Student Perceptions in a Formal Makerspace: A Case Study of Two High School Senior Students and their Collaboration on a Computer-Aided Design Project

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Abstract: While collaboration is a major theme across makerspace studies (Papavlasopoulou et al., 2017), few studies consider how students perceive collaboration within makerspaces. This single case study explores secondary students’ perceptions of their collaborative experiences while working on a computer-aided design project in a formal makerspace. Survey, observation, and interview data were collected and qualitatively coded. Findings demonstrate how a student with technical expertise can take on increasing ownership of a peer’s project and limit learning opportunities for the partner student. Implications include how teachers can orchestrate and monitor collaborative relationships to support students’ success and agency in formal makerspaces.

Background and significance
Many school systems are incorporating technology-enhanced learning environments as formal makerspaces (Peppler et al., 2015) to connect curriculum-based content to professional skills and engage students in communities of practice that cater to their personal interests. While collaboration is a major theme across makerspace studies (Papavlasopoulou et al., 2017), there is little consideration of the students’ perceptions of collaboration or how passion-based learning may affect students’ experiences within the makerspace. Our research seeks to privilege student voice by considering two secondary students’ perceptions of their collaborative experiences while working on a computer-aided design (CAD) project in a formal makerspace. We consider: How do students collaborate within a formal makerspace and to what extent do students’ perceptions of these collaborations affect their experiences within the makerspace?

All students should be supported in gaining the skills needed to engage in the professional communities of their interests and choice. Our findings can provide insight into student perspectives for educators toward better understanding the support that students need to actively engage in positive, collaborative learning experiences within a formal makerspace and creating equitable learning experiences for all students.

Collaboration and equity in makerspaces
Papavlasopoulou and colleagues (2017) suggest that collaboration is a major theme across makerspace studies. Prior research shows that students in makerspaces use collaboration to create relationships in which they work together for access to skills and a diversity of knowledge (e.g., Gutiérrez et al., 2014) by recognizing the skills and interests of their peers. The ability of a peer group to negotiate roles, allocate responsibilities, and build a collective product from individual work is called collaborative agency (Kafai et al., 2012). Additionally, makerspaces emphasize learning through doing where students build upon their existing resources, learn practices that are authentic to professional communities within their areas of interest, and develop their own identities through collaborative interactions (e.g., Baker & Lattuca, 2010). Thus, collaboration may be critical to helping students develop an identity as a member of a makerspace learning environment.

Formal makerspaces may offer an asset-based approach to help traditionally marginalized youth engage in passion-based learning. However, while formal makerspaces offer the opportunity for marginalized youth to engage in passion-based learning at school, collaborations within makerspaces can also hinder equitable participation in learning. For example, a student who needs help may begin to collaborate based on helplessness or replication (Sheffield et al., 2017). Similarly, when makerspace participants feel knowledgeable, they may choose to share their knowledge or either take over the work or refuse assistance (Maltese et al., 2018). While equitable collaboration on long-term projects increases the opportunities for marginalized youth to build supportive social networks, if collaborative roles remain consistent and become part of students’ identities in the makerspace then hierarchies may develop that negatively affect future collaboration (Barton et al., 2017). Collaboration can then also promote inequity (Maltese et al., 2018). Thus, more research is needed to understand how students perceive collaboration in makerspaces to increase the likelihood for equity in collaborations.
Study context
In this holistic, single case study (Yin, 2018), we consider two students (Theodore and Joseph) who worked together on a CAD project in a formal makerspace, Maker High, over a two-week period. Maker High was available for high school seniors across a public school district to attend during the second half of every other school day and receive course credit. Although there were two teachers at Maker High, a preliminary review of Theodore and Joseph’s surveys showed that their passion-based interests of using computers to create designs were outside of the teachers’ range of expertise. Further, Theodore’s survey included his plan to begin work on a CAD project that involved technology that he had never before used but that Joseph had promised to help him learn. The opportunity to focus on a student who may not have been able to seek help from a teacher but was seeking a collaborative relationship with a peer led to our decision to study Theodore and Joseph.

Methods
Over the course of two weeks in the spring, the two students were observed working on the design portion of their CAD project for four days, for four hours each day. Audio recordings of the students’ discussions were collected and transcribed and the observing researcher wrote daily analytic notes in a reflexive journal. Immediately prior to and following each observation, semi-structured interviews were conducted with the students to understand their goals, challenges and successes, and perceptions of collaboration while working on the project that day. Data from surveys conducted at the beginning of the school year, mid-year, and at year-end, asking students questions regarding prior collaborative experiences in non-traditional learning environments and their current collaborative experiences at Maker High, were included in the analysis to increase construct validity using data triangulation (Yin, 2018). Two researchers coded 20% of the data from all of the sources with first-level codes in 5% increments, discussing and reconciling any disagreement after each set of 5% increments to obtain an inter-rater reliability above 80% (Miles et al., 2020). These codes included descriptive coding to summarize when students discuss different settings in which they have experienced collaboration and their perceived success and challenges of collaboration; concept coding, using a symbolic word or phrase that suggests an idea; and emotion coding, when participants recall emotions, to consider when and how students perceive emotional support. The researchers then divided and coded the remaining data separately, discussing any uncertainty. The researchers separately engaged in a second-level method of pattern coding to categorize potential themes and compared their analyses to reach consensus.

Results
Theodore and Joseph’s collaborative roles
Joseph’s prior experiences in four differentCAD courses at his base school led him to have an expertise that no one else at Maker High (including the teachers) had. Theodore approached Joseph for help prior to beginning his project because he was aware of Joseph’s expertise. For Theodore, this was an affordance of attending Maker High: “I have plenty of ideas but I have no idea how to do them and [Maker High] helps make my ideas happen.” Through the two weeks spent working on the CAD design, Joseph took on a mentoring role that surpassed occasional help. As Theodore had questions, Joseph would leave his nearby computer station to provide help. By the second observation, Joseph had made the choice to abandon his project to sit by Theodore for the remainder of our observation period. He began to step into the role of a more constant mentor for Theodore. For example, he said “Theodore got past a mental barrier of not being able to get work done on it. Certain functions of CAD get annoying, but Theodore worked so hard and had a breakthrough today.” Initially Joseph also focused on leading Theodore through the process of making design choices. However, as the project progressed, Joseph sometimes took the computer mouse from Theodore and edited the design himself. At times Theodore was receptive saying, “I see what you’re doing. That looks good.” But other times, he reminded Joseph that it was his project. For example, in the final observation, Joseph went even further in his contributions to the project by making a design change as he continued to work on the project while Theodore went to the bathroom. When Theodore returned, he said, “I said wait, I don’t want you to do it for me.”

After abandoning his own project to more closely help Theodore, Joseph began to express ownership of Theodore’s project. This may have led him to begin to manage not only the project but also Theodore himself. Particularly, Joseph tried to keep Theodore on track and was concerned about his productivity. At first this involved checking in on the completion of goals without statements of judgement regarding progress. As they continued to work together, these statements became more critical. For example, as another group finished a project, Theodore suggested, “We should take a break and see what they’re doing.” Joseph replied, “Stop, you constantly want to take a break. You take too many breaks.” These corrections then took on a more negative tone.
Joseph’s perspective

Joseph’s willingness to step into a helper role was surprising since, when asked at the beginning of the year who he hoped to work with during his time at Maker High, Joseph had written “a person that already has a ton of background knowledge because I’m not a fan of teaching other people something and would like to have a person I can work with, with the same sort of mindset”. However by mid-year, he reported feeling that he did not have equals in terms of technical knowledge or even peers working in the same area of interest, writing, “I don’t have many people doing engineering so I probably can’t find someone to work with.” When asked about helping Theodore manage his time and stay on task, Joseph stated that he was “looking to help to figure out what [Theodore’s] next steps are because he gets sidetracked a lot which isn’t always a bad thing but he needs sometimes someone to tell him what he should be doing next.” Joseph’s investment in the successful completion of Theodore’s project went past simply finishing the CAD design. He offered to help Theodore use technology at his base school, unavailable at Theodore’s, and use 3-D printers, CNC routers, and welding to build Theodore’s project outside of Maker High.

Theodore’s perspective

Throughout the project, Theodore seemed receptive and appreciative of Joseph’s help. He believed that he needed help to stay motivated, and he stated appreciating that Joseph helped him to increase productivity. Yet, Theodore also showed a dependency on Joseph’s help. This made him feel insecure in his lack of knowledge despite his recognition that he was doing this project as a way to learn more about CAD. Particularly, he felt that Joseph could be condescending and was not always willing to explain concepts. Theodore stated that Joseph is “… good at helping when he’s good at helping. He won’t explain what he’s talking about, he’ll say do it. And I want to know the reason behind it. When I ask him to explain sometimes he does, sometimes not.” This was supported in observation:

Joseph: I just made it for you
Theodore: Yeah but you weren’t explaining it.
Joseph: Alright just ask questions if you need it.
Theodore: I don’t know what’s happening.
Joseph: Well now you do the work. Make a hole, is that what you want to do? It’s your project, take control.

Other times, Joseph appeared to attempt to scaffold Theodore’s understanding by asking questions. But Theodore showed signs of frustration, asking what Joseph would do next instead of thinking through the process. For example:

Joseph: Make everything else wood, that doesn’t make sense. What else could you do?
Theodore: Do you have an idea? Are you trying to encourage me toward an idea? That could take a while.
Joseph: First off, I think you should make this plate a little rounder. This could come down, you’ll have a bolt. You’re going to need washers especially with metal and wood it gives it a metal surface to attach on.

Discussion

In this study, two students formed a close collaborative relationship within their makerspace that enabled them to work on solving the problems of a project that were relevant to them (e.g., Sheffield et al., 2017). Theodore leveraged the expertise of his peer, Joseph, who became a mentor in CAD as well as a delegator of tasks and reminder of time management. We propose that collaborative roles of “helper” and “student-in-need-of-help” may be complicated in a formal makerspace. For example, in this data, the student in need of help is also the leader of a project asking a peer for help based on their valuing of that individual’s expertise. As a helper, Joseph is then working for the student leader on their project, although at times it may seem that this helper student is taking on a leader role in the project by assigning tasks to Theodore. Although not necessarily a negative role, if students are always in the same collaborative role, as Theodore and Joseph seem to be within this project, then they may be missing out on opportunities to use their own expertise or receive help on their own project.
For these two students, support and collaboration during this project was limited to their partnership. Theodore was seemingly dependent on Joseph’s prior experience to complete his CAD project. Although working at Maker High allowed him opportunities to engage in professional practices, his dependency and, at times, learned helplessness within the collaborative relationship may affect the development of his identity (e.g., Baker & Lattuca, 2010) as a CAD operator. Further, Joseph’s perceptions of isolation due to a lack of surrounding resources throughout the school year may have led him to work with Theodore despite Joseph’s statement of not wanting to be in a teaching role. Within this partnership, the students did not have support in using their collaborative agency (Kafai et al., 2012) to delegate work. Thus, without explicit structure or support, students may not be able to draw upon or develop individual expertise, which has the potential to reinforce traditional school roles and identities in formal makerspaces.

Implications and conclusions
At Maker High, there were opportunities for rich, sustained collaboration between students that fulfilled the promise of makerspaces as environments for collaborative learning (e.g., Peppler et al., 2015). Yet, despite the idea that students can find success in makerspaces if they have access to expertise and resources through collaboration (Gutiérrez et al., 2014), care needs to be taken to avoid putting undue mentoring responsibility on students. Further, the students who are helping their peers may not support the other students emotionally or mentally despite their content or technical knowledge. Collaborative relationships, as critical as they are for students’ success in makerspaces, may then need to be more carefully facilitated in formal makerspaces to avoid creating too much burden for the helping student or feelings of dependency for the student receiving help. Preferably, partnerships can be formed where students support each other more equitably or students would engage in a variety of partnerships with different collaborative roles. Teachers could then help students to manage their time and learn to manage the progress of their projects. Student partnerships could be based more on the offering of expertise and learning from a peer’s skills rather than being in charge of a peer’s productivity. Teachers then may need support to put into place protocols and norms of collaboration to enable more equitable collaboration opportunities in formal makerspaces.

References