CheerOn: Facilitating Online Social Support for Novice Project-Based Learning Teams

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Novices learn innovation best through project-based learning (PBL), working in face-to-face teams to tackle real-world problems. Yet, real-world projects are complex, stressful, and especially challenging for novices. Online communities could provide social support to motivate novices, but it is unclear how to design online communities to support face-to-face PBL teams. Here we ask: *How might we design an online system that enlists external supporters to provide online social support to motivate PBL students?* Our need-finding study found that PBL students received infrequent social support, rarely engaged in help-seeking, and perceived little progress until the end of their projects. Based on these findings, we designed *CheerOn*, an online social support system that prompts novice student teams to externalize progress allowing external, online supporters to offer social support. We tested *CheerOn* with 3 PBL teams and 15 external supporters over a 6-week course. We found that external supporters provided instrumental, informational, and emotional support that strengthened students' bonds to the community, which increased help-seeking. Supporters also provided appraisal support, which increased students' perceived value of their work. Supporters were more likely to offer informational and instrumental support when they were promoted or saw a clear need for help; supporters who received gratitude from students were more likely to offer emotional support in return; and supporters who were closely connected to the community were more likely to offer appraisal and instrumental support. Theoretically, this research contributes to our understanding of how hybrid face-to-face and online communities can impact the behavior of PBL students, specifically towards the facilitation of help-seeking behavior, as well as increased understanding of how different types of social support (i.e., appraisal, emotional, informational, and instrumental) can impact the participation of PBL students and supporters. Practically, this research contributes to our understanding of how to design socio-technical systems that facilitate social support for offline novice PBL students working, expanding the instructional resources available for preparing novices in PBL environments.

CCS Concepts: • **Human-centered computing** → *Collaborative and social computing; Collaborative and social computing systems and tools; Social networking sites;*

Additional Key Words and Phrases: Social support, self-efficacy, student motivation, progress, project-based learning, teams, online communities, computer supported cooperative work

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1 INTRODUCTION

Solving societal problems, such as climate change, poverty, and illiteracy, requires innovators – people who discover, evaluate, and exploit new opportunities (West and Farr 1990). Innovators create products that promote economic growth, job creation, and positive social impact (Wong et al. 2005). To develop future innovators, project-based learning (PBL) communities engage novices with authentic (Merriënboer et al. 2010), real-world project-based work (Krajcik and Czerniak 2013; Shaffer and Resnick 1999).

Yet authentic PBL work can be difficult for novices due to the complex and uncertain nature of the work (Blumenfeld et al. 1991; Krajcik and Czerniak 2013), especially in the context of innovation work that is inherently uncertain (Scott and Bruce 1994). To succeed, PBL students must have sufficient self-efficacy, defined as the perceived ability to achieve the associated tasks (Bandura 1986), to persist in the face of complex innovation challenges (Shalley et al. 2004). Yet, similar to professional innovators, novice PBL students may experience low self-efficacy when discovering, evaluating, or exploiting new opportunities (Lande and Leifer 2010, p. 8), which decreases their persistence and progress (Lande and Leifer 2010).

Novices, by definition, lack the mastery of innovation work that provides a basis for self-efficacy. However, it is possible to boost novices' self-efficacy, or one's perception of their own ability to achieve a task (Bandura 1981; Staples and Higgins 1998), by providing social support (Bandura 1997). Although social support has been defined in many ways (Heaney and Israel 2008), here we define social support as receiving emotional, instrumental, informational, or appraisal support from others (House 1981). Social support can increase self-efficacy, which leads to increased persistence and ultimately progress (Bandura 1982; Stapeles and Higgins 1998). Social support can create positive emotional experiences that reduce stress (Pearlin et al. 1981), allowing novice innovators to persist despite their inexperience (Blumenfeld et al. 1991). Furthermore, social support enhances motivation to seek help and take risks (Deci and Ryan 2011), skills that novice PBL students may lack (Blumenfeld et al. 1991; Krajcik and Czerniak 2013) but are necessary for innovation work.

Unfortunately, in PBL settings, instructors may have difficulty providing adequate social support because they are overwhelmed by the many responsibilities of managing multiple students working on different projects, helping students deal with complexity and ambiguity in their work, and competing course preparation responsibilities (Blumenfeld et al. 1991; Dillenbourg and Jermann 2010). This research intends to utilize online communities to provide social support for PBL environments.

Researchers in human computer interaction (HCI) have begun to explore the promise of online communities, such as Behance (www.behance.net; Cochrane and Atoczak 2015) and Reddit (Reddit 2017; Bergstrom 2011), to provide social support to motivate novices (Hui et al. 2014). Research suggests that social support given in online communities can help participants, particularly novices, feel greater control and more empowered (Barak et al. 2008; van Uden-Kraan et al. 2008). Participation in online support groups can positively influence one's psychological state (Barak et al. 2008; Seckin 2011). Some online learning communities like the MOOSE community (Mooseworld 2017) allow students to support one another's progress and give each other social support (Bruckman 2006). Online communities offer the ability to draw

on an audience of diverse mentors that may radically expand the instructional resources and social support available to PBL environments, offering a better way to prepare novice innovators (Zitter and Hoeve 2012). As online communities become more widely used for learning, engagement, and behavior change (Kizilcec and Schneider 2015; Prochaska et al. 2008; Subrahmanyam et al. 2008), they offer new possibilities for providing support for PBL students.

However, PBL is inherently a face-to-face group activity – PBL cannot be carried out completely online because it requires a great deal of face-to-face discussion, feedback, and teamwork (Dym et al. 2005). Even if PBL work could be done completely online, that would not mirror the real-world, face-to-face practices of innovation work that students are attempting to learn. But if online-only communities are not appropriate for PBL work, we might instead be able to design *blended* learning environments that integrate both offline and online interaction (So and Brush 2008; Zitter and Hoeve 2012). In other non-PBL contexts, blended learning environments have been shown to increase persistence and progress more than traditional face-to-face instruction alone (Lovett et al. 2008; Scheines et al. 2005). So, utilizing online communities to support blended PBL environments could help to alleviate some of the burden on PBL instructors to support motivation, risk-taking, and inquiry of students (Blumenfeld et al. 1991; Krajcik and Czerniak 2013). While we know that social support can help aid workers in an online context (Harburg et al. 2015), we know little about how online social support might support PBL learners in a blended learning environment.

In this design-based research initiative (Easterday et al. 2017; Easterday et al. 2016; Easterday et al. 2014), we conducted two studies to build our understanding of how blended online communities can provide social support in PBL environments. An initial need-finding analysis revealed how novice PBL students currently receive social support and sustain persistence defined as goal-directed behavior that is instigated and sustained (Pintrich and Schunk 1996, p. 5). Based on these findings, we developed an online support tool, CheerOn, to facilitate external supporters to provide social support to PBL student teams. Through a 6-week deployment, in a PBL environment with 3 PBL teams (12 students), we collected interviews, log data, and observations to examine the effects of online social support on the motivation and progress of project teams, or making concrete actions towards a goal (Amabile and Kramer 2011) in this case project completion. We also interviewed supporters, or individuals giving online social support to students within the online community, as well as peer instructors, to understand what factors influenced their participation in support-giving within the online community.

Our studies asked:

1. *Do students in PBL communities receive sufficient social support to build their self-efficacy, impacting their persistence and ultimately their progress in their project work?*
2. *How might we design a technical system that initiates externalizing team's progress prompt social support and how does this in turn motivate students to make progress?*

This research contributes to the fields of HCI, computer supported cooperative learning (CSCL), social psychology, and learning sciences by increasing our understanding of how PBL instructors can use blended online communities to provide social support to PBL student teams. Specifically, it extends our theoretical understanding of how online communities can provide social support for offline project work to promote novice innovators' self-efficacy and help-seeking and how to motivate external supporters to provide social support. The potential practical benefits include new online platforms that leverage online communities to greatly expand instructional resources available in PBL environments, offering new ways to better prepare novice innovators. The general approach may also be extended to support a wide variety of learners – from novice professionals, entrepreneurs in co-working or makerspaces, to students in Massive Open Online Communities (MOOCs).

Fig. 1. Social support from instructors in the form of appraisal, emotional, informational, or instrumental support can increase self-efficacy. Furthermore, help-seeking can prompt the offering of informational and instrumental support, which can impact self-efficacy. This increased self-efficacy can impact persistence, which can lead to increased progress. An increased sense of progress can help to build self-efficacy.

2 RELATED WORK

We ground our study in prior research from HCI, CSCL, learning sciences, and social psychology to better understand how receiving online social support from external supporters in an online community can influence the persistence of PBL students working in blended learning environments.

Innovative design work is complex and challenging yet critical to social progress (Jonassen and Hung 2008; Mowery 2004). PBL environments that challenge students to design innovative solutions to real-world problems can provide critical training but can be equally difficult, as students often fail to persist (Lande and Leifer 2010; Blumenfeld et al. 2006). The challenging nature of complex, ambiguous PBL work often creates learning situations in which learners' self-efficacy is low.

Instructors and explicit help-seeking provides social support PBL that aids students' progress (see Figure 1). Instructors may provide different kinds of social support to students to boost self-efficacy, leading to increased persistence and progress, which in turn should increase self-efficacy. Explicit help-seeking by students also provides another mechanism for securing social support, particularly informational and instrumental support (House 1981), leading to greater progress.

While social support is critical for building student persistence, PBL instructors often lack time to provide sufficient social support given their need to manage multiple student projects and play multiple roles in the classroom (Krajcik et al. 1998a, 1998b). Furthermore, PBL students often have trouble asking for help or admitting being stuck, which makes providing appropriate and timely social support even more difficult for PBL instructors (Rees Lewis et al. 2017). The lack of social support and failure to seek help can influence progress, persistence, and ultimately the self-efficacy of PBL students.

It may be possible to extend existing instructional resources for providing social support by leveraging online communities of external supporters. Online communities may provide social support to motivate students to persist and ultimately make progress to achieve higher learning outcomes (Bruckman 2006), thus improving self-efficacy.

2.1 Opportunities and Challenges of PBL

Instructors use PBL environments to provide developmentally appropriate experiences that mirror professional practice (Zitter and Hoeve 2012), teaching future innovators how to navigate critical and non-trivial problems (Polman 2000). PBL instructors organize students into small project teams to engage students in the process of "asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts" (Blumenfeld et al. 1991, p. 371).

In a traditional learning environment, instructors hand students carefully scoped, toy problems that don't require real-world solutions (McParland et al. 2004; Gerber et al. 2012). As such, PBL provides an approach to train students in authentic real-world innovation work (McParland et al. 2004; Krajcik and Czerniak 2013).

When PBL presents students with authentic problems, students face greater learning challenges than in traditional learning environments (Lande and Leifer 2010). PBL students must bridge disciplines and solve challenging questions that don't have single correct answers, increasing learners' need for social support (Blumenfeld et al. 1991). Furthermore, students engaged in PBL may respond to challenging problems in non-productive ways. For example, PBL students who avoided challenges tended to have lower self-efficacy, which influenced their persistence and tolerance for error (Davis et al. 2003). Students engaged in PBL solving "non-trivial problems" (Blumenfeld et al. 1991, p. 371) may struggle with managing ambiguous project work, which can lead to failure to persist or make sufficient progress (Krajcik et al. 1998, p. 380). Given these demands, there is a need to provide students with various kinds of social support to help them learn and engage in PBL work (Krajcik et al. 1998)

2.2 Importance of Social Support in PBL

HCI, psychology, and learning sciences researchers have long studied social support and have provided many definitions of the construct (Heaney and Israel 2008). HCI researchers have studied social support as online behaviors that express empathy, understanding, provide assistance, show compassion (Barak et al. 2008; McKenna and Bargh 1998; Tanis 2007; Van Hooft et al. 2013), or lightweight affirmations shown in social media such as "likes," reaffirming tweets, or network connections (Burke et al. 2009; Scissors et al. 2016). Psychologists have studied social support as helpful actions that signal respect, encouragement, emotional support, or affirmation that confirms one's competence (Deelstra et al. 2003; Bandura 1997; Amabile et al. 1986). In this article, we define social support according to the House 1981 definition as actions that express care for another in the categories of:

- *emotional support* that provides empathy, trust, and care;
- *instrumental support* that provides tangible aid and services to assist;
- *informational support* that provides advice, suggestions, and problem solving;
- *appraisal support* that provides affirmation that the acts or statements made by another are appropriate and normal and resembles positive reinforcement.

Social support can strengthen self-efficacy, or one's perceived ability to achieve a task (Staples and Higgins 1998). Through enhancing self-efficacy, social support can "engender positive emotional experiences, thereby reducing the negative effects of stress" (Pearlin et al. 1981). This is particularly valuable for PBL students who may experience high levels of stress while engaging in project work (Krajcik et al. 1998). In PBL, social support from instructors or community members addressing students' competencies and contributions to the community may influence their willingness to persist (Reeve et al. 1999; Ryan and Deci 2000). In addition, social support can influence students' willingness to seek help (Bandura 1997; Borgatti and Cross 2003).

Social support may affect persistence and progress in different ways. Non-specific appraisal or emotional support that does not highlight specific behaviors has been shown to be less helpful for learning (Bangert-Drowns et al. 1991; Hattie and Timerley 2007). However, instrumental, informational, or appraisal support that tells the learner how to change to more effectively reach their goal can increase the learner's self-efficacy. In cases where there is a significant danger that students will not persist, as in PBL, social support may also improve learning indirectly by temporarily increasing learners' self-efficacy and thus the likelihood that they persist. In addition, emotional

support about the self may provide an extrinsic reward for progress or indirectly signal which goals are valued. Furthermore, emotional support can help to increase feelings of psychological safety, or the perception that one is able to take risks on a team, which can impact help-seeking behavior, self-efficacy, and worker persistence (Edmondson 1999; Cheryan et al. 2011). This is particularly important and difficult within an online context where users can feel distant from others and afraid to expose vulnerability and their need for help in a public forum. Thus, fostering supportive virtual learning environments where students receive emotional support and feel that they have access to help can boost feelings of psychological safety, impact self-efficacy, persistence, and ultimately progress (Kizilcec et al. 2017; Cheryan et al. 2011). Changing the feeling of support within an online environment was found to be particularly powerful for women and minority students who typically feel excluded from technical class environments (Cheryan et al. 2011). We believe this highlights the opportunity that online environments can have in supporting PBL students who typically suffer from lower self-efficacy. Therefore, social support may serve an important role in contexts such as PBL where learners may struggle with persistence.

2.3 Challenges of providing social support in PBL

Instructors face a number of challenges in providing sufficient social support for PBL learners. PBL instructors need to create an environment that promotes persistence and encourages inquiry, risk-taking, and thoughtfulness (Krajcik and Czerniak 2013). This places heavy demands on PBL teachers as they attempt to play multiple roles in the classroom, such as facilitator and coach. PBL must also orchestrate multiple groups of students (Mergendoller and Thomas 2005; Blumenfeld et al. 1991). PBL environments require students to take more active roles (Gallagher 1997), so instructors struggle to adapt to the role of social supporter as they try to “shepherd” multiple project teams (Laffety et al. 1998). As a result, consistently tracking teams to provide social support only adds to their existing workload. In addition, projects can create anxieties in students that are difficult for instructors to dispel and support, which can negatively impact learners’ persistence and resilience (Lande and Leifer 2010; Goodyear et al. 2001). Given that PBL work is complex, stressful, and uncertain (Lande and Leifer 2010; Doyle 1983), participants need sufficient motivation to persist in the face of these challenges (Lande and Leifer 2010; Blumenfeld et al. 1991). However, instructors managing PBL environments may wrestle with balancing the specific needs of various students (Marx et al. 1997). As a result of these demands, PBL may not provide learners with sufficient social support. Finally, social support from a single instructor might be less effective in increasing persistence (i.e., expectancy and value of work) than social support coming from multiple peers (Ritchie and Newby 1989; Wegerif 1998) or a wider community (Blumenfeld et al. 1996).

2.4 Social Support in Online Communities

Given PBL students’ need for social support and the difficulty for instructors to provide sufficient social support, we might look to online communities to offer new ways to provide emotional, instrumental, informational, and appraisal support. Researchers have begun to explore the ways in which online community members provide social support to increase self-efficacy, impacting persistence and progress. For example, signals of appraisal support via personal tokens of appreciation on Wikipedia increased participation on the site by 60% (Restivo and Rjit 2012). Editors who displayed their tokens of appreciation publicly edited significantly more than those who did not (Benkler and Shaw 2015). In addition, recognition from peers was found to be the most important motivator for contributors in a Chinese Wikipedia study (Liang and Hsu 2008). Research suggests that informal rewards from peers on Wikipedia had a substantially positive effect on user participation (Restivo and Rjit 2012). These peer interactions can also help to build social capital

(ex: trust, shared identity) between members, influencing their effectiveness and performance within the community (Resnick 2006; Benkler et al. 2015). Participating in such platforms has been shown to help confirm one's self-image of being an efficacious person (Rafaeli and Ariel 2008). As such, participating in an online community can improve users' sense of self-efficacy of their ability to perform and contribute (Kollock 1999).

Research has shown that online social support can help users' social presence, or "the degree of salience of the other person in the (mediated) interaction and the consequent salience of the interpersonal relationships" (Short et al. 1976). Social presence can impact one's perception that others are present and observing their behavior (Tu and McIsaac 2002; Richardson et al. 2003; Zajonc 1965). Social presence can increase feelings of connectedness and performance in learners (Tu and McIsaac 2002; Richardson et al. 2003). A study of online games showed that the presence of an online audience positively improved performance in players (Bowman et al. 2013). Another study showed that when newcomers on Wikipedia received follow-up comments to their posts, they were 12% more likely to post to the community again (Joyce and Kraut 2006). This is consistent with early psychological research suggesting that the presence of others can increase an individual's persistence (Zajonc 1965).

Researchers have identified many of the factors that influence whether online community provides social support across a variety of contexts (e.g., online encyclopedia, movie rating system, business online community, education etc.). People help strangers online to preserve their reputation (Donath 1999; Wasko and Faraj 2005), for future reciprocation (Ackerman 1998), or to build their own self-esteem (Bock et al. 2005; Wasko and Faraj 2005; Hertel et al. 2003; Kollock 1999). Members of communities have been shown to offer social support to those with a shared identity or affiliation (Allen and Meyer 1996; Resnik 2001; Zimmerman et al. 2011), as well as when they feel confident and comfortable in the online community (Rafaeli et al. 2009). In addition, users tend to participate more frequently when they feel that they add value to the community or when they believe that they have a unique opinion to contribute (Rashid et al. 2006; Ling et al. 2005; Zimmerman et al. 2011). As such, we would expect that they would give more aid to others when these factors are present for online community members.

2.5 Online Social Support for PBL Work

In order to facilitate increased social support, online communities may be used as part of a face-to-face PBL environment in which students work and connect to a broader community of social support (Blumenfeld et al. 1991; Subrahmanyam et al. 2008). For example, online platforms can allow students to engage with expert mentors via online chat rooms or listservs as they solve difficult problems (Farquhar et al. 1997) or with online mentors (Sanchez and Harris 1996), facilitating a process of drawing on the experiences of others online (Miller et al. 2005). In addition, peers in massive online open courses (MOOCs) can provide social support to one another and encourage each other to make progress (Kizilcec and Schneider 2015). Students in the online MOOSE community have been shown to learn from and support each other (Bruckman 2006). Online environments, like Blackboard, have also been used to help small groups of students collaborate on project work online (Lou and MacGregor 2004; Palloff and Pratt 1999). In addition, remote collaboration systems, such as The Designers' Outpost, allow for distributed design collaboration for people as they work on design problems (Everitt et al. 2003). In addition, online communities can offer an extension of classroom time in a way that can bridge barriers and power structures that often exist in the classroom through increasing communication channels between instructors and students (Klemmer et al. 2001; McComb 1994). Online communities like Scratch can facilitate communities that collaborate and work on solving coding problems in a context outside of the classroom (Resnik et al. 2009).

However, online communities are not always effective at increasing student achievement. One study showed that PBL groups were not equally successful in their ability to collaborate online due to personality and motivational differences (Thomas and MacGregor 2005). In addition, online instructor facilitation and monitoring of team processes may not be as helpful for lower achieving students (Wang and Holcombe 2010). Furthermore, it can be difficult for instructors to even recognize student anxieties.

While online communities still face similar challenges that offline environments produce, research suggests that there are ways online systems can prompt behavior that is difficult to do offline. For example, research suggests that students working with Intelligent Tutoring Systems (ITSs) tended to not seek help at the right time; however, this problem was aided by providing prompting systems through online tutoring (Roll et al. 2011). Furthermore, the research found that training students on how to seek help via the tool increased help-seeking behavior generally. They found that the improved help-seeking led to increased learning progress. This provides insight into the importance of prompting and incorporating training on help-seeking and help-giving within online communities for PBL students. Thus, we find that PBL can draw on the learnings of ITS related to prompting and training PBL students around help-seeking. However, we can also build to this research as the PBL students in our context have the ability to draw on a larger group of people for help and social support. Thus, we have the chance to explore whether prompting and training help in a community of support can help PBL students get the support they need to boost their self-efficacy, impacting their persistence and ultimately progress. Finally, beyond technical features in the system to prompt help-seeking and giving, there is also a need for PBL students to feel safe online and thus this article explores how to foster an environment of psychological safety for users to be willing to ask for help (Edmondson 1999).

2.6 External Online Communities for Social Support in Blended PBL

Online communities of external supporters provide a possible option for providing social support to students in PBL environments when teachers cannot provide sufficient support. However, such an approach faces many hurdles. First, in PBL environments for learning innovation, students' work involves large, complex, face-to-face, projects as opposed to small, discrete contributions to an online product typically studied in research on online communities (like Wikipedia). Second, most PBL environments, such as 10-week university courses, are short lived, providing insufficient time and resources to establish a new online community or for learners to become established members of an existing online community. Third, even if the first two challenges can be overcome, external online community members may lack the interest or ability to understand students' projects well enough to provide substantial social support. Fourth, even if external community members do provide social support in either in-person or blended PBL environments, it is not clear whether it will significantly impact students' self-efficacy or persistence. The research around online communities provides little guidance in how we might use external online communities to provide social support in PBL environments.

3 STUDY 1: SOCIAL SUPPORT NEEDS IN REAL-WORLD PBL

3.1 Purpose (Study 1)

The purpose of this study was to test whether the theoretical predictions about self-efficacy and social support – suggesting that novices have low self-efficacy and don't receive adequate social support – are applicable in peer-led, PBL environments for teaching innovation. On the one hand these theoretical applications could be entirely consistent in peer-led, PBL settings where novice students feel that they lack sufficient social support and self-efficacy. On the other hand, we could

find that novice students in this context feel that they have sufficient social support and don't wrestle with self-efficacy. To understand whether these theories apply in this context, this need-finding study asked: *Do students in PBL environments receive sufficient social support to feel self-efficacy in their work, which sufficiently motivates them to persist and make progress?*

3.2 Methods (Study 1)

3.2.1 Study Design. We conducted an observational case study (Stake 1995) in a field setting and semi-structured interviews (Drever 1995) to understand social support in PBL environments and provide a baseline for future interventions.

3.2.2 Research Site. We observed a 10-week, extra-curricular PBL innovation program at a medium sized private Midwestern university. We investigated a *peer-led* PBL environment because it has all the challenges of an instructor-led PBL learning environment but is even more likely to expose the challenges of providing proper social support.

The program was created by innovation professionals and professors to prepare novice innovators for solving real-world social problems. The program has chapters at 38 universities, one of which was studied here. University professors, alumnae, and local professionals advised students on their project during their innovation process. In total, there were approximately 127 professionals across the network that volunteered as coaches for teams. Peer instructors, students, mentors, and coaches received no course credit and no pay. Participants designed solutions to real-world social challenges selected by program developers. The four-person student teams were not restricted to a particular solution, designing both services and products. Student teams presented their process and solution at the conclusion of the term at a "final expo" to other members of their university design studio.

This design program provided an ideal context for studying PBL. On one hand, it provided an example at the upper end on the challenge spectrum of PBL in universities, given that students worked full time for 10 weeks, worked with clients from real community organizations, and were led by experienced peers rather than professional instructors. It is also an ideal context because the challenge level of the problem the students are working on is higher than what students are capable of doing. This is interesting whether we're working with pre-professionals, little kids working on projects, or professionals working on complex innovation challenges.

3.2.3 Participants. We observed 15 students, ages 17–25, from diverse disciplines who had between 0 and 4 years of studying design at the undergrad level. Participation was optional. Participants were not compensated for participation in the study. All teams were assigned with an external mentor whom they would meet with in person occasionally or connect with over e-mail.

3.2.4 Data Collection. We conducted individual semi-structured interviews with 15 PBL students to understand if they received sufficient social support to make progress. Each interview began with an explanation of the method and a description of our research interest. We explained that we would record and transcribe the interview and were not evaluating the class and guaranteed anonymity. Interviews lasted between 20 and 30 minutes and averaged 25 minutes. The total time of need-finding interviews was 450 minutes. Interviews were recorded and transcribed resulting in 44 pages of transcripts. Interviews were conducted at different stages of the course to understand if persistence and need for greater support changed over time. This research approach allowed us to collect in situ data, but is susceptible to self-report bias (Spradley 2016). We also recorded time-stamped field notes about each of the witnessed experiences.

3.2.5 Data Analysis. We used structured-case analysis, which involved taking a constructed theoretical framework of social support and comparing whether this theory aligned with our case

Fig. 2. When students don't externalize progress or prompt help-seeking, supporters are less able to offer social support, which hurts self-efficacy, impacting persistence and ultimately progress.

(Carroll and Swatman 2000). This method allowed us to evaluate whether students in PBL communities receive sufficient social support to make progress and stay motivated (see Figure 2 for reference). Upon examination of the data we found that students received different kinds of social support. We reviewed varying definitions of social support to understand which definition aligned most appropriately with the types of social support students reported receiving in the data. From this we choose to follow House's (1981) definition of social support, as it most closely resembles the nature of the social support we observed in our context. Specifically, House's definition allowed us to differentiate appraisal support praising certain actions or statements made, from emotional support, as well as instrumental support that provides tangible assistance from informational support that offers verbal support. These distinctions allowed us to more closely examine the different mechanisms for providing social support online. From this definition, we developed a coding manual (see Appendix) that detailed the four types of social support according to the House (1981) definition, providing agreed upon examples from our social support data of each social support type reported.

We used this literature to construct questions to understand social support phenomenon within the context of PBL teams. After conducting preliminary interviews with 15 students, we coded for instances of social support, specifically, where students expressed feeling: emotional support, instrumental support, informational support, or appraisal support from members of the community including peers, faculty, student leaders, mentors, and coaches. Moving between inductive and deductive reasoning, we identified social support needs. We developed initial inferences through this iterative process. After the first round of interviews, we asked more targeted questions to individuals to test these hypotheses. We reviewed all relevant data and evaluated the strength of our evidence to inform whether initial inferences should be modified or abandoned based on insubstantial evidence. All quotations were directly transcribed from interviews without grammatical corrections.

3.3 Results (Study 1)

Study 1 asked: (RQ1) *Do students in PBL communities receive sufficient social support to make progress?* Study 1 found that social support for PBL students in the form of appraisal, informational, emotional, and instrumental support (House 1981), occurred infrequently and often came too late to support students' progress. This occurred in part because the student's progress was not visible to instructors.

Specifically, study 1 found that students: (a) felt motivated by social support in the forms of appraisal, informational, emotional, and instrumental support as shown in Table 1, yet rarely received any of these social support types until the very end of the project when they externalized progress; (b) often felt stuck, but rarely externalized their progress and need for help; and (c) often

Table 1. Students Receive Emotional, Instrumental, Informational, and Appraisal Social Support, but Too Little and Too Late

Social Support Type	Description	Example
Emotional support	Provides empathy, trust, and care.	<i>"They said, 'Don't freak out, it's ok'."</i>
Instrumental support	Provides tangible aid and services to assist.	<i>"She [coach] did some stuff for us for interior design."</i>
Informational support	Provides advice, suggestions, and problem solving.	<i>"Someone said '...go forward with that. Do more of this.'"</i>
Appraisal support of...	Provides affirmation on the appropriateness of acts or statements.	
...value of project	States qualities about the project.	<i>"[A lead staff member] came by and said 'This [project solution] is really smart!'"</i>
...work	Says something about the correct (right/wrong) or information about the quality of work.	<i>"Having faculty say, 'Wow, you're on the right path.' That helped us a lot!"</i>
...person	Makes statements about qualities of team.	<i>"When we gave our pitch they said, 'Wow, you have a lot of passion!'"</i>

lacked a clear sense of progress while working on their project, influencing their persistence and ultimately progress.

3.3.1 Motivations of PBL Students. PBL students felt motivated by receiving *appraisal, informational, emotional, and instrumental support*, but rarely received these forms of social support until the end of their project when their progress was externalized.

PBL students reported feeling motivated when they received appraisal support that affirmed their project work and instrumental support that offered help, especially when coming from high-status individuals. As one student explained: *"[We were motivated] when people are really excited about what [we're] doing and want to help and share their expertise."* This demonstrates how PBL students found it motivating when supporters offered appraisal support that affirmed their work and instrumental support that showed a willingness to help. Another student explained feeling motivated by people affirming their work at the final presentation: *"People in the [final] presentation were very impressed. [The founder of the program] actually came by and said, 'This is really smart' and I felt really good about that... During the presentation, several other professors came by... and said, 'This is awesome. You guys did a great job.' – and it felt great."* Students expressed feeling particularly motivated when they were given appraisal support from high-status individuals such as instructors, mentors, and domain experts. As one student working on food waste in cafeterias said: *"The affirmation is bigger when it comes from more experienced members."* These students highlighted that the impact of social support was stronger when it came from high-status individuals.

Informational support providing advice and emotional support expressing care helped motivate students to persist and make progress. Students expressed how helpful it was when external supporters shared advice and perspectives on student projects. One student noted the benefits of feedback from expert external supporters: *"I always appreciate having a third party who knows the process extremely well to come in to speak to my team. I just remember... we had outside feedback come in [to their classroom for a critique session], it was so helpful."* This student explained that having external helpers provide informational feedback on what to do next helped them to make

progress. Students also noted that emotional support from external supporters reassured them that they were on track. As the student explained, *“There was a time when my team felt particularly stuck, and the professionals came in and gave us some amazing advice and said ‘Don’t freak out, it’s ok. You don’t need to make this amazing solution that will change the world, just solve the problem’... It was one of those moments where it was not good... but then they said, ‘Back it up and it is all good... Then you get reassured and take a break for a hot sec and come back and it works.”* In this case, appraisal and emotional support reassured and motivated the team to persist.

Despite these instances of social support from external helpers, most social support (of all forms) rarely came until the end of the project when students were finished. PBL students reported that they did not often receive social support from instructors and mentors during the project. As one student said, *“We weren’t getting feedback reinforcing that this was exciting... the affirmation only came at the end from some of the staff and faculty when we were presenting our final projects.”* Given instructors’ and mentors’ limited time, students infrequently received social support on their work during the program. As another student said, *“It [our project] wasn’t really recognized until our final expo [presentation]. When we gave our pitch they said, ‘Wow, you have a lot of passion.’ When we were recognized then, people on our team said ‘Wow, hearing that feedback was helpful.”* Here the students point to fact that they hadn’t received social support until the after their project was complete. Many other students we interviewed expressed receiving little social support before the end of their project, and some did not feel that they received social support even then.

The lack of social support, while unfortunate, is understandable. While PBL students had access to 127 mentors across the network, only 9 local mentors were actively engaged in supporting project teams. Given the many demands of orchestrating PBL environments, instructors and mentors have limited time to provide social support, which is not unique to this specific PBL environment (Lande and Leifer 2010).

3.3.2 Students Felt Decision Uncertainty but Rarely Sought Help. PBL students were often unsure how to move forward. During these times, PBL students reported having trouble asking for help and discussing problems only internally with their team, despite the fact that in cases where students did receive external support, they felt more motivated to persist.

Students reported often experiencing decision uncertainty during the PBL project process. One student working on an urban planning project said: *“If you don’t know where to go, if you don’t know your next step, you’re completely stuck.”* Students reported feeling uncomfortable moving forward when they didn’t hear from their partner organizations. As one student said: *“We didn’t feel comfortable moving to ideate stage because it’s for our user and we’re not getting [user] input. How do we jump to a solution? We got stuck.”* Students reported also feeling conflicted by the multiple options they could take. One member working on building comforting rooms for newly adopted kids said: *“Right now we all feel a little stuck because we’re discussing what we want to do with the room and there are so many ideas and possibilities about what the style of the room is.”* Students also reported struggling with defining the problem they were trying to solve. As one student said: *“A big problem with this project was actually trying to figure out what the real problems were.”* Students often went back and forth between multiple problems and solutions, experiencing uncertainty.

When students faced decision uncertainty, they did not seek help. As one student working on a project for cancer patients described, *“When we got stuck it was more of a ‘Let’s see what we can do this week and come back the week after.’ I usually didn’t reach out to people when we were stuck... We didn’t really let other people know that’s where we were at.”* Most students said that project status was only shared privately via Google docs, if at all. One student said: *“We’re not really checking in with anyone about our progress... we kind of forgot to keep them [mentors] in the loop... we didn’t*

really tell them [mentors] about anything until working up till the final product. It would have been nice [to share our progress with them]."

Students gave several reasons for not seeking help, including evaluation apprehension, time constraints, and the infrequency of meetings. Teams noted how part of not reaching out to mentors stemmed from them not being sure if they were on track, and thus not wanting to admit that they were behind. As one member said, *"You get wrapped up in your projects. You get nervous of where you are or where you should be."* One project team described how the mentors for her PBL team rarely were in the loop with her group given that they met infrequently due to the business of their mentor's schedules. She said: *"Our mentor didn't really know what was going on because meetings were irregular. We met only two times."* Given the infrequency of check-ins, students expressed feeling separated from their mentors and reported being less willing to ask others for help.

3.3.3 Students Reported Feeling a Low Sense of Progress While Conducting Project Work. PBL students often felt they were making little progress and were unaware of how their progress compared to others, demonstrating the lack of appraisal support, which influenced persistence.

Students often felt they were making little progress in their project work. Given the time-intensive nature of PBL work and multi-step design process, students reported feeling a low sense of progress throughout the project. Students discussed how they would get *"deep in the weeds"* and a low sense for all that they had accomplished. As one team working on designing a room described: *"The discussions we're having are all really good and valid but we're not making too much concrete progress. Because we have a lot of ideas to discuss but designing within a whole room is kind of hard because we don't know all of the themes, because figuring this kind of stuff [design decisions] out is hard."* This illustrates one of the challenges of PBL work that comes as a result of difficult decisions with no single answer and a lack of clear progress as a consequence.

Teams reported being unaware of their progress relative to other teams. One student described how he rarely knew how other teams were progressing. As he stated: *"I have no idea where other students are."* One expressed reason for being unaware was due to the time burden on students as a result of project time constraints as well their other homework assignments and extracurricular activities. In addition, students also expressed uncertainty around whether they were on track compared to others given that students are working on different projects and struggle to collaborate. As one student described: *"It takes too much time to look at other student's project updates—I like seeing what they are doing at the end, not a thing that students collaborate that much."* Given that it takes time to check in with other teams, students reported being unsure of how their progress compared with that of other students. Teams also noted that not many members of the community were aware of their work accomplishments. One member working on building sustainable coffee shops talked about how none of the other students knew about his team's progress during the term. As he said, *"Other studio members don't know about the success [of our team],"* suggesting students often operate internally and are not making use of their support resources around them, which can influence persistence. The focal time that students seemed to be aware of their relative progress was at the end of the program. As one member stated, *"Not until the end of the [10 weeks] did we have a sense for where you are compared to other students."* The lack of appraisal support validating the appropriateness of their acts along the way influenced student persistence. That being said, the students still did make some progress, which boosted persistence.

Perceived progress influenced persistence on project work. Students felt that making progress increased their persistence. As one student described, *"Having faculty come in [during final presentations] and say: 'Wow, you're on the right path.' That helped us a lot."* Teams were encouraged when people offered appraisal support through recognizing the progress they were making and confirming that they were working in the right direction. Yet this happened infrequently and

often came too late in the process, influencing retention. As one student working on a dementia project noted: *“We wanted to find progress, but we were struggling... it’s hard to have motivation... our team kind of died out at that point.”* These students lost motivation when they were having trouble making progress. The lack of being able to feel a sense of clear progress influenced motivation and influenced some members’ desire to persist in project work. Other mediating factors that influenced this decision to persist or terminate projects included: project timing and busyness of student schedules amidst other responsibilities, personality of students who felt more or less interest in the topic or desire to conduct this type of work, as well as poor team dynamics that left teams not wanting to work together in the future.

3.4 Discussion (Study 1)

We found that students often faced decision uncertainty during project work, but social support came infrequently and often too late, in part because students did not externalize progress nor seek help, leading to decreased persistence and progress. While students did produce some tangible outputs, which has been shown to help promote a sense of forward progress and strengthen beliefs of creative ability (Gerber et al. 2012), students still often felt unsure as to if they were on track and unclear of what steps to take next. While some students continued to persist on their projects amidst this uncertainty and lack of social support, others decided to terminate their projects at the end of the quarter. Other mediating factors could have influenced this decision including timing, interest, personalities, and team dynamics. While some of these factors cannot be controlled, social support is a factor that has the ability to be better monitored to help boost increase self-efficacy of students, influencing persistence and performance.

The findings from Study 1 were consistent with the expected theoretical challenges and relationships between social support and persistence in blended environments for novice PBL students. However, we found that when students did receive appraisal support confirming the importance of their work, even at the end of their project, they reported feeling more motivated on their projects. This is contrary to empirical research suggesting that positive feedback is unhelpful in the classroom because it does not provide feedback that helps the learner judge their knowledge and skill (Hattie and Timerley 2007). In a PBL environment where persistence cannot be taken for granted, appraisal support may provide needed motivation. In addition, the lack of instrumental and informational support led to students feeling unable to ask for help given that they were unsure how others could help them.

The study identifies a number of opportunities. Although it is unlikely that the peer instructor could provide as much social support as a team desired, there was in fact a larger community of potential supporters that did interact with student teams. Accessing this community to provide social support in the forms of informational, instrumental, emotional, or appraisal support depends at least in part on overcoming student teams’ reluctance to externalize progress. Students may, in fact, be willing to externalize progress and monitor other teams for reasons such as comparing progress with others. Study 1 both corroborates the usefulness of providing social support in the forms of appraisal, emotional, informational, and instrumental support. It also suggests a potential role for online communities to provide social support based on externalizations of student progress so as to help students receive more social support throughout the learning process.

4 STUDY 2: CHEERON: AN ONLINE SOCIAL SUPPORT SYSTEM FOR PBL

4.1 Purpose

The need-finding study indicated that although a peer instructor may not be able to provide frequent social support to students throughout the PBL process, we might be able to enlist a pool

Fig. 3. External supporters in the online community receive prompts and progress reports from teams' project management activities to enlist them to provide social support.

of external supporters in online communities to provide social support through online tools that prompt teams to externalize progress and prompt supporters to provide social support. Study 2 asked: (RQ2) *How might we design a socio-technical system that incorporates external supporters to provide social support to increase student persistence in PBL environment?*

We propose that such a system can be designed to provide social support by engaging students in intrinsically motivating practices whose side effect is to externalize progress to an online community of supporters who are then likely to provide social support, circumventing students' disposition to not explicitly seek help. Specifically, online communities for providing social support to students in blended PBL environments for innovation should:

- engage learners to externalize progress through collaborative to-do lists and stand-up meeting templates that help teams track and review progress and that post progress to an external, online community;
- recruit external supporters from the local design community to provide social support to specific teams;
- facilitate external social support by periodically prompting supporters and providing features that allow supporters to respond to teams' externalized progress.

We expect the intervention described by the design argument in Figure 3 and Table 1 to work as follows:

1. *Recruit:* The community manager, such as an instructor or teaching assistants (TA), recruits members from the local design community, such as senior students and alumnae to become external supporters. The community manager relies on the effectiveness of word-of-mouth recruiting from social networks (Kraut et al. 2012) to bootstrap a group of external supporters with strong identity-based commitment to design teams and bonds-based commitment to the manager, when members feel socially or emotionally attached to particular members of the community, which is further supported by online photos and profile pages (Festinger et al. 1950; Kraut and Resnik 2010; Ren et al. 2012).
2. *Train:* The community manager trains design teams in two project management techniques: collaboratively tracking tasks and daily *stand-up meetings*, daily updates in which teams quickly identify whether they are on track and what obstacles are in their way (Rasmussen and Ludvigsen 2010). Crucially, these practices are seen by teams as having instrumental value to the team's success so teams will engage in these activities spontaneously after a relatively small amount of formal training (Kraut et al. 2012).

3. *Externalize work*: The online platform provides tools for tracking to-dos and communicating stands that scaffold their work (Reiser 2004) and make their thinking visible (Bransford et al. 2000). The purpose of the externalization of progress is to make supporters more aware of the state of the students to increase the offering of social support.
4. *Highlight progress*: The system uses the to-dos and stands to track progress and obstacles and post this on the activity stream.
5. *Broadcast progress*: The system routes information about progress and obstacles to supporters of a specific team, effectively selecting and externalizing communicating (Kraut et al. 2012) of progress.
6. *Prompt support*: The community manager periodically reminds supporters (if necessary) to provide social support – these requests are likely to be fulfilled because they are simple and made to specific supporters from a liked requester (Kraut et al. 2012).
7. *Provide social support*: Supporters *offer social support regarding the* team’s progress displayed on the team’s activity stream.
8. *Broadcast support*: The activity stream is communicated to the team, again effectively externalizing communication (Kraut et al. 2012) of social support.

4.2 CheerOn System Description

We implemented this design argument in the *CheerOn* system with the following features in Table 2:

4.3 Methods (Study 2)

4.3.1 Study Design. Study 2 consisted of an observational case study in a field setting to test the effectiveness of the design argument at providing online social support in a PBL environment.

4.3.2 Research Site. We conducted this research with the same extracurricular design organization used in the need-finding study, this time focusing on a group of PBL students who worked on projects during the summer. PBL teams worked on pro-social design projects on: diabetes, food programs for the homeless, and refugee assistance. The students presented their projects at the conclusion of the 6-week-long project at a “final expo” to other members of their design community.

4.3.3 Participants. The program included 12 design students (7 females, 5 males) and 15 designated online supporters. Students were placed in 3 interdisciplinary teams of 4 students each. Student’s majors included: Chemical Engineering (1), Art, Theory and Practice (1), Manufacturing and Design Engineering (1), Mechanical Engineering (4), Comparative Literature (1), Engineering Sciences and Applied Mathematics (1), Computer Science (2), and Computer Engineering (1).

The summer program was led by an experienced undergraduate “lead” who served as an instructor and coordinator. Each team had 1–2 experienced design professionals who served as design coaches, although 2 of these coaches dropped out of the program midway due to travel obligations.

We recruited 15 professional designers, graduate, and undergraduate students studying systems design, experienced members and alumnae of the local design community network to give weekly social support using *CheerOn* to the 3 student teams. There were 15 supporters (9 females, 6 males). Five were undergraduate peers engaged in design work, 5 were PhD design students, 2 were design professional trainers, 2 were startup founders, and 2 were recent graduates with design research experience. All had some understanding of the projects and had some level of previous design experience. Recruited supporters did not receive credit or pay.

Table 2. We Blend Theoretical and Empirical Research in HCI, Learning Sciences, Psychology to Inform the Design of Socio-Technical System for PBL

Feature	Description	Design Principles
1 <i>Community manager</i>	Community manager (an instructor or teaching assistant): –Recruits online supporters from local community; –Trains student teams in project management practices and tools; –Prompts supporters to provide social support.	Recruiting from manager’s bond-based, social network through word of mouth allows rapid enlistment of supporters (Kraut et al. 2012). Explicit training helps novice teams successfully use platform (Kraut et al. 2012). Prompts involving simple requests to specific supporters who like the manager are likely to be fulfilled (Kraut et al. 2012).
2 <i>User profile and team pages</i>	Online community features allow students and supporters to create user and team profiles with real names, photos, team and community purpose, and conversation threads.	These online community features support identity and bonds-based commitment between supporters and students (Ren et al. 2012).
3 <i>To-do list</i>	Collaborative task management tool helps team track tasks, task owners, and task status. Each student team had an online collaborative to-do list which teams used to track the tasks, task owners, and task completion status.	Positive production externality. The To-Do list and Stands help to scaffold (Reiser 2004) an intrinsically motivating activity that students will spontaneously engage in (Kraut et al. 2012). This process also helps to make thinking and needs more visible (Bransford et al. 2000) to external supporters, an activity students would ordinarily avoid (see Study 1).
4 <i>Stands</i>	Stands would include the following 5 prompts: (a) What’s your sprint goal for this week? (b) Are you on track to achieving your sprint goal? (c) What specific progress have you made toward the goal since last stand? (d) What will you achieve between now and the next stand? And (e) what obstacles are in the way of achieving your sprint goal and whom do you need to talk to or what will you do to overcome these obstacles?	
5 <i>Activity feed</i>	Activity feed records completed to-dos, stands and cheers and broadcasts to supporters and teams. Posts could also be “liked.” Supporters following the feed receive email notifications when teams’ complete items on the to-do list or complete a stand along with a link to the feed.	Activity stream selects and highlights progress and facilitates external communication between teams and supporters (Kraut et al. 2012). The externalization of progress on the activity feed is intended to make supporters more aware of the state of the students to increase the offering of social support.
6 <i>Social support</i>	Underneath completed to-do items and stands posted on the feed is a cheering icon, text field and a prompt to “Give them a cheer!” (Figure 4). Automatic email notifications to followers of completed to-do items and stands also prompted supporters to cheer for their teams. Social support appears on the activity feed and is broadcasted via email to the team members and others following the feed.	This feature scaffolds appraisal social support (Reiser 2004) and makes social support easy to provide increasing likelihood of providing it (Kraut et al. 2012).

Fig. 4. Through the *CheerOn* platform, project-based learning students can post progress on their projects to a group of facilitated supporters. Online social support can then be posted to students after accomplishing their to-do's and stands via *CheerOn* within the online community. On the left, we highlight the core features of *CheerOn*. On the right, supporters give social support on a post reporting team completion of a to-do item.

4.3.4 Intervention. On the first day of the program one member of the research team informed each student team that community members (called supporters in this article) would comment on the team's *CheerOn* page (two to three minute conversation). Supporters were asked to participate over a preliminary email and then were reminded to give social support to students in weeks 1, 3, and 6 of the program as students progressed on their work. In addition to the recruited supporters, 2 of the graduate student researchers served as community managers (which in a traditional classroom would be a responsibility held by a teaching assistant). The 2 researchers and 2 undergraduate research assistants also played the role of supporter in addition to the 15 recruited supporters. We explain the limitations and decision to take this approach in our Limitations section. The *CheerOn* system was a closed system and only open to invited external members who were asked to participate. In addition, there were other community members already in the system (ex: coaches and staff) who participated in the *CheerOn* system and gave social support after seeing the prompts without being asked to give social support. While we asked the 15 recruited supporters to offer social support, some other online community members still participated in offering social support without being asked (ex: coaches, staff, and team members who were already invited into the system).

4.3.5 Data Collection. We conducted interviews with each of the 12 students at the beginning, middle, and end of the program (weeks 1, 3, and 6) for a total of over 600 minutes of interviews. Our interviews focused on understanding how using the *CheerOn* tool influenced students perceived community support, sense of progress, task direction, and self-efficacy (see full coding protocol in Appendix A). We also interviewed the 15 supporters midway through the project and at the conclusion of the project for a total of over 690 minutes of interviews. These interviews with supporters focused on understanding what factors motivated the supporters to participate and offer

social support to students, as well as how supporters perceived using *CheerOn* (see full interview protocol in Appendix B). Over 500 pages of interviews were transcribed for analysis. We collected and analyzed 135 social support posts.

4.3.6 Data Analysis. We conducted four analyses to understand how *CheerOn* affects the provisions of social support in a peer-led, blended PBL environment. Our analyses asked the following:

1. What kind of social support was provided (if any) and by whom?
2. What factors influenced recruited supporters to provide social support?
3. (Post-hoc) What factors caused the lead to provide social support?
4. How did receiving online social support impact PBL students?

To assess our inter-rater reliability and Cohen's Kappa scores we first developed a codebook based on House (1981) definition of social support (see Appendix C). Next we had two raters independently code all of the data (295 social support comments) to assess the validity of the codebook. Once we reached 100% agreement on the coding, we revised the codebook to ensure that these specificities were revised. Next we found a separate, unbiased rater to code 60 randomly generated social support comments, or roughly 20% of the data, which is higher than the recommended 10% of data (Campbell et al. 2013, p. 300). We ensured that a variety of social support comments were present in the 60 social support comments to ensure that all types of data was coded and compared. We compared the 60 data points with the agreed upon codes that had been created, and the measured inter-rater reliability and Cohen's Kappa scores to assess reliability of the data. Following Miles and Huberman's (1984) inter-rater reliability formula, we reached an inter-rater reliability score of 0.816 (81.6%). According to Miles and Huberman (1984, p. 63), a score between 80 and 90% is seen as reliable. Thus, we felt confident in our inter-rater reliability score. Our Cohen's Kappa score was 0.76. According to Landis and Koch (1997, p. 165), a Cohen's Kappa score between 0.61 and 0.80 signifies substantial strength of agreement. As such, we felt satisfied with the reliability of our coding scheme.

For analyses 2–4, we used the interview data, we conducted structured qualitative analysis where we organized the data and then worked to draw conclusions from the data (Miles and Huberman 1994) to assess the effects of using *CheerOn* on the persistence of PBL students. We grouped the comments of the student interviews into the emergent themes of: value of work, identity, and help-seeking. These were compared to the key themes that emerged in Study 1 related to struggles of PBL students. To examine what motivated supporters to offer social support, we examined the data from our interviews with supporters and developed a second coding protocol related to what motivated supporters to offer social support. Themes emerged related to why supporters contributed, including the following: (1) commitment to project and community, (2) perceived ability and understanding of how to help, and (3) sense of reciprocity.

4 RESULTS (STUDY 2)

Study 2 asked (RQ2): How might we design a socio-technical system that incorporates external supporters to provide social support to increase student persistence in PBL environment?

4.4.1 Analysis 1: What Kind of Social Support was Provided (if any) and by Whom? While *CheerOn* was designed for external supporters and community managers to provide support to teams, which they did, almost half of the social support came from leads and coaches who were not explicitly asked to provide social support. Recruited supporters, coaches, researchers, team members, and the project lead gave social support to the project teams (see Figure 5 and Table 3).

Table 4 shows that the lead provided the most social support (29%), followed by managers (researchers and RA's 28%), followed by the 3 coaches (22%), and the 15 assigned supporters (21%).

Fig. 5. Recruited supporters and researchers provided social support comments to Project Teams via *CheerOn*, and unexpectedly, so did the undergraduate studio lead and professional coaches.

Table 3. Appraisal Support, in the form of Appraisal of Work, was the Most Common Social Support Given

Support Type	Description	<i>CheerOn</i> Example	# comments
Emotional	Provides empathy, trust, and care.	"I hope the team is all healthy by Thursday!"	37
Instrumental	Provides tangible aid and services to assist.	"Hey Team - I emailed my contact. I'll loop you folks in as soon as he agrees to help."	37
Informational	Provides advice, suggestions, and problem solving.	"Today it might help to start sketching out the different ideas you have. This will help flesh out some of the details."	81
Appraisal of...	Provides affirmation on the appropriateness of acts or statements.		
... project value	States qualities about the project.	"Super excited to see you guys working on the important problem."	17
... work	Says something about the correct (right/wrong) approach to work.	"Hey guys! Great job at crit today. Love how in-depth you are going with the research."	137
... person	Makes statements about qualities of the team members.	"You guys are great."	8
Total			317

Comments that did not fit into the coding scheme were removed.

Note that as the instructional responsibility of the role increased, the number of people in that role decreased, for example, the single studio lead had the responsibility to oversee all teams, each of the 5 coaches was responsible for mentoring 1 team (though not all did), and 15 assigned supporters who only occasionally provided support to 1 team online. Those with greater instructional responsibility provided more social support, so the cumulative amount of support from each group was roughly equivalent.

This relation also affected the type of support given. The most common type of social support given was appraisal support, which validated the progress students had made on their work and

Table 4. Informational Support came from those with Instructional Roles, While Appraisal Support came from Leads and Managers

Team	Posts		Comments		Emotional Support	Instrumental Support	Informational Support	Appraisal support of...				
	#	#/person	#	%				value	work	person	Total	
Lead	1	38	38.0	92	29%	8	8	33	5	35	4	93
Managers	4	46	11.5	90	28%	13	8	24	5	39	0	89
Coaches	3	22	7.3	69	22%	7	5	13	0	35	3	63
Supporters	1	29	1.9	66	21%	7	15	13	7	27	0	63
	5											
Total	2	135	317	100%	35	36	83	17	136	7	314	
	3											

reinforced the importance of their work, for example, comments such as “great job synthesizing your research.” Recruited supporters mostly gave appraisal support or offered instrumental support (Table 4), given that they knew less about the state of the students and their work. The lead, coaches, and managers gave more informational and emotional support. We believe that this was in part because they saw the students more frequently and knew more about their progress and emotional states.

The type of social support given changed throughout the project. At the beginning of the PBL assignments, social support comments were mostly appraisal support validating the importance of the project and instrumental support offering to help out in any way. The type of social support then shifted to offer more informational support providing guidance and suggestions and appraisal support validating progress. Towards the end of the program, we observed more emotional support expressing care and empathy, as well as continued appraisal support validating work. Of course, not all social support is of the same “value.” We describe how these differences affected students and the implications for designing social support systems later in Analysis 4.

4.4.2 Analysis 2: Factors Influencing Provision of Social Support by Recruited Supporters. Creating online social support communities for PBL students depends on the extent to which supporters participate and offer social support to students, so: what influenced recruited supporters to provide social support?

Recruited supporters described three conditions that increased their provision of social support, when: (a) they had a commitment to the community and felt peer pressure; (b) they understood a team’s need for help and had the ability to help; and (c) they received gratitude from students who heeded their assistance. Unfortunately, these conditions were not always present.

4.4.2.1 Condition 1: Community Commitment. Supporters provided more social support when they had identity-based commitments to the design community and bonds-based commitments to the project members.

Supporters provided social support, particularly appraisal and instrumental support, when they identified with the design community. As one community member familiar with design network said: “I know they are trying to do a quick development of a project that solves a problem. That, in itself, is something I can relate to and appreciate. The problems [the design community network] students are trying to solve—I support that larger mission, by relation I support the team.” Supporters who identified with the design community felt empathy for students and provided instrumental support by offering their services and appraisal support by encouraging the process. Another supporter said, “I’m very familiar with [the design network community] and their process.” This led to

offering appraisal support by giving teams advice. When supporters didn't identify with teams, they wondered what they shared in common with students and were less motivated to provide social support: *"If I had seen what was in common that might have been a bit more motivating."* Feeling a personal connection to the larger mission of the community or understanding and respecting the students design process increased their willingness to participate.

Supporters provided social support, particularly appraisal and instrumental support, when they felt bonds to the design community. As one member stated: *"I feel like an honorary member - I'm very familiar with the process and a lot of the students in there. It didn't feel strange I felt like I was familiar with most people..."* Familiarity with the community increased supporters' willingness to contribute. Supporters outside the organization who didn't have a personal bond to the student teams often found it difficult to provide social support for people they did not know. As one community member said: *"It was hard to cheer for people I had never met before, I felt kind of awkward doing that."* Supporters without a connection to the community, online or offline, seemed less willing to give social support to students online. Some supporters noted how it felt *"artificial"* to give social support to students they didn't know. While *CheerOn* allowed users to see profiles of the students, supporters said that this was not enough for them to feel connected to them. As one supporter said: *"I would have liked to know a little more about them... I guess it doesn't really build a connection with the people that I was going to be cheering [giving online social support]. If I knew more about them I might have commented more."* Supporters also desired to know more about the students to whom they were giving social support.

4.4.2.2 Condition 2: Peer Pressure. Social facilitation (peer pressure) among supporters increased social support. While many of the external supporters did not initially know their teams, they sometimes knew other supporters. Supporters were moved to participate when they saw other supporters giving online social support. As one supporter said on their purpose of commenting: *"I think it might be partially because I knew those people who were cheering [giving social support]. I knew the [design network] community and it had the community aspect to it and they were participating in something I also wanted to participate."* Some supporters said that they felt that it was a bit less odd to give social support to those they didn't know when they saw other supporters also commenting on the site. As one member stated: *"When I first got the email, I thought it was going to be a little awkward because I don't know these people. At the same time, I felt a little less awkward when I saw others on there, so it's totally cool."* Seeing other supporters posting helped them feel more willing to participate, as they felt less alone. In addition, supporters tended to mirror the social support type of those who had gone before them. For example, if someone gave appraisal support, others would mirror similar appraisal support comments. One student noted how they were more motivated when they noticed others comment: *"It was cool to see the posts from other people—I felt that it was good that I cheered and that I wasn't the only one. When I didn't see interactions from other people, I felt like I didn't have to do it as much."* Supporters were heavily influenced, both positively and negatively, by the others participation within the online community. By seeing the other participants within the community actively giving online social support that they knew, supporters wanted to in turn also participate.

4.4.2.3 Condition 3: Supporter Saw Clear Need for Help. When external supporters received specific help requests or saw a clear need for help they provided informational support by giving concrete advice or provided instrumental support by offering their services.

Perceived ability to provide help increased giving of informational and instrumental support. Supporters tended to offer social support only if they felt they could help students, and responded with both informational and instrumental support. As one supporter said: *"I would really comment if I had some value to add - if I had a question that I thought they should consider or a connection*

that I knew if I could help them." Supporters who felt that they had informational or instrumental support to share were more likely to participate. Another supporter noted that she was eager to offer informational support when she saw that the team was facing a problem that she knew a lot about. As she expressed: *"There was one stand that I saw people had commented on and then I jumped in on it. I saw the question about blockers... I had some experience with that... I felt really good being able to share that with them. Felt like easy pickings."* This supporter was motivated by the fact that she could share something that she knew about and it was an easy way for her to offer informational support.

Supporters perception of their ability to provide social support was influenced by the examples of previous social support comments given by others online. Supporters were also motivated to give informational and instrumental support when they felt that they had something new to add that was not already being voiced. Members noted that they were eager to participate when they had something they felt they could share and the proper skills or experiences to help. However, when members were not clear what the students needed or didn't feel like the students needed informational or instrumental support, they were less likely to help.

Supporters participated when they felt like the team genuinely needed help. If the team noted that they were doing fine, they felt less obliged to give them informational or instrumental support. As one community member who does design research work stated: *"They say: 'We're on track. We're good' so it makes me think they're fine—it keeps saying 'Oh we're fine, we're fine, we're fine'. If they said 'Oh no, we're struggling with this', what information can I give them to help them."* We found that even when students were struggling, they often reported that they were "on track", which confused supporters trying to offer social support. As another community member expressed: *"If it looked like they were doing fine, I just kind of let them go. If there were times when I felt they needed a little booster..." It was harder for me though... I felt the team is struggling more than I expected. I think there's nothing I can do via [online support] to help them, in that sense, it was much more beneficial for me to sit down in person and give insights that way."* Supporters were not always sure of what exact challenges the students were facing and where they needed informational or instrumental support. Informational and instrumental support, as well as other forms, was thus influenced by whether supporters had a clear understanding of the project and the needs of the students.

We also found that supporters often didn't want to simply give vague appraisal support, but wanted to give more direct informational or instrumental support that they felt could help the team meet their needs. Despite this desire, supporters tended to give appraisal support rather than other forms of social support.

Supporters could not always tell what help was needed, negatively influencing the instrumental or informational help they offered. As one supporter stated, *"It's hard for me to directly give useful feedback without having more context."* Some students said that they were working on the same thing from the day before. Thus, supporters were not always sure what had changed between the days. As another supporter stated, *"But sometimes it's a little unclear to know the difference between their stands [progress posts]. It takes a bit more effort."* Supporters were not always sure where students were in their project process and what they needed help on. This influenced their willingness to offer informational and instrumental support. The vagueness of the progress posts frequently left supporters unsure how they could actually give instrumental or informational help. As one supporter who was a graduate researcher familiar with the design process stated, *"What's missing in this daily process is specificity in terms of what exactly they're doing. The stands are so vague so it's hard to pinpoint what they're working on and need help with."* Some supporters struggled to understand what the students were saying through their daily posts and updates. Another supporter stated: *"If I had been given some kind of notification that this is something they need help or feedback on. This would help with giving them a frame for what they need help on."*

Table 5. Stands were more Likely than to-do Posts to Elicit the Types of Social Support that Provide useful Feedback and Resources

Reply to	Emotional Support	Instrumental Support	Informational Support	Appraisal support of...			Total
				value	work	person	
<i>Stand</i>	20	20	62	5	70	3	180
<i>To-do</i>	1	0	1	0	34	0	36

Supporters were not always sure what kind of help was needed, which influenced their willingness to give positive support and participate within the online community.

Stands were more likely than to-dos to elicit instrumental or informational support. Supporters provided instrumental or informational support in response to a stand more often than to a to-do post (Table 5). When supporters responded to to-do posts, it was almost exclusively with a form of appraisal support. Whereas when supporters responded to stands, it was typically with instrumental or informational support. In other words, stands elicited informational or instrumental support whereas completed to-do posts did not. This is likely because to-do posts do not surface any problems or need for help, so appraisal support is the only type of support that supporters can provide in direct response to the post.

4.4.2.4 Condition 4: Supporter Received Gratitude for Previous Social Support. When external supporters felt that the students appreciated their efforts, they felt more willing to offer additional social support. This social support came in all forms, but was often increased emotional support given to students.

Supporters were more likely to provide social support when students responded to or expressed gratitude for their comments. As one supporter for the diabetes team stated: *“I went back to the [online community] to see if there were any responses. But then I saw that someone who had read the post had responded and said, ‘Hey, thanks so much’ and that felt really good. I went back and was eager to see whether my input was considered... After that I started to read the stands again. I became re-interested again.”* Another member said that he felt good knowing he was in dialogue with the members of the team he was supporting. As he remarked: *“Having someone respond in text felt good. It was like we were engaging in a conversation... Made me feel good that they appreciated it.”* Supporters felt higher levels of social support when students gave them some type of recognition, such as appraisal support for their efforts.

When supporters did not receive a like or reply from students for instrumental or informational support they offered, they wondered if their social support was actually seen. As one member stated: *“I was really curious ‘are they even going to see this?’ That demotivated me a little bit. Even if I gave them [appraisal support]... then they wouldn’t see it.”* Another supporter noted that she was unable to know if she was being helpful when she didn’t hear back from the students. As she said, *“Well no one is responding to me, I have no way to know if it’s useful.”* We also had several instances where supporters asked questions or made comments and no one replied to them. This led them to feel less willing to give social support to students via *CheerOn*. There were only a few scenarios where supporters did not care if they received confirmation. One community member commented: *“It would be nice if they responded but I’m just putting out there to take it or leave it. It wouldn’t make a difference to me. Unless they want to have a conversation.”* This instance tended to be far less common than those who felt offended if no one responded to the instrumental or informational support they offered and decided in turn to stop offering instrumental or informational support in the future.

Supporters who didn't feel that their informational or instrumental support was helpful to students had less desire to participate afterwards. For example, one supporter who gave informational support to her team became frustrated when the social support didn't seem to help the team and they expressed continually having the same issue. As she stated: *"I saw that they were struggling with the same issue [supporter had given team informational support on before]. I thought maybe they need more support but at that point I didn't feel as motivated to help again, I guess it was demotivating to see that my support didn't help them."* In this scenario, she was both upset that she couldn't help and she felt that the team was neglecting to follow her informational support. This led her to stop participating within the online community. In addition, some supporters did not participate because they didn't feel like their informational support would help. As one member explained: *"Having been on design students as mentor and participant, the kind of feedback they're getting is truly dependent on the feedback process and whom they are giving it to. I don't feel they have any connection with me. It's hard to believe anything I'm saying is beneficial."* Overall, our results showed that if a supporter did not feel that their informational or instrumental support had been noticed or heard, they were more likely to feel less motivated to give online social support and would give less time-consuming appraisal support as a result.

4.4.3 Analysis 3: The Lead's Goals to Provide Social Support. While *CheerOn* was designed to promote social support from recruited supporters, the undergraduate studio lead unexpectedly provided more social support than any other group including recruited supporters, coaches, and managers, so we ask: *why did the studio lead to provide social support?*

4.4.3.1 Studio Lead Goal 1: Boost Morale. The studio lead saw her role as monitoring teams in order to provide social support, particularly emotional and appraisal, to boost their morale, which *CheerOn* allowed her to do: *"For the most part it has been one of the more memorable parts of my Loft experience this summer. I think in part because it's part of my role in overseeing them. So, I'm reading their stands and motivating them and trying to create a positive environment. So, I think it's particularly helpful for me, or those in a similar position of mine."* The lead saw social support, particularly in the forms of appraisal and emotional support, as a humorous way to boost morale. She saw boosting morale as her responsibility: *"My role is so much more focused on what their experience is like. Since that's my role I'm more attuned to morale boosting."* At first, cheers provided a humorous, gratuitous way to provide support: *"It kind of started as a joke - [students] were like 'oh we just got cheered,' which I thought was awesome, it got them to laugh."* However, it became a useful way to show support: *"Why I've been doing it a lot is that it gets them to smile but it lets them know that I see how much work they're doing and notice how awesome it is."* The lead could perform this role through generic posts as well: *"I realized [team members] were low on morale so I went in to post a more 'great work, keep it up' and that was more on a post. Why I did that separate from a cheer was because I didn't have a specific to-do ... I wasn't posting advice or suggestions, it was just wholly for the sake of boosting morale."* Providing social support thus provided a convenient online means of helping boost student persistence: *"I think cheering or posting some sort of morale has been a good account of that."*

4.4.3.2 Studio Lead Goal 2: Providing Assistance. The lead also used *CheerOn* to provide more substantive informational and instrumental support to students. As she reported: *"I'm not picky about my likes but definitely with commenting if they have an obstacle that I can help with, I will comment, or if there is an obstacle that I can help with. I will elaborate and say, hey I can help with this."* This informational and instrumental support often started a face-to-face interaction. As the lead explained: *"I try to ... comment on that to create a conversation."* For example, after one team was disheartened after a critique session, the lead attempted to normalize the situation and offer

emotional and informational support online to the team: *"I felt like it was kind of necessary to be like 'brainstorming can be frustrating' and trying to follow-up the conversation we had, which was like what can we do to get better feedback from crit."*

4.4.3.3 Studio Lead Goal 3: Support Routine. *CheerOn* became an online complement to the ongoing support routine of the lead. The lead reported using both online and offline for monitoring teams: *"I kind of do both. I check in with the teams regularly and a few times throughout the day. I feel most of my time is spent checking in with the teams."* The online system provided another support channel: *"I try to change their Loft pages every few days and cheering is a part of that. Just every couple of days I'll cheer a few things. So for the most part it's just been generally pretty routine."*

4.4.4 Analysis 4: The Effect of Social Support on Students. Analysis 1 found that external supporters did indeed provide social support and analysis 2 and 3 identified factors that influenced supporters' behavior, but we must also ask: *how did receiving social support impact PBL students' self-efficacy, impacting persistence and ultimately progress?* In this section we will show how we found that receiving *appraisal support* helped to increase students' perceived value of their project work, influencing their work persistence; and *instrumental, informational, and emotional support*, helped students to feel a sense of progress, greater identity in the community, and lowered hierarchical barriers within the community which increased online and offline help-seeking.

4.4.4.1 Social Support Increased Perceived Value of Project Work. Students perceived their project as valuable when online supporters and community members wrote comments offering emotional and appraisal support on the activity feed. One student said about receiving online social support through the tool, *"It makes you think that people care about what [the work] you're doing."* This appraisal support also led the students to feel that they were not alone in caring about their topic. As one student working on the diabetes project, *"[Receiving appraisal support] facilitated this [online] atmosphere that you are doing something and what you are doing is important."*

The number of external supporters magnified this effect. One member on the diabetes' team highlighted how seeing the large number of online supporters led him to feel that he was making a real-world impact. As he stated, *"Because so many people cared about this project [online] and it feels that I am making a difference."* Teams noted that seeing the number of followers supporting their project online was impactful for recognizing how many people valued their work, which made them feel that they were making more impact. As a student working on the food truck project remarked about being a part of the online community stated, *"It [appraisal support] made me realize that other people [online supporters] actually really, really cared about all these [food] issues."* Through receiving appraisal support, students better recognized that other people also felt that their problem was meaningful to a larger community working towards a big problem. The fact that support came from external supporters also mattered. As one student said: *"When someone comments on your page that you don't necessarily know, it's more... encouragement."* Another student pointed out a similar feeling related to receiving appraisal support from strangers: *"The fact that people we don't even know are interested in our problem... The fact that an entire network of [the national student design network] people were following your project [online], that made it feel more official."*

Dedicated, open, online space for project content and comments from online supporters and community members increased the students' perceived value of the project: *"I felt that the [web-site] sort of gave that feeling of importance to whatever I was doing, especially since there's a whole site devoted to whatever project you're doing. A page with your specific feedback questions that you could modify or your own [to do list] for instance."* Receiving appraisal support from an extended

network helped to increase students' perceived value of their project work, influencing their work persistence.

4.4.4.2 Social Support Increased Perceived Progress. Although the social support features were designed to enlist external supporters to motivate progress (Amabile 2011), which in turn should have boosted student self-efficacy and in turn increased persistence (Bandura 1994), online social support affected progress in a different way. Making progress explicit increased students' public commitment, and more detailed descriptions of obstacles elicited substantive instrumental and informational support from supporters on what to do next, which helped students make and perceive progress.

Appraisal of work and emotional support did not always seem to encourage progress as might be expected from social models of motivation and work on online communities. For example, unlike Wikipedia Barnstars, appraisal support did not seem to provide a strong extrinsic incentive for PBL teams, likely because teams are already highly intrinsically motivated to work on their design projects (Restivo and Rjit 2012). Social support in the form of emotional or appraisal support seemed to function similar to praise (Hattie and Timerley 2007) that is, they did not provide useful or believable information useful for making progress. As one student stated: *"I think just the types of comments... like, 'Oh, great job,' like, 'Looks like you guys are doing really well.' Yeah, like they just didn't say anything that substantial..."* Or as another student said in reference to less specific, impersonal comments: *"It almost seems forced because comments that are a bit cheesy, at times."*

At other times, appraisal support did seem to positively affect students' self-efficacy by helping students judge their progress: it's a *"nice thing to see, like, oh, we're on the right direction."* As one student stated that appraisal support increased *"confidence in what we're doing, that we know what we're doing, ... that we're working towards this goal and it's going to be fine"*. This student reinforced that appraisal support helped students to feel that they were working on the right path and that *"things would be okay."* In these cases, appraisal support helped them feel like they were successfully taking steps toward their end goal.

Whether or not students found appraisal support beneficial, *tracking progress* online *did* increase public commitment. Posting progress did help students track and publicly commit to their work. Students noted how posting their work online helped them to keep track of their results: *"Seeing [goals online] there and saying that these are my goals for the week, in a way, it makes it easier to track them and create a schedule."* This visible record in turn created public commitment, as one student said: *"As a team, having it as a public record matters, I think it's important to have accountability... it's more measurable."*

Receiving instrumental and informational support (rather than appraisal of work and emotional support) influenced perceived progress. More importantly, when supporters were able to understand students' work and provide substantive assistance, this both helped students make progress and increased expectancies. One student said that it was encouraging to receive specific informational and appraisal support on their work, *"When people [online supporters] gave positive critiques that were substantive rather than commenting on smaller things, that indicated that we were on the right track."* Other teams also noted that it was motivating getting feedback on their work. As one student stated, *"Having people who just see the work that is on the activity feed and give you feedback... it's nice. It's that extra motivation, like good job."*

Offering social support, particularly instrumental or informational support, was contingent on understanding students' progress, which was often difficult. Some students did not feel that supporters cared about their small wins or accomplishments. As one student stated about to-do posts, *"Nobody cares about our small steps forward."* Some commented that they were unsure who was actually looking at their page particularly the case when they didn't receive comments. However,

many of the recruited supporters' comments were non-specific appraisal support on work (e.g., "good job") and that supporters often reported difficulty understanding teams' progress: As one supporter stated, *"It's hard for me to directly give useful feedback without having more context."* or, *"... sometimes it's a little unclear to know the difference between their stands [progress posts]. It takes a bit more effort."* Or *"What's missing in this daily process is specificity in terms of what exactly they're doing. The stands are so vague so it's hard to pinpoint what they're working on and need help with."* Even if supporters did care about teams' progress, they would not be able to provide substantive feedback if they could not understand the progress made. By this interpretation, external online social support may indeed affect progress and expectancies through surfacing students' work to supporters in a way that allows them to provide substantive informational or instrumental support.

4.4.4.3 Social Support Increased Community Identity. Appraisal support increased students' connection to the larger design network and community. As one student stated about receiving appraisal support from a mentor, *"It kind of makes it bigger than just our team or just [design program]... Like what we're doing, the work we're doing... It makes it more part of [the national student design network] as a whole."* This team noted how using *CheerOn* to receive appraisal support made their project work feel beyond their own team and part of a larger community. Another student said in that after receiving emotional support from supporters in the form of welcoming to the community and expressions of empathy for the design process: *"I definitely felt that it made me more a part of the [national design network] community."*

Emotionally supportive comments expressing care led students to feel comfortable in the community and influenced engagement in their project work. One student described the experience of receiving a comment that expressed their care for the students as it influenced her comfort level and engagement. She said that receiving the emotional support comment impacted her *"comfort level, knowing that these people are encouraging us, like are participating, like cool things coming out of this, I think that is what makes me more engaged with the project itself."* This demonstrates that students felt more engaged in their project work through receiving emotional support from others via *CheerOn*.

Through greater comfort in the community, students reported feeling more connected to the design network community as a result of receiving social support via *CheerOn*. As one student stated about a comment from a high-status person in the community, *"I definitely felt that it made me more a part of the [design network] community."* When students received social support from others, they felt greater connection to the community. However, some students reported that they still did not know who was giving them social support. As one student said, *"It'd be more helpful if we actually knew who they [online supporters] were sometimes."* This suggests that social support comments were not as meaningful to students when they came from strangers, given that they did not feel they fully understood their work and cared about them personally.

Beyond the internal network of support, appraisal, emotional, instrumental, and informational support helped students feel that there was a larger pool of social support online. As one student stated, *"I feel like classes generally had a instructor or a TA to go to, so the pool of resources was less... I guess the pool [online community], like a bigger community."* This student demonstrates how social support facilitated the sense of a larger community of social support, beyond their internal network.

4.4.4.4 Social Supported Increased Help-seeking. Social support built community bonds that, to a limited extent, increased help-seeking. Building bonds between teams and external community members led to surprising benefits that students explicitly sought help face-to-face.

Students reported that receiving only social support led them to feel that they were a part of a supportive community who wanted to help them. As one student stated about receiving social

support, particularly in the forms of instrumental and informational support, *"It [social support] gave me a better idea that [design network] is more of a network of people who are helping each other."* Social support helped to facilitate a culture where students felt part of a community whom they could reach out to for help.

Through receiving social support comments, particularly instrumental and informational support, from online supporters, students reported feeling more capable to ask for help. As a student working on the food project remarked about being a part of the online community, *"It makes asking for help easier... Even though we're not always talking to them, it's like they're there, so we should be able to ask help if we want."* This student demonstrates that social support helped facilitate greater convenience for asking for help as well as an increased perception of supporters being willing to help them.

Online introductions demonstrating emotional support by supporters helped to make students feel comfortable asking for help. As one student said, *"Knowing that there were people [online supporters] who had introduced themselves [online] at some point, made it easier to reach out."* Students reported feeling more comfortable asking for help when there was some sort of connection built online between students and supporters stating their emotional support and willingness to give instrumental and/or informational support. We had some comments that when students did not know who was providing social support for them, these comments had less value given that they seemed more artificial.

Expressions of emotional, instrumental, and informational support helped break down hierarchy and led students to feel they could reach out to more experienced members of the broader community. As one student working on the diabetes project stated, *"I think it [receiving social support] makes it less of a hierarchy, I guess, in a way that you can interact with anyone... it's more like just go to anyone for help. They all are able to contribute in some way or another."* Another student affirmed that help-seeking came more easily after receiving social support comments online: *"It makes the whole asking and communicating with superiors easier."* This helps demonstrate that social support helped make superiors more approachable to students. Receiving social support from higher status members shows students that these members were *"willing to give their resources."* We didn't find evidence of the contrary.

As a result, supportive comments that demonstrated emotional, instrumental, and informational support led to instances of in-person help-seeking by students to supporters. One student from the diabetes project team explained that a supporter offering informational support led to an in-person meeting. As they stated, *"Well, when [design network leader] commented on our [team page], she posted a comment about us interacting with our community partners. That sort of brought something up, just like we started talking about it. And then eventually, we were like, 'Oh, well let's just go talk to [the network leader] in person,' so we brought her in... I think the [social support] comments sort of facilitated it as an implicit, like, 'Hey, if you have more questions, you can talk to us.'... the comment was kind of the reason that there was the connection there."* Here social support in the form of informational support helped to establish communication channels. This in turn led project students to feel more willing to go in and ask for help and receive in-person feedback providing the team with new insights for their project work.

However, online social support did not fully remove barriers to help-seeking for all students. It is important to note that some students still expressed ambivalence about asking strangers for help. As one student working on the diabetes project stated, *"You don't really ask strangers for help. You'd rather ask people that you interact with a lot or someone that you've been commenting with."* This reinforces that, despite receiving online support, some students still preferred to ask for help from those who was familiar. We coded all comments using a Codebook Manual (see appendix), which

Fig. 6. *CheerOn* facilitated social support, which increased persistence through heightening the perceived value of the project rather than students' expectancies, while the connection to external supporters unexpectedly facilitated face-to-face help-seeking and a stronger identification with the community.

helped us to identify what categories of social support each comment fit into. When the comments provided sufficient detail, we would code them according to the social support category that they fit into based on House's 1981 definition. We found no negative comments posted using *CheerOn*. We believe this was the case because it was a system specifically designed to support positive comments.

4.5 Discussion

Study 2 asked: (RQ2) How might we design a socio-technical system that incorporates external supporters to provide social support to increase student persistence in PBL environments? We predicted that a system that externalized teams' progress would prompt online supporters to provide social support, and that this social support would motivate students to make progress in their work. We found that the *CheerOn* system did indeed successfully prompt social support that teams found beneficial (Figure 6). The *CheerOn* system succeeded in increasing social support for PBL students. The combination of engaging teams in useful project management practices that externalize progress and minimal prompting was sufficient to enlist the online, external community of supporters in providing support. Supporters were motivated by predictable factors such as their identification with the community, social facilitation (peer pressure), clear needs for help, relevant expertise, familiarity, and students heeding informational or instrumental support.

However, there were also a number of surprises. First, the surprising amount of social support provided by the lead, and to a lesser extent, the coaches. We had assumed that instructors would not have time to provide social support, based on Study 1 and previous research on PBL, thus the need for an online community to provide social support. However, it seemed that in providing the tools to elicit social support from recruited supporters, *CheerOn* also lowered the barrier for the lead to provide social support, which she saw as part of her responsibility as an instructor. The lead and coaches provided social support even without being explicitly asked.

Second, teams often desired substantive informational support that would provide feedback on what to do next. While the system was designed to surface completed to-dos to elicit social support, these to-do posts elicited primarily appraisal support rather than substantive feedback. Rather, the stand posts, which effectively surfaced problems, showed clear help needs that were more likely to elicit substantive informational support. Appraisal support did sometimes give teams a sense of progress that increased self-efficacy, but it sometimes was perceived as unhelpful or too superficial to be credible.

Third, social support increased persistence through increasing the perceived value of the project, rather than through increasing team's expectancies. Social support in PBL functions differently than in online communities where it encourages members to perform small tasks they would not already do—as shown by Study 1, PBL teams persist in their project work even in absence of social support, albeit with decision uncertainty and stress. Nor does it have as little effect as praise had in a classroom, as predicted by learning sciences research (Hattie and Timerley 2007). In this PBL environment where students are motivated by, but have serious doubts about, their project's real-world impact, appraisal support from external supporters signal that the project is important enough to warrant the attention of an external audience, increasing the value of the goal and thus students' persistence. While substantive appraisal and emotional feedback on progress (indicating mastery or nearness to goal) can also increase persistence (Amabile 2011), the appraisal and emotional support comments given on *CheerOn* were sometimes too superficial to communicate this progress, likely in part because the externalizations of progress did not provide sufficient detail to supporters.

Fourth, social support also resulted in unexpected positive side effects such as in-person help-seeking and community commitment. Providing a community of external supporters to offer emotional, appraisal, informational, or instrumental support helped to increase the psychological safety (Edmondson 2006) of asking external supporters for help. When external supporters became aware of the need for help, they often offered to help students. This, in turn, led to students being willing to ask for instrumental or informational support. There were several scenarios where students reached out to supporters only after a simple introduction on *CheerOn*, but most help came from formal offerings to provide informational or instrumental support. Furthermore, students reported that receiving social support, particularly emotional and appraisal support, from external supporters made them identify more strongly to the larger design community. This stronger sense of identity in the community increases the likelihood that they would participate in the larger PBL network and is itself an important learning goal in adopting an identity of an innovator.

Nevertheless, there is room for substantial improving of the intervention. Most notably, supporters often wanted to give more substantive informational and instrumental support to students, instead of merely appraisal of work such as “good job,” – though research does suggest that even a ‘like’ of validation on Facebook can be of value to users' self-esteem (Scissors et al. 2016). Part of the difficulty of supporters providing substantive informational and instrumental support was that the externalizations of progress were not always clear to supporters, and students did not always accurately articulate obstacles. Furthermore, even when supporters gave substantive instrumental or informational support, students did not always heed this social support, decreasing supporters' motivation to provide social support. In addition, both students and supporters reported hesitancy communicating with strangers, perhaps impeding a greater amount of help-seeking and giving.

5 GENERAL DISCUSSION

5.1 Key Findings

This project explored the potential of online communities to provide social support to motivate students in real-world, PBL environments.

Study 1 asked: (RQ1) *Do students in PBL environments working on real-world problems receive sufficient social support to sustain persistence?* Study 1 found that, given the large orchestrations burden on the peer instructor facilitating the PBL environments, students do not feel that they receive sufficient social support. Unfortunately, this is compounded by the fact that students do not explicitly ask for help or spontaneously externalize their progress so that instructors and coaches can provide appropriate social support. Study 1 thus corroborates that expected challenges of

real-world PBL (Solomon 2003) do indeed arise in a PBL environment. Based on the needs identified in Study 1, Study 2 then asked: (RQ2) *How might we design a technical system that initiates externalizing team's progress prompt social support, and how does this in turn motivate students to make progress?*

The *CheerOn* system was intended to enlist outside supporters to provide cheers as a way to highlight progress and increase persistence. The system successfully elicited social support that positively impacted students, but often in unexpected ways. First, *CheerOn* facilitated social support not just from recruited supporters, but also from the peer instructor and professional coaches for whom the system offered another channel by which to perform their roles of monitoring and supporting teams. Second, *CheerOn* stand posts elicited instrumental support from supporters through externalizing problems. Third, appraisal support did not provide much of an extrinsic reward, sometimes increased self-efficacy, and more importantly, increased the perceived value of the project, especially when from an unfamiliar external supporter. Fourth, by connecting students to external supporters, students built bonds to the larger design community, which they reported increased their likelihood of explicitly seeking help (unlike Study 1).

Of course, there is also room for improvement. The system was not designed to specifically address many of the factors that influenced supporters to provide the right kind of social support. Specifically, the system was not designed to influence social facilitation (peer pressure) among supporters, consistently make student help needs and progress clear to supporters, or sufficiently encourage students to thank or show how they heeded assistance, all factors that influence whether supporters provide social support. Thus, accounting for our findings related to the way users experienced *CheerOn* and “designing the user experience” to allow a greater feeling of appreciation could be of use to improve this system in the future (Forlizzi and Ford 2000, p. 419; Zimmerman et al. 2007).

Nevertheless, these findings point towards a clear difference between how to design online communities for blended PBL environments. Whereas “likes” and “barnstars” can serve as effective extrinsic incentives in communities such as Facebook and Wikipedia (Restivo and Rjit 2012; Burke et al. 2009; Scissors et al. 2016), these are not effective strategies for blended learning community platforms where participants have very different needs and relations to supporters. In the social media and peer production platforms described in related research (Restivo and Rjit 2012; Burke et al. 2009; Scissors et al. 2016), participants do not have difficulty making contributions such as posting pictures or making edits—the problem is simply to increase activity on the platform by incentivizing them to do so, often through public recognition. In PBL however, students’ greatest needs concern ambiguity about whether their offline work is succeeding, how to work more successfully, and overcoming the motivational challenges associated with real-world project work (Blumenfeld et al. 1991). Therefore, online social support communities for PBL need to instead focus on helping students see the value of their work to a larger community, help them surface problems so that supporters provide substantive assistance, and demonstrate that supporters are eager for students to ask for help (online or offline).

5.2 Design Implications

The needs of PBL environments suggest that social support communities for blended PBL would do better to utilize external supporters within online communities to assist in offering social support for students, as opposed to encouraging social recognition as an extrinsic incentive as in other online communities.

We propose that the system should engage students in intrinsically motivating practices that externalize progress to an online community of supporters (which students will not do through explicit help-seeking) who are then likely to provide social support. It is also important for such

platforms is to apply a principle of educating requests, in which the system should engage students in intrinsically motivating practices whose side effect is to externalize progress to an online community of external supporters so that they offer assistance, thus, overcoming students' initial aversion to help-seeking to crowdsource help-giving. The implications of these findings extend beyond the PBL context to provide social support for others experiencing trying experiences where social support is helpful – from medical patients and families in need of social support as they go through a trying operation, to entrepreneurs running stressful crowdfunding campaigns, political candidates in need of social support to endure challenging elections, individuals in need of social support as they work through addictions, or individuals working on stressful projects in a company in need of social support, to name a few.

These studies provide a grounded causal model explaining the mechanisms by which blended PBL environments communities can “jump-start” help seeking. While novices show initial reluctance to surface problems and seek help (Argyris and Schon 1974), indirectly surfacing problems to external supporters through stands prompted support to provide assistance. This help-giving built bonds-based commitments to the larger community which, in turn, facilitated explicit help-seeking. The model also bridges HCI and Learning Sciences literature by showing where we can apply well-researched CSCW principles for promoting online contributions (Kraut et al. 2012) and well-researched LS principles for scaffolding more substantive feedback and learning. The process model of social support (Figure 3), and analysis of remaining obstacles from Study 2, point to a number of specific design recommendations (Table 6).

Based on this model, a principle of educating help-requests, *how might we redesign the online social support system?*

5.2.1 Distribute Orchestration Burden (Features 1–2, Table 6). Online communities of external supporters promise to reduce the orchestration burden of PBL environments (Mergendoller and Thomas 2005; Dillenbourg and Jermann 2010). Research in CSCL and CHI has shown that help can be distributed to other peers in the community within online learning communities (Bruckman 2006; Kizilcec and Schneider 2015), but less is understood about how this might work within a blended learning context and the effects of calling on specific people to support throughout a research project. This study shows that PBL classes can utilize external supports to distribute the instructors' task of providing social support. However, given the amount of social support provided by those who assume instructional responsibility (leads, coaches, and managers) community managers may do better to reframe the supporters' role to that of *assistant coaches* and perhaps even focus effort on recruiting experienced coaches. The amount of social support provided by coaches implies that even a small number of online assistant coaches could result in greater amount of social support. Program alumnae might fulfill this role well. For example, the studio lead suggested that senior undergraduate leaders in the design network see their role as curating teams' experience and seek greater interaction with teams, and online coaching provided a desirable channel for them to carry out this role. In this study, managers' reminders seemed to be sufficient to encourage recruited supporters to provide social support, so future systems might automate this prompting to reduce the orchestration burden on PBL teachers. This includes tracking which supporters do not provide social support and surfacing social loafing to the manager only when automated prompting fails.

5.2.2 Community-based Social Support (Features 3–5, Table 6). CSCW research suggests that familiarity increases contribution within online communities and that people tend to relate and connect with others similar to them online (Bachrach et al. 2012; Sosik and Bazarova 2014). Our findings build on this work suggesting that connecting PBL students to external supporters requires drawing on people with related interests and a sense of project familiarity. Teams described

Table 6. Proposed Features to Improve Usability of an Online Social Support System Based on the Needs and Rationales Found in Study 2 Related to (a) Distributing the Orchestration Burden, (b) Providing Community-Based Social Support, (c) Externalizing Student Help Needs, (d) Encouraging Supporters to Provide Social Support, and (e) Increasing Guidance for Supporters Related to How to Give Specific Social Support

Need	Rationale from Study 2	Feature
<i>(a) Distribute orchestration burden</i>		
1 Distribute coaching	Study 2 found that leads and coaches provided a great deal of assistance.	Recruiting coaches – reframe supporters task as coaching rather than offering social support and focus efforts on recruiting coaches.
2 Reduce orchestration burden of prompting	System required manual prompting by manager and found some supporters cheered infrequently.	Automated management – rather than have community manager track and remind supporters, could automatically track and prompt. Escalate to manager only when prompts fail.
<i>(b) Community-based social support</i>		
3 Highlight support network to teams	Students were motivated by being part of community.	Highlight network – show students larger community and network supporters and connect teams working on similar topics.
4 Highlight support given to teams	The quantity of social support increased the perceived value of the student’s project.	Highlight social support – highlight cumulative number of followers and cheers.
5 Facilitate bonds	Lack of familiarity hindered help-seeking and social support.	Supporter matchmaking – match supporters and teams by interest and facilitate more extensive introductions and discussion perhaps through face-to-face or video meeting.
<i>(c) Externalize help needs to supporters</i>		
6 Externalize progress	Supporters didn’t understand what progress students were making and thus could not give feedback on progress.	Stand goals – expand stands to also externalize current goals, tasks completed and tasks remaining to give better indications of progress.
7 Externalize help needs	Supporters didn’t understand what help students needed and students would not always surface obstacles in stands.	Stand obstacles – expand stand by requiring students to explain the lack of progress to better surface help needs.
8 Externalize affect	Students valued messages that “it will be OK” but only communicate anxiety face-to-face.	Stand affect – need to better encourage help-seeking and sharing of vulnerabilities
<i>(d) Encourage supporters to provide social support</i>		
9 Increase perceived bonds-based commitments	Expertise, identification to community, and impact on teams all increase contributions, but supporters sometimes did not perceive these factors.	Highlight bonds – highlight personal factors in prompts to provide support, remind supporters of their expertise, their connection to the design community, and their impact on teams.

(Continued)

Table 6. Continued

Need	Rationale from Study 2	Feature
10 Increase social facilitation (peer pressure)	Supporters more likely to provide social support when they see other supporters providing support.	Highlight social facilitation – highlight other's social support using prompts to provide support, show leaderboard of supporters.
11 Increasing thanks	Supporters more likely to provide social support when teams heed their advice.	Prompt thanks – prompt/scaffold teams to thank supporters.
<i>(e) Shift from vague appraisal support to more specific instrumental or informational support</i>		
12 Scaffold value. Facilitate face-to-face help	Supporters and teams both wanted more substantive social support beyond cheers, which research indicates promotes greater learning and progress.	Prompt substantive assistance – rather than simply scaffold cheers, scaffold supporters to also convey: the value of project; feedback on task, process and regulation; that on track and not to worry; offers of help; and need for clarification.

the importance of getting social support from a larger community of people with similar interests. This might be enhanced by better visualizing the network of external supporters to teams; highlighting the cumulative amount of support provided by the network; facilitating bonds-based commitments (familiarity) between individual students and supporters; by facilitating a more extensive introduction process; and perhaps by matchmaking between teams and recruited supporters. Perceiving the network and identity- and bonds-based connections to the network all positively affected social support and persistence and the system could highlight these factors to more quickly impact teams.

5.2.3 Externalize Help Needs to Supporters (Features 6–8, Table 6). Students and supporters desired more substantive social support (such as the sorts of feedback known to enhance performance and learning), but supporters were unable to understand enough about teams' current status to provide that support. Past research suggests that externalizing specific questions can help students initiate answers (Klemmer and Carroll 2014; Sawyer 2005, 2008), but this can be difficult in PBL settings when students are unsure of how to ask or have difficulty publicly saying that they need help. We found that with relatively small modifications, the system could externalize more useful information to supporters. This should include externalizing: high-level goals; tasks completed and remaining show progress; clearer descriptions of obstacles by asking students to explain progress; and surfacing teams affective state to indicate when morale boosts are needed.

5.2.4 Encourage Supporters to Provide Social Support (Features 9–11, Table 6). Supporters are more likely to provide social support when they see that they have relevant expertise, identify with the larger community and understand the positive impact on teams. Past research in CSCW suggests that interaction between users online can decrease over time and many users never interact, thus, some sort of prompting or notification is important as a reminder (Viswanath et al. 2009; Resnik 2001). In addition, research suggests that users contribute more within online communities when they feel that they can uniquely help others within a community (Ling et al. 2005). We found that supporters could easily be reminded of these factors when they were prompted to provide social support via e-mail and when they realized that students needed their unique expertise. Likewise, supporters were also more likely to provide social support when they saw others providing social support, which could be increased by displaying leaderboards of top supporters.

More importantly, supporters were influenced by teams that sought their advice, so it is important for the system to also prompt teams to thank supporters the same way that supporters are prompted to provide support.

5.2.5 Shift Non-specific Social Support to Substantive Informational and Instrumental Support (Feature 12, Table 6). Students and supporters desired to receive and give more substantive informational and instrumental social support (such as the sort of feedback known to enhance performance and learning) so it is important to allow and scaffold social support beyond non-specific appraisal support comments such as “*Good job.*” Research suggests that it’s hard to give honest and good feedback (Miller et al. 2005), yet we found that creating more specific prompts conveying the value of project; feedback on task, process and regulation; that are on track and not to worry; offers of help; and need for clarification can help to increase more honest and specific social support.

This research helps to build our understanding of how to design features within socio-technical systems that prompt external supporters to offer social support to PBL students. These features can be applied to building social support systems for workers and users of all kinds. This research also shows how online communities can provide emotional support for students that can help to foster feelings of psychological safety (Edmondson 1999). The findings provide evidence for the fact that social support online can help to prompt feelings of safety and the perception that one is able to take risks and thus ask for help.

5.3 Limitations

The need-finding (Study 1) and *CheerOn* design study (Study 2) provided an exploratory, comparative case study of how we might design hybrid online/offline communities to provide social support to build self-efficacy, impacting persistence and ultimately progress. Future work should address the methodological limitations of this exploratory, qualitative work, in several ways such as providing additional measures of learning and interest, and eventually, should the results hold, more rigorous study designs such as randomized controlled trials with pre- and post-treatment measures. A related issue concerns students’ reactions to praise. Hattie and Timerley (2007) shows us that non-specific praise is not helpful for learning, but research also suggests that the need to feel a sense of social support and belonging from others is critical to persistence (Baumeister et al. 1995). Increased understanding related to the nuance of when non-specific social support can be helpful or unhelpful will improve the effectiveness of building socio-technical tools that facilitate social support.

The intervention presented in Study 2 also relied on researchers to manually track supporters’ participation and prompt them to provide social support. While this did not take an exorbitant amount of time (approximately 2 hours for recruitment, 4.5 hours sending email reminders over 6 weeks), this time must be reduced sufficiently so the cost of managing the community is worth the benefits that social support provides in orchestrating and motivating students. In addition, researchers contributed to upward of 35% of comments within the *CheerOn* tool, suggesting that more support will need to be prompted by external supporters. Fortunately, most of this prompting can be automated (as described in the Design Implications 5.2) and future field trials should test whether this sufficiently reduces the teacher’s orchestration burden. Furthermore, researchers participating in the intervention by helping provide social support is an additional limitation of this study. We chose this method as it allowed us to ensure that students received sufficient social support according to our hypotheses. This is a common method for participatory action research (PAR), where research is a collaborative, participatory process that requires involvement from the community of interest as well as the researchers (Walker 1993). Furthermore, within intentionally designed learning environments, instructors and TA will always be working behind the scenes, similar to a community manager. Thus, we felt that this approach is less of a concern than if this

were a purely voluntary online community (where even there, the manager is often doing work to encourage participation). In addition, as we were conducting the research, we were in the context. Therefore, we felt that it could have been even more polluting to the results not to comment as it might have been viewed as tacit disapproval of the system and of giving social support. Additionally, we believed it to be more natural and realistic than students receiving support from artificial sources, such as Mechanical Turk workers (Deeflets et al. 2015). Now that we know this general design works, next we will test it with supporters' independent of the researchers.

Finally, as described in the design implications section, future work should explore how to better externalize teams' progress and obstacles and how to scaffold more substantive support. This offers an opportunity to greatly increase the benefits of social support for learning and design. Nevertheless, this study provides an important starting point in exploring these interactions in hybrid communities that value both design and learning.

6 CONCLUSIONS

Providing sufficient social support to students in real-world PBL environments places a significant orchestration burden on instructors and is hindered by students' reluctance to seek help. However, this research suggests we may be able to use online communities to create blended learning environments where students interact with an external online community to provide social support for offline project work. This research shows that we can design such online communities in which external supporters conveyed the value of students work to a larger community through appraisal support; and facilitate PBL student help-seeking and a stronger sense of identity in the community through emotional, instrumental, and informational support messages.

We can create these communities by applying a principle of educating help-requests and recruiting a local community of supporters to offer online social support. Blended coaching platforms for social support lower the bar for instructors, coaches, and supporters to provide social support; elicit informational support by surfacing problems to supporters; motivate teams by showing the value of their work to a larger community; and build social bonds that encourage explicit help-seeking within the community. Such blended PBL communities have broad applications across higher education as well as any professional context in which innovators must improve their processes to solve real-world problems.

APPENDIX A

Interview Protocol for *CheerOn* Students

CheerOn Hypotheses to test:

1. perceived community support / feeling valued – the work you've done is valued,
2. perceived progress,
3. perceived task direction,
4. perceived self-efficacy.

Analysis:

- Observe how they use tool (# of cheers received, # of cheers given).
- Code for key themes in interviews.

CheerOn Interview Questions:

1. Name/year? What project are you working on?
2. How have things been going thus far? How has it been using the Loft? Any changes this week?

3. How has it been doing stands? Using the workbench?
4. How did it feel getting cheers? Do you get this feedback often? Which input was most helpful or unhelpful?
5. How did receiving cheers influence your sense of the community, if at all?
6. Did receiving cheers influence your behavior in any way?
7. How did this make you feel in terms of your ability as a designer?
8. How did seeing this feedback influence your to-dos?
9. How did these comments influence your sense of progress, if at all? How did this influence your sense of value of the tasks you completed? Did this change your perception of tasks in any way?

CheerOn in Crit Interview Questions:

1. How helpful does the tool seem to be in showing your project's next steps? How helpful is this? Do you feel that you would use this tool? How could this tool be more useful in showing you next steps?
2. How do you feel about the project steps that you have completed? (people are bad at speculating– won't be able to give you good information).
3. How does checking off tasks make you feel?
4. Do you feel that checking off task items will help you to feel motivated to complete your goal?
5. How does using this tool influence your relationship with your mentor?
6. Do you think that *red light/green lights will help to motivate you to complete a goal?*
7. Do you feel that email reminders are helpful in achieving a goal? When would you want to be reminded of tasks?
8. How often would you want to be notified of completed tasks? Completed bigger goals?
9. What comments/shout-outs/cheers would you like to send to your team now? Would you include a photo in your post?
10. How does knowing that other people have seen what you have done influence your work?
11. How useful is the comment bar to you? Would you prefer "like" accomplishments, comment, or cheer for them?

APPENDIX B

Interview Protocol for *CheerOn* Supporters

1. How has cheering for your team been these past few weeks?
2. What has it been like to follow your team's progress?
 1. How often do you go on Loft? Why? What triggered it?
 2. When was the last time you visited Loft?
 1. What did you do?
 2. How do you typically interact on Loft?
3. How do you decide to cheer for your team? (take me through the process)
 1. What prompted/motivated you to cheer for the team? Why did you or did you not cheer?
 2. What features motivated you to cheer?
 3. How do you decide when to cheer?
 4. How do you decide what to cheer on? [*Show them their cheers - why did you cheer on this?*]
4. How have you cheered for your team thus far?

1. How did you decide what to write for your cheer?
2. What informs your comment?
5. How does the activity feed influence or not influence your cheers?
 1. Stands
 2. Workbench
6. [If team has responded to cheer]
 1. How did that feel?
 2. Did that influence your future cheers?
7. [If cheerers have responded to cheer]
 1. How did that feel?
 2. Did that influence your future cheers?
8. Has anyone from the team contacted you outside the Loft?
 1. How did that feel?
 2. Did that influence your future cheers?
9. Did you cheer for any other teams? Why or why not?
10. What is incomplete from this cheering experience?
 1. How would you like to cheer?
 2. What information would you like to have about the team?
 3. What relationship would you like to have with the team?

APPENDIX C

Codebook Manual for *CheerOn*

Coding Instructions:

1. *Read*: Please read the Social Support Definition and Codebook Chart for *CheerOn* (below).
2. *Code*: Please code the 60 data points (social support comments) in the first tab based on this coding definition and put a 1 in the social support type that best fits the comment in your opinion.

Social Support Definition: Social support has long been a study of researchers in HCI, psychology, and sociology and consequently, many definitions for the construct exist (Heaney and Israel 2008). HCI researchers have studied social support as online behaviors that express empathy, understanding, provide assistance, show compassion (Barak et al. 2008; McKenna and Bargh 1998; Tanis, 2007; Van Hooft et al. 2013), or lightweight affirmation shown in forms of a “like”, a reaffirming comment, or a network connection (Burke et al. 2009; Scissors et al. 2016). Psychologists have studied social support as helpful actions that signal respect, encouragement, emotional support, or affirmation that confirm of one’s competence (Deelstra et al. 2003, Bandura 1997, Amabile et al. 1986). Sociologists have studied social support as: (1) *emotional support*, that provides empathy, trust, and care; (2) *instrumental support*, that provides tangible aid and services to assist; (3) *informational support*, that provides advice, suggestions, and problem solving, or (4) *appraisal support*, that provides affirmation on the appropriateness of acts or statements made by another (House 1981). For this article, we follow House’s definition of social support as it most closely resembled the nature of the social support we observed in our specific context. Specifically, the definition allowed us to differentiate appraisal support praising certain actions or statements made, from emotional support, as well as instrumental support that provides tangible assistance from informational support that offers verbal support. These distinctions allow us to more closely examine the different mechanisms for providing social support online.

CheerOn Codebook Chart:

Social Support Type Definitions (<i>House 1981</i>)	How to code for this in data:	Example from <i>CheerOn</i>
1) <i>Emotional support</i> that provides empathy, trust, and care	<ul style="list-style-type: none"> –Comments that show empathy (ex: <i>express that they understand where the student is coming from or that what they are feeling is normal</i>). –Comments that show trust (ex: <i>express that they believe in the students and that they are capable</i>). –Comments that express care and encouragement to students (ex: <i>show affection to student as a person</i>). –Specifically focused on the students as humans and not on their work. –<i>Nuanced Coding</i>: Comments that are expressing personal support / care for students. Differ from Appraisal of Person which are comments that are saying “you as a person are doing well” - these are comments that are more centered around the supporter being there for students and expressing care for students. 	<ul style="list-style-type: none"> –“<i>I hope the team is all healthy by Thursday!</i>” –“<i>Looking forward to meeting you.</i>” –“<i>Good luck!</i>” (we read most of the “good luck” comments to be expressing that they cared about the team’s success, so a form of encouragement and care).
2) <i>Instrumental support</i> that provides tangible aid and services to assist	<ul style="list-style-type: none"> –Comments that offer tangible aid (ex: <i>offering ways that they can come in person to aid with a task</i>). –Comments that provide tangible services (ex: <i>offering to connect to contacts or give resources</i>). –<i>Nuanced</i>: Comments are not advice but tangible services to help students – whether it be saying that they can come help them in person or bring some kind of service/aid to help them in person. These are comments about something physically present for students, not just advice. 	<ul style="list-style-type: none"> –“<i>Hey Team - I emailed my contact. I’ll loop you folks in as soon as he agrees to help.</i>”
3) <i>Informational support</i> that provide advice, suggestions, and problem solving	<ul style="list-style-type: none"> –Comments that offer advice to students (ex: <i>give tips of what to do</i>). –Comments that suggest a way for students to complete a task (ex: <i>offer a suggested course of action</i>). –Comments that help students solve a problem (ex: <i>comments that think about how to make a decision</i>). –<i>Nuanced</i>: Comments are advice/ recommendations on what to do and not tangible services offered. They are merely spoke advice and not a physical presence of service. 	<ul style="list-style-type: none"> –“<i>Today it might help to start sketching out the different ideas you have. This will help flesh out some of the details.</i>”

4) <i>Appraisal support</i> that provides affirmation on the appropriateness of acts or statements made by another	(See below)	
4a) Appraisal of value of project, that states qualities about the project.	<ul style="list-style-type: none"> —Comments that <i>affirm the value of the work</i> students are doing (ex: express that students work matters). —<i>Nuanced</i>: Comments are related to value of the work and not the person. They are expressing support for past work's value. 	<ul style="list-style-type: none"> —“Super excited to see you guys working on the important problem.” —“Excited to follow your progress.”
4b) Appraisal of quality of work, that says something about the correct (right/wrong) or information about the quality of work.	<ul style="list-style-type: none"> —Comments that <i>affirm the work or quality of work</i> that students have done (ex: express that the students are doing a good job). —<i>Nuanced</i>: Comments are around the progress students are making, and not the value of them as people or their work. Comments express that the students did some form of past work correctly or are doing future work well. 	<ul style="list-style-type: none"> —“Hey guys! Great job at crit today. Love how in-depth you are going with the research.” —“Awesome” (when in response to students' report on what work they did) —“Great work!”
4c) Appraisal of person, that makes statements about qualities of team.	<ul style="list-style-type: none"> —Comments that <i>affirm the students as people</i> (ex: affirm that students are great, not related to their work). —<i>Nuanced</i>: Comments are solely related to the value of the students, not their work. Differ from emotional support in that comments are not just saying: “I'm here for you”, but that: “you as a person are great”. Not just empathy for the students but encouragement that they are doing well as students. 	<ul style="list-style-type: none"> —“You guys are great.”

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