particular skill to focus on, and while they were observing and working with students that week, they gave each student a score on that skill. Others, such as capstone projects, naturally extended challenge work and engaged students. For example, in her end-of-year interview, one student proudly told us about how she does cosplay (dressing up as a character from a movie, book, or video game) and how for her capstone project, she had used an Arduino and Electric Apparel challenge materials to create a jacket with a giant eye on the back that blinked open and shut. Still other forms of assessment, such as written reflections, however, were met with resistance, as they interrupted challenge work, were more prescribed, and were viewed by students as less useful and less engaging. For example, in one class we observed, when students were doing FUSE challenges, they needed no extrinsic incentives. In fact, the facilitator talked about how the students who often engaged in problem behaviors during science class did not display these behaviors during FUSE. However, when the facilitator asked students to do written reflections, many complained or effectively refused to do them. As a result, the facilitator had to incentivize the practice by telling students they could either do the reflections and get an A for the day or abstain and get a failing grade. This facilitator also told them they couldn't leave until they had finished, but even then, some students turned in reflection sheets that were only partially complete. This indicates that, from a student perspective, written reflections were not the best form of assessment for this environment.

Encouraging students to reflect on learning

On the other hand, many of the facilitators who used student reflections as a form of assessment, also described the value of getting students to be both intentional and reflective about their learning. On the benefit of periodic reflection, one facilitator commented, "It's kind of a nice way of making it visible for them too, because the change is so incremental that if they reflect at the end to what they saw at the beginning…"

In practice, structured student reflections took a number of different forms. One was daily or weekly written reflections, in which students were required to individually respond to specific writing prompts, reflecting on their work (e.g., "What were two challenges you overcame today, and what did you do to overcome those hurdles?"). Another was a weekly video reflection. Still another was whole-class reflections at the end of each class period, where students were asked to respond collectively to prompts. For example, one facilitator described this practice, saying, "[U]sually at the end of period, as long as we have time, I bring them back together, and I say okay who had a success today who had a fail today? …How did today feel?"

In general, facilitators believed that reflection practices were achieving their desired goals. For example, facilitators mentioned the quality of reflections improving over time, saying things like, "some of the reflections, like at the beginning were very simplistic, like 'Yeah, didn't work for me today' or 'Yeah, I didn't enjoy it.' And then growing into a little bit more of explaining what didn't work or what they were going to try differently." Facilitators also had positive things to say about the benefits of whole group reflection. For example, one facilitator described students' sharing during whole-class reflections, saying, "They've been so honest and candid with their reflections. It's awesome to see. There's no holding back in these group shares. They talk about the things that are frustrating them, and the students are naturally supportive of each other." However, as mentioned in the previous section, written reflections, in particular, were not viewed as positively by students.

Maintaining materials

Facilitators also expressed a need for strategies to maintain materials. The biggest challenge here, particularly for facilitators who didn't have much technological experience, was maintaining the 3D printers. For example, one teacher said, "[O]ur 3D printers, it's been a struggle with them, like I think I've had them running like three days out of the whole school year." However, maintaining the physical materials for other challenges (which arrive organized into kits for each challenge) proved challenging for some facilitators as well. For example, one facilitator said, "Whoever it is that's running the classroom really has to be okay with how much effort, time, and energy it takes to properly manage the materials so that you have them ready for the kids."

Facilitators dealt with this need in a number of different ways. First, when it came to maintaining the 3D printer, facilitators took one of two approaches. Some took control of the printer themselves, not allowing students to touch it, out of fear that they might break the printer. For example, one facilitator said, "I'm still trying to involve the kids more in the print process. That's my big struggle. Mostly because the printers fight with me so much that it makes that hard for me to turn them over, because I'm going to be right there with them trying to fix anything like that." In these classrooms, if a student wanted to print, they had to add their name to a queue, and the facilitator would print their objects for them. The inverse strategy, taken by other facilitators, was to turn over responsibility for the 3D printer to one or more students who had demonstrated interest and competence. For example, one facilitator said, "I teach a couple of people how to work the 3D printer and how to put [files] on the SD card, so that when somebody says, 'Hey, can I print this?' 'Yeah, go talk to so and so.'" In these classrooms, when other students wanted to print, they went to the students in charge of the printer. In many classrooms, this practice included letting students troubleshoot problems with the printer. For example, in one classroom, when one of the printers broke down, rather than the facilitator calling the member of our team who provides technical support, he encouraged his two 3D printer managers to make the call instead.

This practice of handing control over to students had two major benefits. First, it relieved stress from facilitators, freeing them up to do other things. For example, when explaining his reason for putting students in charge of the 3D printer, one facilitator said, "[T]here's 24 of you and there's one of me, so if I'm helping you for five minutes, don't just sit there for five minutes, ask someone else." Second, it provided an opportunity for students to develop and be recognized for their expertise. For example, when we asked one 3D printer manager what he remembered most about FUSE, he said, "My best memory would probably be actually becoming manager. Because…I started working with printers more and [my teacher] was like 'Well, you can be the 3D printer manager.' And it was really cool to feel that I was getting a bigger role just by actually working." When we asked him what he was proud of from FUSE, he said, "I mean I've had to fix the printers a lot of times, but every time I actually fix it, I kind of feel proud, because it feels good to get something working again."

We observed a similar dichotomy in the way facilitators dealt with management of other materials. In order to ensure that the materials for each challenge were not lost or destroyed and got returned to their proper boxes at the end of each class period, some facilitators implemented rigid control over materials. Many required students to check kit boxes out at the beginning of class and back in at the end and performed a visual inspection of these kits at the end of the class to make sure all materials were intact. Other facilitators limited the number of challenges students could work on at any given time or revoked access to particular challenges with delicate or complex materials. In contrast, other facilitators put students in charge of maintaining of materials. For example, one facilitator talked about appointing "Materials Managers" in each class, saying,

> Behind me, I have, I guess in some places they call it a 'genius bar', but I have four students that are in each class…that are my materials managers, and…they go immediately up there, and then the students that are at a point where they need to check out one of the kits, they'll come up there [to] sign out a kit. The Studio Manager will go get the kit…and they'll check through and make sure everything is in the kit that's supposed to be there.

As with appointing 3D printer managers, the strategy of turning materials management over to students both took a burden off of the facilitator and empowered students. For example, when we asked one of the Materials Managers whether she enjoyed that role, she said, "It's really fun…sometimes [my teacher] walks in and he'll give us cool jobs to do, like we get to work on every single kit, we help [him] with his students."

Maintaining student engagement

Another need experienced by facilitators was maintaining student engagement over a school year (or multiple school years) of doing FUSE. While, in general, students were described by facilitators and by themselves as being interested and engaged in challenge activity, facilitators noticed variability in engagement both between students and over time. For example, in some of our year-long FUSE studios, facilitators have reported noticing a dip in engagement right around Winter Break. For example, in January, one facilitator talked about student engagement, saying, "[A]t the beginning of the year, students were very engaged about FUSE, actually especially about 3D printing…Right now student engagement is kind of low. I don't know if I can say low, but it is steady right now…They are not as engaged as the beginning."

Facilitators enacted multiple strategies to address engagement. First, in many studios, rather than opening all the challenges right away, at the beginning of the school year, facilitators opened just a few (e.g., five). Then, as students got to a point when they'd done most of open challenges of interest, facilitators would gradually open up more and more, until all the challenges were open. In some of the studios where facilitators took this approach, if there was a particular student who was having more difficulty finding an interest and staying engaged, the facilitator might let that student have input into which challenges would be opened next or let them be the first one to try a new challenge, as a way to stimulate excitement and engagement.

A second strategy many facilitators took, particularly in FUSE classes that met every day for a semester or year, was to take periodic breaks from challenge work to do other, related projects. These projects took two forms. One was what we've come to call "Quick Fire Challenges" (a name drawn from the short cooking challenges on the show Top Chef), simple engineering challenges that the whole class does together for one class period, before returning to regular challenge work. One example of this was a zipline challenge, in which the facilitator divided students into teams, gave them a basic set of inexpensive materials (e.g., tape, paperclips, straws, and paper cups) then challenged them to create a vehicle that could transport a set of metal washers down a diagonal string "zip line". The other form that these projects took was more extended projects that interrupted or ran in parallel to regular challenge activity. For example, in some classes, facilitators took a break from challenge activity to do a whole class extension project, such as making and 3D-printing holiday cookie cutters or having students use the Electric Apparel kit materials to make 'ugly' holiday sweaters. Still other facilitators periodically introduced related activities that students could then choose to do instead of regular challenges (e.g., Hour of Code, Scratch, or a Ringtones competition, based on the Ringtones challenge). All of these strategies proved effective at reigniting or sustaining student engagement.

Making connections between challenge activity and STEAM careers

A final need that some facilitators articulated was to make connections between FUSE challenges and STEAM career pathways. For example, at one magnet school, FUSE was implemented as part of a ninth grade Magnet Pathways course. There, the facilitator talked about the need to make connections between FUSE challenges and course and career pathways, saying,

> I think, just going back to what we're using it for, connecting it with our Magnet Pathway elective, so I spent the first part of the semester teaching them, you know, here are all of our different electives on campus. So now we're trying to connect each of the challenges with our specific electives, or specific careers. You go, 'Oh, if you like this, well, maybe then you wanna take the engineering class.'

In other cases, facilitators organized field trips to or brought in guest mentors from local STEM companies. Other facilitators assigned projects where students researched connections between FUSE challenges and careers, while still others shared examples in class of ways in which people in different professions used tools like 3D printers, coding, or robots employed in the FUSE challenges.

We don't have the longitudinal data, at this point, to determine how effective these different strategies were at actually encouraging students to go on in particular STEAM professions. However, student feedback on these connection experiences was generally positive. For example, when we asked one student in the CTE pathways course whether FUSE was different from her other classes, she said,

> Yeah…this class, we get to go on computers more, we have hands on more…we're writing notes, but we're also like engaging, we're learning new things every day. Sometimes we're leaving the classroom to go look at other like careers. And this is just like a class for like careers…like you're like trying out the careers. So it gives you a little bit of an idea, like if you want to do construction there's one for like the fastest roller coaster…Or you can be like a designer, because you can design like houses…and it's like so cool.

Students were particularly positive about hands-on projects or experiences (e.g., group research projects and presentations or field trips) as compared to lecture-based lessons. For example, in the quote above, the student said, "Yeah we're writing notes, *but* we're also like engaging," highlighting the contrast between her feelings about notetaking and her feelings about the more hands-on, engaging learning experiences in FUSE. Therefore, as with the tools and practices implemented by facilitators to address the other needs they experienced while facilitating FUSE, our analysis suggests that there were better and worse strategies implemented to encourage students to make connections between FUSE challenge activity and STEAM careers.

Discussion

The analyses presented here begin to answer the question, 'What happens when the teacher's job is not that of instructor and content expert, but rather facilitator and guide of learning and exploration?'. We have described how teachers navigate the role of 'facilitator' and the pedagogical practices they employ to achieve goals that align with their own and the program's philosophies. Our analyses also shed light on seven needs experienced by teachers facilitating making activities in a choice-based, peer learning environment and provide examples of interactional practices, routines, and artifacts that they implemented to address these needs.

These findings have direct implications for practice, among teachers thrust into the role of facilitating FUSE or similar making activities and makerspaces. They also have implications for the tools and strategies researchers and designers develop to better support educators in these roles. For example, our findings make clear the benefit of a "boss board" as one of the tools included in a choice-based, peer-learning environment. They suggest the benefit of involving students in shared (as opposed to individual, written) reflection on their experiences and having students participate in routines to collectively reward other students' desirable skills and practices. They suggest the benefit (to both students and educators) of turning over maintenance of technology and materials to students. They suggest ways to spark or reignite student interest, by introducing new activities or temporarily changing up routines. And they provide potential strategies for both assessing student growth and making connections to STEAM careers in less intrusive and more engaging ways.

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