

A Focus on Contribution Towards Product and Performance in Collaborative Design

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Abstract: This paper presents a comparative case study to illustrate how resources are used for contribution in collaborative design. One case draws from video data of an urban high school robotics team which designs a robot for competition, and the other from a program where youth produce a documentary film for a public showing. Building on a view of participation as learning (Lave & Wenger, 1991), we use video-based micro-analysis to make sense of how members participate through contributions to design. We frame learning as a collaborative practice where contributions are used to make arguments with different resources. Across both cases, materials and laminations of space-times (Leander, 2002) are used as: 1) evaluative resources, and 2) knowledge constructing resources for design. In this view of learning, the final product and performance are not only end goals but used as resources in the design process through laminations of imagined future space-times.

Purpose

Collaboration is an important practice in the learning structures of Problem Based and Project Based Learning (Barron et al., 1998) as well as many other pedagogical practices in school (e.g. learning communities, Brown & Campione, 1994). Learning Sciences literature has shown that youth engage in learning through collaboration in many settings outside of school as well (e.g. The Fifth Dimension, Cole & Distributive Literacy Consortium, 2006). Further, the effectiveness of collaboration as a learning structure is dependent on the contexts and quality of interactions (Barron, 2003). Therefore, it is important to gain an understanding of how collaboration unfolds in learning settings that are not directly framed as part of schooling. This case comparison study focuses on making sense of the participation structures of collaboration, particularly how to contribute to design, for two distinct after-school activities involving secondary school youth.

In each of these cases, although we classify them as learning spaces, content learning is not typically the primary goal of the community. Rather, an end-of-semester product and its performance drive the goals of all activities for these groups; yet learning is necessary to participate in the knowledge-building process of design. The first case focuses on youth participants on an urban high school robotics team that co-produced a robot (a product) in 8 weeks, and then used the robot in competitions (a performance). The second case is set in an afterschool program called Digital Studio (all names in the paper are pseudonyms). Over the course of 14-16 weeks, youth, typically aged 16-21, developed, captured, edited, and publicly presented (a performance) a 20-minute social justice/critically engaged documentary (a product) about a social issue that impacted their lives. We classify each setting as a “semi-formal” learning space because, while occurring temporally outside of school they still exist in spaces and places that are typically considered part of school.

In both cases, being part of the community means taking action and contributing to the final product and its performance. We frame the activities portrayed in the chosen episodes as indicative of contribution, building on Lave and Wenger’s (1991) view of legitimate participation, to understand how participants contribute in collaborative interaction towards collective goals. Analyzing learning with a focus on the community provides us with the ability to make sense of contribution to design as a kind of participation. Using such a lens for analysis crafts a view of learning that privileges the shared collaborative space rather than a view of an individual’s participation trajectory within a community of practice that most analyses of learning centered on participation take. Further, it pays particular attention to the socio-historical and material contexts of contribution by members of the learning community and their differing opportunities to contribute.

In this study we analyze a set of interactions from each case, seeking to compare the different dynamics of each group engaged in collaboration as an ensemble (Ma & Hall, in press). We are interested in how these collaborative episodes unfold, what resources are used and how community members (youth and mentors/coaches/facilitators) use them to make arguments about possible design. Particularly, we are interested in how the imagined futures of the product and performance, as a lamination (Leander, 2002) of the driving goals of the design activity, are animated in the interaction and how they are taken up. The study’s guiding questions are:

- What kinds of resources are used for contribution to the collaborative design activity in the process of making arguments?
- How are the imagined future products and performances used as resources in interaction for the purposes of collaborative design?

Collaboration-as-learning: A Collective Approach

Taking a sociocultural view of learning and development informed by Lave and Wenger's (1991) conception of learning as a progression of participation we view the design practice of both settings in this study as instances where participants of a community learn and develop by collaboratively engaging in creative activity. Further we take up the lens of "collaboration-as-learning" (Enyedy & Stevens, 2014) where the analytical unit of interest is the collective group engaging in, in this case, a design task with a focus on describing and making sense of how collaboration is organized and enacted.

In the cases of this study, the learning environment is framed around activities of collaborative design by a community of practice (Lave & Wenger, 1991) with the goal of creating a product to be used in performance. Therefore, with an analytic focus on the collective work of collaborative design, the way contributions to the design are brought to bear is important in making sense of the participation structures. Here we focus on contribution as a particular type of participation, specifically how contribution happens including what resources are needed and used to collaborate.

Contributing to the design of a product and performance like in these two cases requires access to resources for contribution which can be brought to bear on the interactions of collaborative work. Influenced by Latour's (2005) view of social practice in scientific work as ongoing assembling of associations of material and human experiences, we treat the work of these communities of practice as authentic authoring of activity where associations are assembled to contribute to design. The remaking of associations takes the form of resources used for contribution; these resources are animated interpretations that participants bring, through interaction, to the collaborative activity to make an argument. They are derived directly from the material experience at hand in the interaction, from a remaking of past space-time, or imagining a future space-time (Leander, 2002). Building on Leander we call "laminations" the co-creations of space-time representations (chronotopes), or instances where members of an interaction take up, add to, and utilize social representations of past, present, or future space-times.

Data and methods

Data comes from two distinct studies of semi-formal learning. In each study data includes video and audio recordings, ethnographic field notes, and images. Hennessy Elliott collected the data of the Robotics Team analyzed in Case 1. Data from Case 2 came from a larger study of the Digital Studio by Radke and Ma. Analytically, we focus on interactions where youth contribution to collaborative design of the product and performance is the driving activity. This focus structured our search for and selection of episodes for analysis to those in which the facilitators were either not physically present or were not directly guiding the activity. The episode for the Robotics Team in Case 1 occurred just after the competition rules for that year were released. It portrays a portion of the team collaborating with two coaches and a mentor on crafting robot design ideas and competition strategy. The episode from Digital Studio in Case 2 also occurred early in the design process (in this case, of the documentary) and shows a subgroup of youth building a topic idea to pitch to the rest of the group. Methods of multimodal and interaction analysis (Goodwin, 2010; Jordan & Henderson, 1995) were used to examine instances of contribution during design activity.

Case 1: Robotics Team

The Robotics Team's home is in the basement mechanics shop of Engineering High School (EHS) in a midsized northeastern city. EHS is a technology and engineering focused high school that serves students from all over the city, the large majority of whom are Black and or Latinx. The team has participated for over 20 years in annual robotics competitions which are re-imagined and remade every year by an international governing organization. The particular episode for this study was chosen because it occurs shortly after the year's competition rules were released. It portrays a moment where different members of the team collaborated on 1) developing ideas for this future robot, and 2) developing a better understanding the rules of the new competition style (see Table 1 for a summary of all participants in the episode). The coach, JF, had a youth participant print out the competition manual and put it into a three-ring binder for access during discussions like the one analyzed here. In this episode, Matt, the college student mentor, holds the manual near the table that all of the participants are crowded around.

Table 1: Participant list robotics club

Name	Major Position/Duties	Grade	Year # on Team
Jav	Captain, builder	11 th	3 rd
Spock	Builder	10 th	2 nd
Harrison	Support for scouting and design	12 th	1 st
DV	Math Teacher and Coach	Teacher	1 st year as coach
JF	Coach and Engineering Teacher	Teacher	4 th year as Coach
Matt	Mentor/ Driving coach	Alumnus, current undergraduate	2 nd year as mentor

Three youth members of the Robotics Team collaborate with two coaches and a college mentor (See Table 1) to talk through the design of a robot and the new rules of competition that would influence both in-game strategy and how the robot should be designed. This analysis focuses on the resources brought to bear on this set of interactions over a five-minute period.

Multiple times in this episode, members use references to previous competitions in order to gain traction with their own ideas for how the future robot should be designed. For example, responding to JF's suggestion to build a conveyor belt in order to gather competition balls that need to be shot into a certain goal, Spock attempts to contribute to the design discussion by sharing an idea in terms of another robot he saw at a competition the previous year:

JF: No matter what the balls have to be picked up. Ahh conveyer belt won't be a problem to do. ((looks down to the table))

Spock: Are we gonna do it, uhh, Remember last year's team. The giant one with the ((gestures up and points with right hand, index finger; looks away)) like the ... it was... Basically, last year there was a um, a robot that ((gestures with arm as grabbing something)) grabbed the ball and it was like a conveyer belt ((spins arm in a circle)) and it just went straight into the shooter and they just kept like rotating the whole time...

While he struggles to get his ideas out, Spock's continued gestures fortify his attempt to describe a past competition that they should learn from. Here, the experience of a past time-space at a previous competition is a resource for contributing to the design discussion, linking to JF's idea that this year's robot could have a conveyor belt for picking up balls. This is an example of laminating a past space-time into the present as a resource to build on the collective knowledge of a design. Once brought into the discussion it is picked up and responded to, particularly by JF:

JF: Yeah but that. Remember how tall that was.

Spock: Yeah but it. Can we do some[thing like that]

JF: [And there were only]. They were only doing it with one ball.

Spock: Yeah but I mean is, can we do something like that but on a larger scale like make it wider ((gestures out with both hands, a widening gesture))

In this exchange, JF rebukes Spock's contribution with another frame of the previous year's competition, "remember..." only one large ball was picked up and shot; whereas in the current competitions multiple smaller balls needed to be picked up and shot at a goal to score points. The "but...remember" sequence frames the exchange as an evaluative resource that references the same space-time. Here, while referring to the same historical time-space as Spock, this is also an example of bringing the resource of the competition rules to this collaborative design process in order to make an argument against basing their design off of the previous robot Spock refers to. Later, JF, as the mechanically inclined coach, clarifies that a design suggested by Spock and Jav was an "overly complex design" that would have too many spots of possibly not working, using mechanical knowledge to laminate an imagined future space-time. In this comment JF brings the proposed robot design into talk by describing a space-time where something could go wrong if the robot were designed that way.

Besides the mention above by JF, the competition rules, as a resource, are brought into the collaborative discussion into the interaction in two different ways. First, they are recruited as a reference to physical manipulations of the game pieces built to scale out of wood in the shop around them. Second, they reference the competition game manual printed and placed in a binder which sits in front of Matt in this specific interaction. Both examples mediate the rules of the competition through physical artifacts that can be referenced.

At one point in the collaboration, the group begins to construct a strategy for how the robot should move around the competition field, in addition to constructing a working design of the robot itself. In the example below, Matt (the mentor) is seated in front of the game manual which is flipped to the page with a figure that shows the layout of the competition field with dimensions and labels:

Jav: Everything's fair game in this=

Matt: You have to go here ((points end of screwdriver to field map)) and then ((drags screwdriver to a new spot)) right here ((moves screwdriver back and forth)) diagonal

Spock: I mean I'd guard our neutral zone ((points to the field map)) or retrieval zone.

Matt: [Cause if you] go down here you run that risk as well. ((Points, with screwdriver to the field)) Remember there's one here. ((moves screwdriver to another point on field map)) And there's one here.

Spock: Que--- I mean ((points to the field map)) uh...

Competition strategy has large implications for design choices here. In this set of utterances, Matt uses this representation of the field, or field map, to argue his view of what their strategy should be in the competition. The game manual animates the rules of the competition and structures its vocabulary ("neutral zone" and "retrieval zone") for Matt, Spock, and those looking on. It also directly mediates the lamination of a future time-space where an imagined robot moves through a competition ("you have to go here"). As Matt points with the screwdriver to the map of the competition field, he merely has to bring the imagination into the future while the map in the manual does the work of constructing the spatial relationships for other participants. The screwdriver he touches the page with becomes the future robot. Spock takes this up pointing to the map and also speaking in future tense "I'd guard..." These resources, the map in the competition manual and space-time representation, are used to build the collective knowledge of the rules ("you have to...") and competent strategy in future performance ("you run the risk of").

The use of the physical game manual is picked up by JF, and DV, all referring to the representation of the field in order to bring the future competition into the design conversation, as seen in the excerpt below.

JF: Is there a danger zone in front of the, ((leans in to the binder)). Oh there it is. Yeah I see it

Matt: Right here

DV: So Andy was talking about that pattern ((Spins finger in a vertical circle)) (0.4s) remember, the board he had that loop pattern? ... So I think that loop pattern ((Spins hands in loop)) will keep us away ((points to the field map)) (0.2s) from the penalty spot.

In these turns at talk, the game manual becomes an integral resource for the collaborative design process, even mediating other space-time resources. The two excerpts above show that the manual is a materialization of competition rules, which is taken up to laminate the future performance of the robot to make arguments about how the robot should move, and how it should be designed. As these contributions are brought to bear on the interaction the learning community collaboratively negotiates their implications and legitimacy.

Overall in this case, members bring 1) previous competition experience, 2) the competition rules manual, and 3) mechanical knowledge into the interaction to drive collaborative design. These are called upon through talk and gesture with reference to experiential time-spaces, past and future, and material resources physically available in the room. They are used to recruit other participants in the group to engage in building collective knowledge for design, and strategizing for the performance of the robot in future competition.

Case 2: Digital Studio

The Digital Studio is a non-profit youth media organization focused on engaging underserved youth populations in documentary film production and civic engagement. The program is offered for school credit or as a paid internship and emphasizes community building and cooperative problem solving. Over the course of one school

semester, interns work together to develop, capture, edit, and publicly present a 20-minute documentary. Starting with students' own questions and their own lived experiences, these documentary inquiry projects look to challenge social issues and institutions. Digital Studio youth are supported by one adult facilitator, but ultimately, they were responsible for all the footage collection and editing, as well as for developing and realizing a strong story line (called the line of inquiry).

The episode below occurred early in the semester as the interns worked to choose the topic of their documentary. We meet six male youth as they prepare for their pitch presentation where they will attempt to convince the whole group to select their production idea. The episode was chosen because it was a moment of facilitator-free collaborative negotiation in an effort to 1) formalize their answers the Pitch Packet questions, and 2) develop or share understandings of the critical components of a documentary film. Table 2 provides names and other pertinent background information for the participants in this episode.

Table 2: Participant list Digital Studio

Name	Role	Age	Grade	Other pertinent information
Benjamin	Intern	18	11 ^a	(1)
Carl	Intern	17	10 ^a	(2); First language is Spanish
Elliot	Intern	16	10 ^a	(2); First language is English
Ian	Intern	17	10 ^a	Nominated to be the scribe
Jorge	Intern	18	11 ^a	(1)
Nicholas	Intern	18	12 ^a	(1)
Hank	DS Facilitator	N/A	N/A	(1); Second year as a DS Facilitator
(1) Does not appear in transcript excerpts but is part of the data analyzed for this paper.				
(2) Recent immigrant to the United States				

The small group collaborates to finalize their documentary idea and complete their Pitch Packet. This packet, created by the facilitator, Hank, is a collection of questions they must be able to answer during their formal pitch. The packet's questions are divided into the following five categories: Line of Inquiry, Personal Profile, Relevance, Professional Interviews, and Closing Argument. They will have to present a formal pitch later this same day and have been researching and developing their idea for the past three days. During the formal pitch, the packet they are finishing now will be available to them as a reference for their talking points. Similar to the Robotics Club, resources are called upon through talk and gesture with reference to experiential time-spaces, past and future, and material resources physically available in the room. These are used to contribute to the collaborative design for both evaluation and knowledge building purposes. In the following excerpt, their work to finalize their pitch turns to a discussion of one aspect of the documentary, the personal profile.

Carl: Oh, and also for example history profile ((Gestures towards Nicholas)).

Ian: What? ((Holding the Pitch Packet))

Carl: The history of? profile.

Ian: Personal profile? =

Carl: =Uh huh?

Ian: Like, every single video that you watch uh, is is connected to uh personal profile. So it's, i-if you don't have a personal profile you cannot, you cannot start working on your documentary.

In this excerpt Ian, who is in charge of recording their ideas in the pitch packet, leads the discussion. Carl's first utterance was originally in response to the question, "How will this be different from other Digital Studio films?" However, Ian takes it up as a content question. This is evidenced in his reply of what a personal profile is and why it is important to a documentary. Carl rejects Ian's interpretation of his idea as a request for information.

Carl: No but I say, no but I, no, I means that they history, in the history, always different for each people uh the history of the don't trust the internet like that.

Ian: Well:: ((Still holding the Pitch Packet)) I didn't get your question I'm sorry but like I want you to elaborate a little bit for me, [like explain it.

Carl: [Yes. For example - for example, not to trust the internet because I ha:::ve one day I have to computer it? ((make typing motion)) that's why - I was::: five years old, no? ((gestures with hand to the height of a five year old)) And I put uh, computers like that ((typing motion)) and appear a virus in my computer like that...and I don't trust the internet. Another person for example, hack or like that or um, anything else, anything like that um::: don't trust the internet because eh, security of the pages is low.

Ian: Okay, I got, I got what you said, but is that, is that a real personal story? Like, it-it must be real. It-it must be something that happened to you already. I-you cannot make from your own. That's what I was tryin' to do. When - when I spoke to Hank, told me like, this should be a real his-story.

Carl's example seems to clarify for Ian that he understands *what* a personal profile is. For Ian this leads to a new issue of authenticity. We see Hank animated through Ian's talk when he refers to a past interaction ("Hank told me..."). Carl never replies to Ian's authenticity question and the group moves on when Carl admits that he is, "sleepy" and "[doesn't] even know what [he's] talking about." Because of his responsibility to record their ideas, Ian has been positioned as the leader. His uptake of this role is evidenced by his multiple returns to the pitch packet from which he produces lines of direct questioning, one of which he poses to Carl in the excerpt above. Furthermore, he animates lessons from Hank ("it must be real") to clarify what counts as a personal story and why it is relevant to documentary making. Finally, he uses a past experience with Hank ("when I spoke to Hank") to evaluate their answers and work to negotiate the final record. Across the excerpt the pitch packet acts as a mediating artifact, connecting the lessons on documentary making Hank has taught and their current collaborative work efforts.

The pitch packet also becomes useful in elucidating a historical framing which the youth take up in developing and evaluating their answers. This first occurs when the youth work to answer the question, "How will this be different from other Digital Studio films?"

When Nicholas begins to say their topic has never been covered, Elliot interjects, relying on his knowledge of past production topics. Another student, Ian, recalls that the Digital Studio has produced over 190 documentaries so, "even Hank haven't watched uh the videos, like all the videos, there might be one." In this utterance grouping the youth work collaboratively to evaluate the strength of their originality argument. Ian animates the then-absent facilitator, Hank, in reminding them of the multitude of completed projects. This could be taken as an evaluation of Nicholas's first comment and support of Elliot's warning that they "don't want to make assumptions," about uniqueness. This historical framing then becomes crucial in formalizing their final argument. The three youth decide to skirt the absoluteness of Nicholas's original statement and change their answer to say, "It's an unexplored topic."

Across the episode learners collaboratively produce the documentary and position both the pitch packet and the facilitator as resources in their work to develop and finalize their group's documentary idea. In these excerpts, the pitch packet becomes an integral resource for the collaborative design process. It laminates their shared lessons from Hank about documentary making and the future completed film as resources for completing the final draft of their pitch. The interns bring three different kinds of resources to this collaborative exercise: 1) shared historical framing, 2) the pitch packet, and 3) Hank's ideas and lessons. These resources get recruited by the youth producers in the collaborative process of negotiating and evaluating ideas as well as in support of knowledge-building.

Discussion

Collaborative design work is driven by the ways resources are brought to bear on the interaction in each of these settings. As Barron (2003) argues, focusing on the group as the analytic unit allows us to analyze the resources they use, the "types of contributions they make and how they are taken up or not," (p. 311). Learners interact in authentic practice of designing and do the work to position each other as active members of the "epistemic community," (Kim, et al., 2015). In the theoretical view we take, this positioning in the community is facilitated by learners' access to usable resources, crafting their context for contribution and the ways contributions are legitimated by the group. Across both cases these resources are used as: 1) *evaluative resources*, or resources to legitimate an emerging part of the design, and 2) *knowledge constructing resources*, or resources to further construct local knowledge needed for the design or as part of the design. In each analysis it proves difficult to

separate product from performance in what future collaborators are designing. Therefore, both cases take on future oriented analyses that do not directly distinguish the two.

Above we identified three resources used in interaction in each case. Each resource was used, at times, in both evaluative and knowledge constructing contexts. These two lists of three, while somewhat different, map quite well onto each other. First, previous competition experience, a resource identified from the Robotics Team case, matches well with Digital Studios's shared historical framing. Each resource indicates the agentic use of the institutional historical contexts. This points directly to the importance of historical framing and experience in how youth can contribute to design work. Second, both the competitive game manual (Robotics Team) and the pitch packet (Digital Studio) are physical material resources that facilitate the interaction and are used to structure the design process including creations of imagined future space-times. Third, Hank's ideas and lessons (Digital Studio), which youth take up, can be construed as the mechanical (technical) knowledge of making a documentary. JF and others clearly use mechanical knowledge of robot construction to design and evaluate possible design.

Youth interpretations of past space-times were used in both cases to help construct a vision of a future design. On the Robotics team, previous experience at a past competition was repeatedly used as a resource through lamination of past time-spaces. In the Digital Studio, youth reimagined the past program documentaries to argue for the originality of the idea they were proposing. Both are examples of how this type of contribution resource requires knowledge of or experience with past iterations of the type of product they were aiming to design. In the Robotics example, the learner had the previous experience and therefore was able to bring that to bear on the interaction through a lamination of a past space-time while the learner in the Digital Studio example needed to speak to a historical context by referring to previous time-spaces where the facilitator discussed yet another previous time-space, limiting the possible lamination. This is a secondary layer of space-times for reference.

Kim and colleagues (2015) describe integrating the design process into classroom learning as an "emerging learning process" where learners define the learning trajectory. This lens can also be taken in these semi-formal learning spaces. Ways to contribute are continually re-created depending on both the resources at hand for youth, how previous contributions have been legitimated, and the collaborative interactions that come before it, laying the groundwork for what is needed to be learned in order design and create the artifact. This required us to pay attention to the ways that future products, and in these two cases their performance, were brought to the design process as both evaluative resources and knowledge construction resources. In both cases, the groups interacted, constructing imagined products with past and future space-times, and articulating understandings of the goals of future performance to make arguments.

Future space-time representations are particularly important in design work for a product and a performance. Participants frequently try to make arguments and build consensus for a design choice by animating their imagining of a future product and/or their performance through talk and gesture. Learner contribution to the design process in both cases required directly constructing and sharing an imagined future of the final product and the final performance of the learning community. Therefore, the product and performance become part of the design process, instead of simply being end goals. Learners, and mentors in the case of the robotics team, used resources, including imagined and interpreted space-times, physical objects, and technical knowhow, to bring these final goals into interaction in the design process. In both cases these resources were used to evaluate a current design idea and to build collective knowledge about the rules for the products and their performances and the design itself. While the pitch packet and the game manual, themselves, were designed to do this work for learners in collaboration, many other time-spaces and objects were used to further construct design ideas. These case analyses illustrate the nuanced ways youth contributing to design discussions bring together constructions of varied space-times, including interpreted past and imagined future, as resources in conjunction with the material resources at hand, i.e. the pitch packet or the game manual.

Therefore, in collaborative work for learners in semi-formal learning spaces, it is important to recognize the different resources (material and temporal-spatial) that learners have access to, how contributions are collectively taken up, and to be intentional about how they are facilitated. It is that access, or perceived access in conjunction with the ways the group takes up learner contributions which gives learners the agency to contribute to the design and, in turn, the construction of the learning environment.

Significance

The analysis showed the ways in which collaboration is guided by the youths' knowledge and imaginings of their end goals in each setting—both the physical products and the final performances. Hmelo-Silver writes, "the goal of becoming a good collaborator and the process of learning collaboratively are often woven together," (2004, p.214). With this view of the learning community, it becomes clear that differentiated access to resources, both material and spatio-temporal, structure the types of contribution learners can collaboratively make to a design process. Further, the ways in which contributions are valued, evaluated, and taken up play a large role in later

access to resources and contribution. Therefore, designing and facilitating these types of learning spaces which include a focus on a final product and/or performance requires paying attention to learners' previous experiences, their developing imagined final product and performance, and their material contexts for design. This is also important for crafting more formal learning spaces with project-based and problem-based learning pedagogies.

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