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Distributed Apprenticeship in Online Communities

Julie S. Hui, Matthew W. Easterday, and Elizabeth M. Gerber
Northwestern University

Supporting learning in online communities is an important direction for the future of human–computer interaction as people increasingly leverage social technologies to support professional growth and development. However, few have studied *how* people leverage the socio-technical affordances of online informal workplace communities to develop professional skills in the absence of dedicated expert guidance. We draw from theories of apprenticeship to introduce an emergent theory of *distributed apprenticeship*, which outlines how community expectations of transparency and mutual support allow for instruction to be directed by a distributed network of nonexperts. We develop distributed apprenticeship through a qualitative study of crowdfunding entrepreneurs, where novices leverage social interactions with community members to develop a wide range of entrepreneurial skills. We then generalize distributed apprenticeship to other workplace contexts and provide design implications for online communities where people develop professional skills with minimal dedicated formal guidance.

Julie S. Hui (juliehui@u.northwestern.edu, juliehui.com) is a design researcher with an interest in understanding and developing social technologies that support novice innovators. She recently completed her Ph.D. at Northwestern University's Segal Design Institute and is now a postdoctoral research fellow at the University of Michigan School of Information. **Matthew W. Easterday** (easterday@northwestern.edu, matteasterday.com) is a learning scientist with an interest in online project-based learning platforms for social innovators; he is an assistant professor in the Department of Learning Sciences of Northwestern University. **Elizabeth M. Gerber** (egerber@northwestern.edu, lizgerber.com) is a researcher and designer with an interest in technology, organization, and innovation; she is an associate professor in the Segal Design Institute of Northwestern University.

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1. INTRODUCTION

Apprenticeship—the practice of novices observing and working alongside an expert to develop strategic and metacognitive skills—has been lauded as one of the most effective approaches to instruction in offline contexts (Collins, 2014). But, dedicated one-on-one guidance is not easily scalable as experts have limited time and resources to provide in-depth instruction to multiple novices (Collins, 2014). This is a growing challenge as an increasing number of people shift to nontraditional jobs outside corporations where there is less access to formal support for professional development (Florida, 2004). We seek to understand how people are leveraging the affordances of social technologies to construct apprenticeship-like instruction for professional work in the absence of dedicated guidance.

Understanding how social technologies are supporting skill development in the future of work has become a key goal in human–computer interaction (HCI) as today's jobs are more likely to require lifelong training with limited dedicated expert guidance (Pew Research Center, 2016). For instance, researchers have described how amateur self-taught product and web designers seek inspiration and feedback through online creative communities (Hui, Gerber, & Dow, 2014; Marlow & Dabbish, 2014; Xu, Huang, & Bailey, 2014); how crowd workers communicate with peers in online forums to navigate workplace tools and carry out tasks (Gray, Suri, Ali, & Kulkarni, 2016); and how novice entrepreneurs coordinate with peers and supporters through crowdsourcing tools to perform publicity and manufacturing (Hui, Greenberg, & Gerber, 2014). While previous work describes behavior specific to certain platforms, HCI literature lacks a sufficient conceptual understanding of what overarching instructional methods are shared amongst these communities and how social expectations are shaping opportunities for skill development.

We answer the call by HCI researchers to apply learning sciences theories to better understand skill development online (Williams, Kizilcec, Russell, & Klemmer, 2014; Williams, Renkl, Koedinger, & Stamper, 2013). Building on traditional theories of apprenticeship (Collins, 2014; Collins, Brown, & Holum, 1991; Lave & Wenger, 1991), we introduce an emergent theory of *distributed apprenticeship* to uncover how community expectations of transparency and social support, combined with the growing affordances of social technologies, are fostering opportunities for apprentice-like instruction in informal workplace communities. Specifically, we observe how distributed interactions in these communities are simulating methods of dedicated instructional guidance, which we define as being able to provide pedagogical *and* domain expertise to novices (Shulman, 1986).

Until now, apprenticeship in HCI has primarily been studied in offline learning communities, intelligent tutoring systems, and one-to-one mentorship relationships (Bransford, 1997; Collins & Brown, 1988; Collins, Brown, & Newman, 1989; Rosner, 2012; Su Yin, Haddawy, Suebnukarn, & Rhienmora, 2016; Suzuki, Salehi, Lam, Marroquin, & Bernstein, 2016). In these contexts, learning is directed by a dedicated instructor or central tutor, and target learning tasks are

often clearly defined (e.g., solving a textbook math problem) (Collins, 2014; Suzuki et al., 2016). Our study broadens our understanding of apprenticeship in HCI to online informal workplace communities where there are hundreds or thousands of members performing different types of work tasks with little to no formal guidance. We explore *how* people seek out apprentice-like experiences in the growing landscape of social technologies. In doing so, we identify benefits and challenges for professional skill development in the modern digital age.

Crowdfunding—the online request for resources from a distributed supporters often in exchange for a reward (Belleflamme, Lambert, & Schwienbacher, 2013; Gerber & Hui, 2013)—is an ideal context to study skill development in informal workplace communities because it encompasses many of the characteristics that distinguish informal workplace communities from traditional organizational contexts. Unlike previously described vignettes of social learning in professional settings (Wenger, 1999), crowdfunding entrepreneurs are geographically distributed, are expected to learn how to perform complex tasks with little guidance or training, must build and maintain relationships with hundreds of thousands of supporters around the world, and must search through and make sense of online examples of peer work in order to inform their own campaigns. Without the help of dedicated expert instruction, many novice crowdfunders face difficulties developing the skills to perform tasks in this novel workplace environment (Hui, Gerber, & Gergle, 2014; Hui et al., 2014).

In order to support skill development in informal workplace communities, our driving research question is, *How do the socio-technical affordances of online workplace communities support opportunities for apprenticeship?* To answer our research question, we conducted semi-structured interviews with 62 crowdfunding entrepreneurs (from now on referred to as "crowdfunders"). We contribute to the field of HCI by proposing an emergent theory of *distributed apprenticeship*, which describes how the socio-technical affordances of online workplace communities allow novices to seek and combine instruction from distributed sources to simulate benefits of apprenticeship. By studying how novices in online workplace communities, such as novice crowdfunders, acquire skills through online interactions, we can inform the design of social technologies to better support scalable opportunities for instruction.

2. THEORETICAL DEVELOPMENT

Online communities—virtual spaces where people interact to converse, exchange information or resources, learn, or play (Kraut & Resnick, 2012)—provide opportunities to develop skills by interacting with a diverse range of individuals. We build on related work in HCI, learning sciences, and cognitive science to understand how people combine instruction from distributed sources using social technologies in the absence of dedicated expert instruction.

2.1. Social Technologies to Support Learning in Online Communities

Learning environments with social interaction have long been shown to support retention, critical thinking skills, and motivation to study (Hadwin, Järvelä, & Miller, 2011; Smith et al., 2009; Wenger, 1999). Social technologies provide avenues to support learning in online communities, such as inquiry through social Q&A platforms (Adamic, Zhang, Bakshy, & Ackerman, 2008), expert recommender systems (McDonald & Ackerman, 2000), social search tools (Morris & Horvitz, 2007), massive open online courses (MOOCS) (Brooks, Thompson, & Teasley, 2015; Kulkarni et al., 2013), and social media sites, like Facebook (Lampe, Wohn, Vitak, Ellison, & Wash, 2011). We define social technologies as any type of online tool or platform that provides affordances that allow people to communicate, interact, and/or share information with each other (Kraut & Resnick, 2012). Social technologies are distinct from technologies in general as the term technology has previously encompassed machines and equipment that facilitate or take the place of human labor (Blau, Falbe, McKinley, & Tracy, 1976; Orlikowski, 1992; Woodward, 1958). Rather, we take a socio-technical perspective, which describes technologies in a social context and "a product of ongoing human action, design, and appropriation" (Orlikowski, 1992).

HCI researchers have developed specific social technologies for educational contexts to better facilitate apprenticeship between students and mentors. For example, Rees Lewis et al. developed a system that connects novice designers and professional coaches in extracurricular project-based learning environments (Rees Lewis, Harburg, Gerber, & Easterday, 2015). Zhang et al. developed a set of community-based tools to support interactions between student design teams working toward similar project goals (Zhang, Easterday, Gerber, Lewis, & Maliakal, 2017). In addition, researchers studying MOOCS have found that those that offered a social component, such as peer discussion and evaluation, have greater student retention (Krause, Mogalle, Pohl, & Williams, 2015; Kulkarni et al., 2013). However, most of these systems assume a designated set of instructors to facilitate the learning process. Instead, we study online workplace contexts where novices must identify and connect with instructors (who don't often identify as instructors). Limited access to dedicated expert guidance is a common problem in informal workplace contexts, like entrepreneurship, where few people have the exact set of expertise and/or time to mentor others through the entire work process.

A handful of HCI researchers have studied how learners use social technologies to coordinate and combine instruction from distributed sources in order to mimic the benefits of dedicated expert instruction. Researchers have primarily used the lens of collaboration and coordination to study information access from distributed sources. For instance, Gray et al. (2016) investigated how crowd workers—people who perform tasks online for pay—collaborate with other crowd workers to manage administrative overhead, share information about tasks and requesters, and even perform the work itself (Gray et al., 2016). Lampe et al. (2011) found that students use Facebook to coordinate outside the classroom to organize study groups and learn

more about course processes (Lampe et al., 2011). However, the process of learning, while similar to collaboration and coordination, requires different theoretical frameworks that focus more on how people acquire knowledge to perform tasks rather than how they perform the tasks themselves.

Evidence of a distributed approach to skill acquisition has recently been described in online creative communities where members use online platforms to look at other projects for inspiration and seek advice through peer discussions. Marlow and Dabbish found that novice and expert designers on Dribble, an online community for graphic designers, solicited feedback on their work through online comments and looked at peer work for inspiration (Marlow & Dabbish, 2014), while others similarly found that artists sought feedback and took inspiration from others in online fan fiction communities (Campbell et al., 2015; Evans et al., 2017; Fiesler, Morrison, Shapiro, & Bruckman, 2017).

Unlike these initial studies, we study how people use multiple online platforms (rather than a single platform) to perform complex work. We define complex work following sociologist's Strauss's definition of ill-defined complex tasks (Strauss, 1988), meaning tasks that are difficult to plan, take a certain level of expertise, require specific resources, involve different types of workers and coordination, and/or include various goals. Complex work is likely to involve using multiple platforms because it allows people to acquire a diverse set of skills and resources at different project stages. For instance, crowdfunding work is particularly complex in that it involves acting as a publicist on social media platforms, a project manager on team-management platforms, and financial manager on crowdfunding platforms, in order to coordinate activity with hundreds to thousands of supporters (Hui et al., 2014). Meeting the skill development needs of increasingly complex jobs is a key goal in today's economy and a primary motivation for performing this study (Pew Research Center, 2016).

2.2. Social Technologies to Support Learning in Formal Workplaces

Research on learning through social technologies in the workplace has primarily focused on formal workplace contexts (Hollingshead, Fulk, & Monge, 2002; Orlikowski, 1992) where organizations have the resources to design and develop tools primarily to connect workers. Early research on knowledge sharing in organizations describes the use of "intranets," "online knowledge communities" (Hwang, Singh, & Argote, 2015), and "enterprise social media" (Leonardi, 2015) among others as technologies that can be used to identify and locate experts outside usual communication networks, such as in other departments and work groups (Hollingshead et al., 2002; Rulke & Galaskiewicz, 2000). Being able to use social technologies to search for and communicate with any peer is seen as particularly useful for distributed work groups that had limited opportunities to meet or maintain awareness of each other in person (Hollingshead et al., 2002; Olsen & Olsen, 2000). Leonardi and Meyer (Leonardi, 2015; Leonardi & Meyer, 2015) found that social technologies that

afforded third-party observation of online conversations improved accuracy of employee metacognition—knowledge of who knows what and who knows whom (Ren & Argote, 2011). Enterprise social technologies also make it easier to established awareness of others skills and connections especially in organizational contexts where people are typically unaware of the majority of communication occurring around them (Ackerman, 1998).

Unlike employees in an organization, who identify as working together for a company and are paid to perform work to further company progress, nontraditional workers in informal contexts (e.g., entrepreneurs) are often in competition with each other and therefore have little to no obligation to help their peers (Bhide, 2000). Furthermore, unlike large established institutions that provide access to experts, business advisors, and various instructional tools, entrepreneurs not part of a school or accelerator program must rely more on personal means, such as prior experience (Dew, Velamuri, & Venkataraman, 2004; Grant, 1996) or communicating with friends, family, and extended ties, to access needed resources (Hite, 2005; Hite & Hesterly, 2001; Kaish & Gilad, 1991; Ozcan & Eisenhardt, 2009; Pfeffer & Salancik, 2003). This lack of a formal support network poses unique challenges for entrepreneurs who seek to access instructional resources.

2.3. Apprenticeship

Apprenticeship has long been considered one of the most effective ways to learn new skills in workplace environments because instructors closely monitor and support novice learning through guided participation (Collins, 2014). Traditional apprenticeship is mainly useful for teaching easily observable tasks, such as shoemaking or farming, situated in workplace contexts (Collins et al., 1991; Lave & Wenger, 1991). In traditional apprenticeship, the primary methods of instruction include modeling, coaching, and scaffolding. Modeling involves an expert performing a task so that learners can watch and emulate their processes; coaching involves having someone provide feedback and advice as they see fit or as problems arise; scaffolding refers to the supports a coach may provide and slowly remove to facilitate increasingly independent performance (Reiser, 2004). When novices encounter unanticipated barriers, as is common in workplace environments, the instructor models behavior and provides relevant and timely advice specific to the workplace context.

However, the small instructor-to-learner ratio of traditional apprenticeship makes it difficult to scale. To address this issue, Collins and colleagues first developed cognitive apprenticeship as a way to apply apprentice-style instruction to classroom contexts (Collins et al., 1991). This would allow for two primary benefits: (1) scaling apprenticeship to classroom-sized communities (i.e., 30 students) and (2) applying methods of apprenticeship to teach the cognitive processes of more broadly applicable skills, such as reading and math. In order to teach the cognitive aspects of generalizable skills, like reading and math, in the classroom, Collins expanded the methods of traditional apprenticeship to encourage instructors to voice their thought

processes and for learners to do the same. In his words, "The teacher's thinking must be made visible to the students and the student's thinking must be made visible to the teacher. That is the most important difference between traditional apprenticeship and cognitive apprenticeship" (Collins et al., 1991). For cognitive apprenticeship, Collins adopted the core methods of modeling, coaching, and scaffolding, in addition to adding methods of articulation, reflection, and exploration. Instructors are not only expected to visually guide novices through modeling, coaching, and scaffolding, as with traditional apprenticeship, but also provide cognitive guidance by verbally articulating problem-solving processes. Articulation involves asking the learners to explicitly describe their knowledge, reasoning, and problem-solving processes as they perform the task (National Research Council, 2000). Reflection involves encouraging the learner to evaluate their performance by comparing their work to a mental model or others' work and identifying opportunities for improvement (Schön, 1983). Exploration requires performing the task in an authentic environment with minimal to no guidance.

Like Collins, our goal is to understand how the benefits of apprenticeship instruction can be applied to more scalable learning environments, like online workplace communities, where novices have the opportunity to interact with hundreds or thousands of others performing similar work. As people increasingly turn to online communities and social technologies to develop skills and careers, we seek to understand through what social mechanisms novices use to develop skills in online communities. Unlike traditional and cognitive apprenticeship, novices in online workplace communities typically have limited to no access to dedicated expert instructors (e.g., schoolteacher) and primarily interact with a distributed network of nonexpert instructors (e.g., peers, supporters, domain experts) accessible through community social technologies.

3. AN EMERGENT THEORY OF DISTRIBUTED APPRENTICESHIP

While apprenticeship has been lauded as one of the most effective ways to develop skills, its existing theories do not describe how it can be best facilitated in informal workplace contexts, where work is learned on the job often with minimal support. Professional work outside traditional corporations increasingly relies on using social technologies to acquire skills and develop professional relationships. However, people working in informal contexts face challenges of developing skills where (1) there is often no dedicated instructor, (2) there are increased expectations of transparency and social support with a global network of peers and supporters, (3) there are thousands of examples of peer work to view and make sense of, and (4) the work is often more complex in that is nonroutine, difficult to plan, and involves various subgoals and diverse expertise. A new theoretical understanding of how people access apprentice-like instruction in online workplace communities is needed

to advance how we design socio-technical systems that can better support the growing population of people developing professional skills through online communities.

To inform theory development, we state key assumptions about the behavioral phenomenon being described, provide explicit definitions of key terms, outline principles that can be tested through research, and explain the underlying psychological dynamics that influence learning (Gredler 2009). In the following sections, we outline the basic assumptions of *distributed apprenticeship*: (1) in order to scale apprentice-like opportunities in informal workplace communities, instruction can be directed by a distributed network of nonexpert instructors, and (2) social expectations of transparency and mutual support in these communities are needed to drive this distributed nature of instruction. We go on to define the explicit variables of distributed apprenticeship, outlining principles as observed in the context of crowdfunding, and provide data describing the cognitive mechanisms that encourage learning via online social interactions.

3.1. Attributes of Distributed Apprenticeship

Through a study of how people perform skill development activity in the informal workplace community of crowdfunding, we identify six attributes of distributed apprenticeship: nonexpert instructors, distributed instructional network, workplace context, instructional methods (consulting examples of peer work, seeking feedback from extended networks, explaining work processes to maintain relationships, and sharing work reflection for community well-being), ill-structured work tasks, and the ability to scale. We briefly describe how distributed apprenticeship is unique from traditional and cognitive apprenticeship in Figure 1, followed by in-depth descriptions of each attribute.

Instructional Directors

Instructional directors are people who initiate instructional activity, such as identifying the need for coaching or encouraging articulation. Unlike in traditional and cognitive apprenticeship, instructional directors in distributed apprenticeship are *nonexpert instructors*, meaning they are not necessarily trained as instructors or intentionally perform instruction to support novices. Nonexpert instructors might include people who have similar work goals (peers), people who are interested or benefit from one's work (supporters), and people who have skills relevant to performing one's work (domain experts). At most, domain experts might possess instructional expertise, but it is not assumed. As Lee Schulman states in his seminal work on pedagogical content experts, "Mere content knowledge is likely to be as useless pedagogically as content-free skill" (Shulman, 1986). We describe how novices in online workplace communities benefit from the community expectations of transparency and social support in order to experience instructional guidance from distributed community members.

FIGURE 1. The attributes of distributed apprenticeship in comparison to those of traditional apprenticeship and cognitive apprenticeship.

Attributes	Definition	Traditional Apprenticeship	Cognitive Apprenticeship	Distributed Apprenticeship
Instructional Directors	People who initiate instructional activity	Expert-directed	Expert-directed	Non-expert directed
Instructional Network	Distribution of people involved in supporting instruction	Centralized	Centralized	Distributed
Instructional Context	Context in which instruction occurs	Workplace (mainly offline)	Pedagogical	Workplace (mainly online)
Instructional Methods	Methods to support learning	- Modeling - Scaffolding - Coaching	- Modeling - Scaffolding - Coaching - Articulation - Reflection - Exploration	- Consult posted examples of peer work (like modeling) - Seek feedback from extended networks (like coaching) - Explain work process to maintain relationships (like articulation) - Share work reflection for community wellbeing (like reflection)
Task Complexity	Complexity of tasks typically learned	Semi-complex	Semi-complex	Complex
Scalability	The extent to which the instruction is scalable beyond small teacher-to-student ratio	Not scalable (~4) (e.g. small group)	Minimally scalable (~4E+1) (e.g. size of a large classroom)	Scalable (~4E+3) (e.g. average number of crowdfunders running campaigns at one time)

Instructional Network

Instructional network is the distribution of people involved in supporting instruction, such as the instructional directors and those who provide instructional material, like feedback. The instructional network in distributed apprenticeship is a *distributed instructional network,* which means novices develop skills by seeking and combining instruction from diverse community sources using different social technologies. Unlike traditional and cognitive apprenticeship, where a single or small group of instructors guides the novice through the entire problem-solving process, instructors in online workplace communities are transient. For instance, a novice might leverage interactions with peers to gather feedback and interactions with domain experts to seek advice. Similar to the theory of distributed cognition, where cognitive processes are distributed in a social group (Hollan, Hutchins, & Kirsh, 2000), we describe distributed apprenticeship as the process by which instructional processes are distributed in online communities. While this approach to instruction allows novices to piece together knowledge in order to perform a diversity of tasks, novices are often burdened with the additional responsibility of identifying, connecting with, and motivating distributed community members to perform instruction.

Instructional Context

Instructional context is the context in which novices develop skills. In distributed apprenticeship, instruction takes place in an *informal workplace context*, which means that novices develop skills on-the-job with minimal guidance from an

instructor or in a formal organization. Workers may share broad professional goals with their community (e.g., crowdfunding) but work on individually different projects (e.g., startup on food vs. fashion). Novices are more likely to be motivated to learn in this context because skills are directly applicable, allowing them to easily see how the skills are relevant and applicable to their work (Collins et al., 1991). This is different from cognitive apprenticeship where novices develop generalizable skills (e.g., algebra) in a pedagogical context, like a classroom, and then apply their knowledge to workplace contexts later on in an "exploratory" stage (Collins, 2014). While informal workplace contexts provide the benefits of directly applying knowledge, it limits opportunities to practice skills in a low-risk environment.

Instructional Methods

Instructional methods are methods applied by instructional directors to support learning. Distributed apprenticeship includes four instructional methods inspired by traditional and cognitive apprenticeship (Collins, 2014): (1) *consulting posted examples of peer work* is similar to traditional modeling and refers to novices observing examples of others' work to inform how to perform one's own, (2) *seeking feedback from extended networks* is similar to traditional coaching and refers to novices identifying and seeking advice and feedback about their work from various community members, (3) *explaining work processes to maintain relationships* is similar to articulation and refers to novices explaining their planning and problem-solving process to community members invested in the work, (4)*haring work reflection for community well-being* is similar to reflection and refers to novices describing their performance and identifying opportunities for improvement in order to support others work.

Task Complexity

Task complexity refers to the complexity of skills needed to perform in one's workplace environment. In distributed apprenticeship, novices must develop skills to perform *complex work*—work that is nonroutine, difficult to plan, takes a certain level of expertise, requires specific resources, involves different types of workers and coordination, and includes various project goals (Strauss, 1988). Complex work has also been referred to as ill-structured problems (Simon, 1973) and wicked problems (Buchanan, 1992; Rittel & Webber, 1973). To say that work described in traditional apprenticeship (e.g., shoemaking, farming) and cognitive apprenticeship (e.g., math, reading) is not complex would be misleading as it takes a certain level of cognition to perform these tasks well. However, we focus on work that does not necessarily have a "right answer," as with classroom math problems, or preset performance pathways, as with professions traditionally studied for apprenticeship, like shoemaking. Rather, the work that we study is more reflective of the increasingly complex responsibilities of modern-day professions where skills have a limited lifetime of a few months to a few years, and perpetual skill development is required for continued employment (Pew Research Center, 2016).

Scalability

Scalability refers to the extent to which instruction is scalable beyond a small teacher-to-instructor ratio. In distributed apprenticeship, instruction is more *scalable* because the socio-technical affordances of the online community can accommodate a growing community of learners. Unlike literature on classroom technologies, which describes how teachers scale instruction by shifting responsibility to tools (Bain, 2012), our framework of distributed apprenticeship expands this work to describe how social technologies can scale instruction by distributing instructional responsibilities among different members of an online community. While Collins (1991) developed cognitive apprenticeship as a way to scale apprentice-style instruction to classroom sizes of at most a couple dozen students (Collins et al., 1989), we expand this work to describe how social technologies can help to further scale apprentice-like instruction to communities of hundreds or thousand of members.

We believe that this description of the attributes of distributed apprenticeship provides a useful framework by which to view and understand skill development in online workplace communities where there is no dedicated expert instructor. In the following section, we describe how the instructional methods of distributed apprenticeship were developed through a qualitative study of the online crowdfunding community.

4. DISTRIBUTED APPRENTICESHIP IN CROWDFUNDING CONTEXT

Crowdfunding is an ideal context to study distributed apprenticeship because it requires members to leverage many of the unique affordances of social technologies for skill development. In the absence of dedicated instructional guidance, crowdfunders turn to crowdfunding platforms and social media to access thousands of peer work examples and communicate with a large distributed network. While social technologies open these new opportunities for skill development, they also uncover unique challenges that come with working in large online communities with heightened expectations of transparency and social support.

4.1. Context

We define the crowdfunding community as anyone performing crowdfunding work (novices and peers), people who invest in or benefit from crowdfunding work (supporters), and people who support the process of crowdfunding by sharing relevant skills (domain experts). Many of crowdfunding skills are parallel to primary work skills of entrepreneurship, such as (1) innovating to produce new products, services, or methods, (2) marketing to distribute one's innovations, (3) managing to set and reach goals, (4) risk-taking under uncertainty, and (5) controlling finances to manage costs and profits

(Chen, Greene, & Crick, 1998; Kazanjian, 1988; Long, 1983; Miner, 1990; Shane, 2003). Similar to traditional entrepreneurs (Shane, 2003), crowdfunders also create new products and services, market on and offline, manage their budget, and take the risk of posting their early project work publicly online.

Since the first crowdfunding platform launched in 2001 (Knowledge @ Wharton, 2010), there are now estimated over 1250 crowdfunding platforms across the world (Drake, 2016). A range of platforms have expanded to support a wide range of project types and fundraising goals, many of which are launched by people who have little to no entrepreneurial experience (Hui et al., 2014). Crowdfunding platforms have raised project donations ranging from a couple dollars to over $20 million dollars ("Kickstarter Stats," 2016), for an estimated total of $17.5 billion, setting new funding records almost every year and soon to surpass venture capital funding (Massolution, 2015). Our study focuses on reward-based crowdfunding platforms—funding in exchange for a reward for creative projects—as they have historically appealed to novice entrepreneurs for supporting the launch of new products and services (Hui et al., 2014). We refer to people who request funds as *crowdfunders* and people who provide resources as *supporters*.

Researchers across different domains, including human–computer interaction, entrepreneurship, management, and economics, have primarily studied what factors affect crowdfunding success, such as project description wording (Mitra & Gilbert, 2014), updates (Xu et al., 2014), donor coordination (Solomon, Ma, & Wash, 2015; Wash & Solomon, 2014), and role of communities in the enterprise (Muller, Geyer, Soule, Daniels, & Cheng, 2013; Muller, Geyer, Soule, & Wafer, 2014) and non-enterprise contexts (Hui et al., 2014). However, simply knowing what factors affect success does not help entrepreneurs perform crowdfunding tasks successfully; participants must also have the knowledge and skills for implementation. There is little work describing *how* people acquire these skills needed to lead successful campaigns. In crowdfunding, this is particularly troublesome considering that many crowdfunding entrepreneurs are novices who have never launched an entrepreneurial endeavor. Novice entrepreneurs are in the greatest need of advice and other forms of support (Collinson & Gregson, 2003; Davidsson & Honig, 2003; Hoang & Antoncic, 2003) and are the least likely to have access to adequate resources and training (Audet & St-Jean, 2007; Bennett, 2008; Bennett & Robson, 1999).

Unlike the more quantitative approaches to studying crowdfunding behavior (Ahlers, Cumming, Günther, & Schweizer, 2015; Colombo, Franzoni, & Rossi-Lamastra, 2015; Mollick, 2013; Solomon et al., 2015; Wash & Solomon, 2014), our in-depth qualitative approach through interviews allows us to develop a rich understanding of how crowdfunding entrepreneurs leverage social technologies to acquire skills. We apply theories of apprenticeship (Collins, 2014) to address our research question, *How do the socio-technical affordances of online workplace communities support opportunities for apprenticeship in the absence of dedicated expert instructors?*

4.2. Methods

Sample and Procedure

We interviewed 62 crowdfunding project creators from the crowdfunding platforms, Kickstarter and IndieGoGo—two of the most popular reward-based crowdfunding platforms in the United States (Alexa.com, n.d.). Project types, as defined by the crowdfunding platforms, included art (2), comics (2), dance (1), design (7), education (5), fashion (2), film and video (6), food (4), games (5), music (3), photography (5), publishing (7), radio and podcast (1), science (1), technology (9), and theater (4). Participants (26% female) raised between $41 and $433,365 in 1–3 months and include 41 first time project creators and 21 creators who launched more than one campaign. The majority of participants described having a full-time job or freelance position outside of crowdfunding. Participants' ages ranged from 20 to 65, and the majority of participants were Caucasian. However, it is difficult to know what is a representative sample based on demographics because the crowdfunding platforms that we studied do not make racial and gender demographic data publicly available.

We recruited participants through a random seed and snowball sampling (Miles & Huberman, 1994), which allowed us to identify participants from a wide range of project categories, who had both large and small funding goals, and who succeeded and failed. While random sampling would have produced a more representative sample, limits on using the crowdfunding platform messaging systems prevented this approach.

We followed a semi-structured interview protocol where we asked the participants how and why they decided to crowdfund, and how they learned to perform different crowdfunding tasks. Interview length ranged from 30 min to 1 h and took place in person, over the phone, and through video calls. Interviews were conducted both during and after the crowdfunding campaign, which allowed us to collect both reflective and *in situ* data. Four researchers performed data collection, but one researcher ran or co-ran 85% of the interviews. Data collection occurred from 2011 to 2015. Through the interviews, we gathered in-depth data on the experiences of multiple people performing crowdfunding work not easily accessible through surveys. Additionally, we also actively participated in the crowdfunding community by following recently launched projects, donating to multiple projects, running our own campaign, and following platform updates through regular platform observation and posted news and social media updates. This allowed us to observe how the platform practices and design changed over time.

Analysis

In our previous studies of collaboration, networking, and motivation in crowdfunding (Gerber & Hui, 2013; Hui et al., 2014, 2014), the theme of apprenticeship emerged. Therefore, immediately following interview transcriptions, we analyzed data using prestructured case analysis (Miles & Huberman, 1994) using a coding scheme

based on existing theories of apprenticeship (Collins, 2014; Collins et al., 1991) and then adding nuance by amending and developing codes as we analyzed data. Analysis occurred during and after data collection, which allowed us to amend our interview protocol to better capture data related to skill acquisition.

Our first round of codes was based on the six instructional methods of cognitive apprenticeship: modeling, coaching, scaffolding, articulation, and reflection (which includes traditional apprenticeship methods of modeling, coaching, and scaffolding). Two researchers read through interviews and collected instances of these methods in a spreadsheet. To insure high inter-rater reliability, two researchers coded 15% of the data to calculate a Cohen's Kappa score ($\kappa = 0.81$). After this initial check, one researcher coded the remainder of the data.

We then performed a second round of coding to identify how data initially coded into apprenticeship methods were similar or different from the traditional definitions. This allowed us to identify how the context of crowdfunding influenced the instantiation of apprenticeship in a new way. In doing so, we did not change our view of crowdfunding so that it would fit within existing apprenticeship frameworks but rather provided an amended view of how apprenticeship is instantiated in the social context of an online informal workplace community. For instance, examples of people looking at other crowdfunding campaigns for inspiration were initially coded under modeling, which describes novices observing others' work to inform their own. While looking at other crowdfunding campaigns is an example of traditional apprenticeship because it highlighted the visual aspect of modeling, it led us to question how and whether novices were experiencing the cognitive aspects of modeling as well. Taking an analytical lens through both traditional and cognitive apprenticeship allowed us to identify how participants consulting related posted peer material, such as through blog posts and videos, provided an avenue to observe cognitive aspects of modeling lacking from many project campaign pages. These activities were then coded under the final theme of *consulting examples of peer work*, in which we describe the nuances of how modeling is experienced in online contexts.

We also removed codes pertaining to skill development that did not rely on social interactions in the online workplace context. For example, this included a participant description of working on a friend's project full-time before starting his own. While this might be considered an example of traditional apprenticeship, we excluded it from our final analyses because it did not address our original research question to understand how social interactions through the online community influenced novel learning opportunities. Rather it provided a traditional example of apprenticeship where a novice works full-time alongside an expert to develop skills in-person. Other examples of excluded data included individual instances of trial-and-error, such as filming multiple versions of the campaign video without feedback from others in order to develop videography skills. While these instances are important to the learning process, we felt that they distracted from the main findings of the study. We welcome future research to better understand these offline and individually driven approaches to skill acquisition of complex work.

4.3. Findings

Our data highlight how crowdfunding entrepreneurs leverage social technologies to identify and combine apprentice-like instruction from different community members across many platforms. This is the first study to develop a theoretical understanding of how skills are being developed in informal online workplace communities through the theoretical lens of apprenticeship. Apprenticeship has been shown to be one of the most effective approaches to professional skill development, but little work has been done to effectively adapt apprenticeship instructional methods to modern work practices online. We study how people leverage multiple online platforms to acquire resources, develop relationships, and seek knowledge. Through our qualitative analysis of online behavior in crowdfunding communities, we uncover four main instructional methods of distributed apprenticeship (see Figure 2).

Similar to prior theories of apprenticeship, we offer a description of how participants participate in activity typically shown to provide learning gains, rather than evidence of explicit learning gains (Collins, 2014). While each section describes an instructional method of distributed apprenticeship, the methods are not always mutually exclusive as one method could trigger or overlap with another.

Consult Posted Examples of Peer Work

One of the most common ways novice crowdfunders described developing skills was by consulting work examples posted by peers. Traditionally, modeling involves a pedagogical domain expert intentionally performing a task, so that a novice can emulate their actions (Collins, 2014). However, in crowdfunding, there is no single or small group of designated instructors who model the entire process of crowdfunding because only portions of their work are displayed publicly online. Rather, novice crowdfunders must search for and combine example work posted on multiple platforms by a *distributed network* of *nonexpert instructors* such as crowdfunding *peers*. The plethora of crowdfunding projects online provides the opportunity to *scale modeling* because novice crowdfunders are able to access a repository of examples from which to take inspiration. Having access to relevant work models is particularly useful for developing skills in a *workplace context*, like crowdfunding, where novices must develop and apply skills within weeks or days.

Participants described searching through campaign material on crowdfunding platforms and related social media platforms, watching videos, and reading through reward ideas and project descriptions to identify which crowdfunding practices to emulate. For example, one novice crowdfunder raising funds to launch a food truck venture described how he contrasted the language of successful and unsuccessful campaigns to identify what tone to use when publicizing his project:

> It was very clear to see on the failed versus projects that didn't fail, there was almost like an arrogance for the ones that failed, "I'm so great. I'm so wonderful. You've got to give me money!" And they failed miserably. And the ones with a little more humility and a little more earnestness seemed to be more successful. (P23)

FIGURE 2. Instructional methods of distributed apprenticeship as described through the context of crowdfunding. Unlike traditional and cognitive apprenticeship, distributed apprenticeship is performed by a distributed network of nonexpert instructors.

	Instructional Methods of Distributed Apprenticeship			
Attribute	**Consult posted examples of peer work**	**Seek feedback from extended networks**	**Explain process to maintain relationships**	**Share reflection to support community wellbeing**
Definition	Looking at other people's campaign material and related media posts across platforms for inspiration or advice.	Seeking and/or receiving feedback and advice on one's campaign material, process, or final product.	Explaining one's campaign process or final product in campaign material, social media, or Q&A.	Sharing one's overall experience, lessons learned, and plans for the future.
Instructional Directors *(Non-expert instructors)*	-*Novice* searches for and consults examples of peer work	-*Novice* identifies and seeks feedback from domain experts, peers, and supporters	-*Supporters* requests work updates and Q&A from novices	- *Peers* solicit advice from (former) novices - *Supporters* request work overview
Instructional Network *(Distributed)*	-*Peers* (e.g. Other crowdfunders)	-*Peers* (e.g. Other crowdfunders) -*Domain experts* (e.g. Professional videographers, marketers) -*Supporters* (e.g. People who financially/socially invested in work)	- *Supporters* (e.g. People who financially/socially invested in work)	-*Peers* (e.g. Other crowdfunders) - *Supporters* (e.g. People who financially/socially invested in work)
Instructional Context *(Workplace)*	-Example models created for work, not instructional, purposes -Example reflections posted by peers, not instructional experts	-Feedback sought from member of workplace community (domain experts, peers, supporters), rather than dedicated instructor	- Supporters request work updates and Q&A for their own benefit, not to facilitate instruction	- Peers and supporters request project reflection to support their own needs, not to perform instruction
Task Complexity *(Complex)*	- e.g. How to structure materials unique to one's work	- e.g. How to plan work - e.g. How to manage team - e.g. How to manage supporter relationships	- e.g. How to plan work - e.g. How to overcome unexpected challenges	- e.g. How to evaluate one's performance - e.g. How to plan for future work
Scalability *(Scalable)*	More examples of peer work created as more people create projects	More and diverse set domain experts, peers, and supporters available as more people create projects	Supporters intrinsically motivated to request updates and Q&A because they are invested in novice work	More reflections requested as crowdfunding community grows
Challenges	- Finding examples that share process and cognition - Finding examples created by similar others - Sensemaking of examples	- Identifying feedback providers - Motivating responses from feedback providers - Facilitating useful feedback from providers - Encouraging timely feedback from providers	- Facilitating mutually beneficial relationships where supporters benefit from explanations and novices benefit from articulating - Supporting process documentation at all project stages	- Facilitating mutually beneficial relationships where peers/supporters benefit from consuming reflections and novices benefit from reflecting - Managing advice and feedback requests - Efficiently distributing advice and feedback requests among crowdfunders
Relation to cognitive apprenticeship	modeling	coaching	articulation	reflection
Relation to traditional apprenticeship	modeling	coaching	N/A	N/A

Similarly, other participants described looking through existing campaigns on crowdfunding platforms to "figure what was common to the successful ones and common to the failed ones" (P49). In the case of crowdfunding, project "success" (meeting the campaign funding goal) is easy to determine because it is publicly displayed on the campaign page, which indicates to novices what projects may serve as better work examples.

While crowdfunding platforms have made it easier to find projects in a certain category with a particular funding goal or amount pledged, they still make it difficult to find failed projects. In response, members of the crowdfunding community have

created third-party platforms that facilitated searching for unsuccessful campaigns so that crowdfunding entrepreneurs could learn from them. However, in the past years many of these third-party platforms were pressured to shut down by crowdfunding platforms for unknown reasons (KickSpy, 2015). Since then, crowdfunding platforms, like Kickstarter, have advanced their project search features, highlighting how members of crowdfunding communities influence the development of and competition for formal crowdfunding platforms, an example of user innovation (Von Hippel, 1988, 2005).

Having access to a repository of examples through crowdfunding platforms provides a way to *scale* modeling in *workplace contexts* where people work on different projects, with unique goals and challenges. Because crowdfunding platforms allow searching of projects by certain attributes (e.g., category, funding amount), novice crowdfunders can find models that are similar to their own campaign. For instance, one crowdfunder of a product design project to manufacture a new type of wall hook described how he searched for projects similar to his in order to inform his own campaign format:

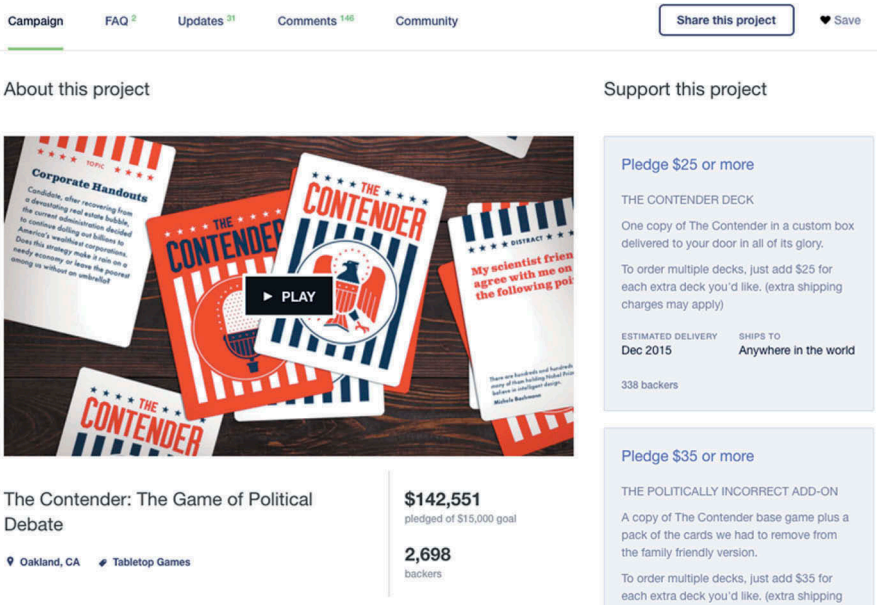
> Before I launched my Kickstarter I spent quite a few days going through other projects, looking at their videos, how they structured their rewards and learned a lot from that, and figured out what was important for Kickstarter. I had a lot of projects in the similar bracket and picked things I liked from them and then figured out what I wanted to do. (P50)

Already, there are over 350,000 launched projects on Kickstarter, the most popular crowdfunding platform in the United States, and one of over 1250 platforms in the world (Drake, 2016; Kickstarter Stats, 2016). As more people continue to crowdfund, new examples get added to the repository of example work that can serve as models for future novice crowdfunders.

While seeing examples of finished crowdfunding campaigns (e.g., Figure 3) provides a useful outline for what one's finished work should look like, these examples can be lacking because it is harder to understand the reasoning behind other project creators' decisions. Unlike modeling in cognitive apprenticeship where an instructor performs a task in front of a novice while articulating their reasoning, most online examples of crowdfunding are just of the end product (e.g., final campaign video) rather than the entire production process with the reasoning behind it (e.g., how video was planned and filmed), which limits the extent to which novices can learn from examples of others' work.

One way that crowdfunders understand other's reasoning behind a choice is by reading social media updates and blog posts in which crowdfunders have articulated their reasoning. One-third of participants described reading blogs posted by other crowdfunding entrepreneurs to learn more about crowdfunding responsibilities. While some posts just provide a narrative description of how they felt during their crowdfunding experience, others go as far as structuring each step, providing reasoning, and performing statistical analyses to show which strategies produced the highest

FIGURE 3. Example of a Kickstarter Campaign Page, which includes a video, description of rewards, funding goal, updates, and comments section (The Contender, 2015a). Publicly available campaigns serve as instructional material by acting as models of what high- or low-quality campaigns might look like. Permission to use this image granted by campaign creator, John Teasdale (https://thecontender.us/collections/all).



funding contributions (Mod, 2010). For instance, one participant raising funds to develop a new art-based education program described reviewing others' crowdfunding blog posts to help him set his publicity strategy.

> I just did searches for, you know, Kickstarter projects and I found examples where people had written in their blog about their own projects and how they had organized their approach. So some people were very scientific about saying, okay, I'm going to you know contact X number of blogs, I'm going to send so many thousand emails and I'm going to do it in this specific order for a particular reason. And then they graphed how many responses they would get and had a plan I tried to read what some of what [they] had done and pay attention to the ones of people who were successful and tried to learn from them. (P4)

In this case, P4 describes how reading these blog posts allowed him to understand an expert's process and *why* they performed a task "for a particular reason," highlighting how these posts illuminate some of the invisible cognitive processes behind structuring and running a campaign. Previous work we have done on crowdfunding communities uncovers

a shared feeling of responsibility to "give back" to the community and support novice members (Hui et al., 2014), a motivation perhaps extended from related creative communities, such as hackerspaces (Toombs, Bardzell, & Bardzell, 2015).

In another example, a project creator who ran a successful campaign to fund a political card game wrote an update on their campaign page, saying "In the spirit of giving back, we wanted to share what we learned on the Kickstarter campaign trail. We put everything in a Medium post you can find below" (The Contender, 2015b). In this post, they describe why and how they made certain decisions regarding their campaign, such as how they structured their rewards:

> In the interest of keeping cost down and maximizing our resources we refrained from many physical perks beyond the highest donor levels. Why? Because physical products need to be customized by order and possibly create more expensive shipping. THINK OF THIS STUFF AS EARLY AS POSSIBLE. (The Contender, 2015b)

Supplemental posts on social media and crowdfunding platforms provide an additional place for experienced crowdfunders to explain reasoning that is not immediately visible by just looking at the campaign page. A novice crowdfunder looking at a campaign page for ideas might notice that there are not many physical rewards, such as t-shirts or hand-made thank you cards. But, without reading the supplemental posts, they would not know the reason why and therefore be at risk of making mistakes with their own campaign, such as promising rewards that are difficult to make or ship.

While supplemental posts allow project creators to articulate cognition behind their work, people might often forget certain parts of their process or describe their actions in a different way than how they were performed—a fundamental problem in instruction (Shulman, 1986). This is an especially difficult issue to address in communities like crowdfunding, where instruction is not always intentional and the people providing instruction are typically *nonexpert instructors*.

Advances in communication technologies are providing easier ways for crowdfunders to communicate in-the-moment thought processes with their supporters. For instance, in November 2016, Kickstarter launched a live video feature called Kickstarter Live in which they encourage crowdfunders to "connect with their community in new ways," such as "[sharing] early designs and [demoing] prototypes" or "[hosting] a Q&A with everyone involved in the project." Crowdfunders have also been using similar features on other social media platforms, like Snapchat and Instagram Live to communicate with their supporters as they work.

In order to acquire observable and cognitive skills, novice crowdfunders leverage modeling to study both visual examples of finished products, such as the main campaign page, and related social media posts where peers articulate cognition behind their process. While online search features help novice crowdfunders to identify relevant examples, novices still need to be able to make sense of these models with limited guidance.

Seek Feedback from Extended Networks

Seeking feedback and advice from an extended network of domain experts, peers, and supporters provides a way to receive a wider range of instruction through **coaching**. Unlike traditional coaching, where pedagogical domain experts direct instruction by observing learners and providing advice and feedback as needed (Collins, 2014; Hattie & Timperley, 2007), coaching in distributed apprenticeship is directed by the novice, who must often self-identify when and from whom to seek support. Like many *workplace contexts*, where novices are in charge of their own skill development (Yarosh, Matthews, Zhou, & Ehrlich, 2013), novice crowdfunders must self-direct coaching opportunities by identifying or motivating advice and feedback from a *distributed network of domain experts, peers*, and *supporters*.

Participants described establishing relationships with *domain experts*, people who have expertise in an aspect of crowdfunding work (e.g., marketing) but are not crowdfunders themselves, through existing offline and online connections. For example, two participants in graduate school who launched a campaign to manufacture an electronics kit described being advised by an online media professor:

> We had several email exchanges. We sent her drafts of our video, and had 2 or 3 face-to-face meetings & She gave us a lot of constructive criticism like, "Ok, you're getting better but here's some more things to think about." She gave us tips on how to compose videos, which none of us have done before, so that was really helpful. She gave us like lighting diagrams, so like if you want to light someone well, here's where you put the lights. If you want to record good audio, here's what you need to buy. (P54)

P54 exceeded his $25,000 goal by raising over $121,000 in 30 days. Participants who had access to long-term expert support were typically enmeshed in a rich knowledge network, such as a school, incubator program, or online community specific to their project topic.

Other participants described connecting with domain experts through online forums or listservs in their project domain. When developing a new board game for a crowdfunding campaign, P52 described asking questions on different active board game design forums, such as on Reddit, to "get additional feedback" on their campaign and ask product questions like, "What do you think of this concept?" Another participant (P5), who graduated from a prestigious design program, described how he emailed out to the alumni design listserv and received various feedback responses.

Participants also leveraged search functionalities on crowdfunding platforms to identify *peers* (other crowdfunders) who ran similar crowdfunding campaigns. For instance, one crowdfunder running a campaign for a publishing project described how he searched for all the people who did a campaign similar to his and asked them for advice:

> I went and surveyed everybody who had done a Kickstarter project to fund digital fonts, which is like 12 people or something. And all but one of them was willing to give me feedback, and it was pretty interesting and useful. (P39)

Similarly, one participant developing a food startup to support local beekeepers described how friends and supporters would connect her with others running similar campaigns.

> I'd get people who were like, you need to get in touch with so-and-so & I even got in touch with two girls up in Minneapolis who are doing something exactly the same. So I was on the phone with them & and that was just so much fun to get to connect with them. (P10)

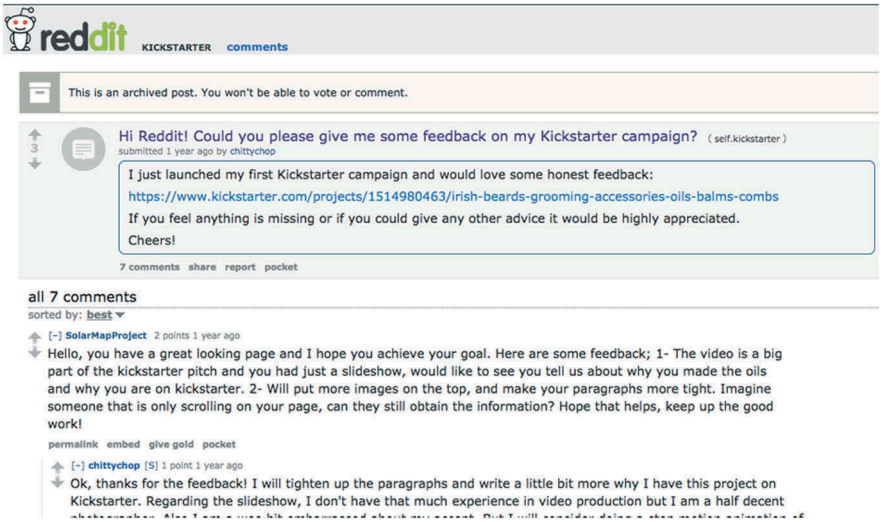
In addition to seeking work process feedback, novice crowdfunders described how the online public nature of crowdfunding helped them receive product feedback from *supporters*, such as people who donated to the campaign or generally interested in the topic (e.g., Figure 4). Supporters can provide authentic consumer feedback, which helps novice crowdfunders adjust the design of the final product or service being funded. For instance, one participant creating a product that interfaces game controllers with DIY electronics projects described how he received feedback on what features his product could include.

> You also get very fast feedback about your project. So, in the course of running this campaign, a lot of people will ask me for features like, "Hey can your project do this," and I'll be like, "No, but it could." And I'll just go and add some software and add some computer code and be like, "Okay, yea, I have this feature now." So it's a good tool to get an idea of what people like and what people don't like about your project. (P56)

Another creator of a publishing project described how he got "hundreds of people" to send comments on his book text (P31).

While supporters are less likely to have knowledge on how to run a campaign, they are inherently motivated to be a source of consumer feedback, which helped participants inform design changes and future strategy. For instance, one participant described how her team member posted a video blog reflecting on what went wrong in the campaign. In response, their supporters sent feedback on the campaign design in addition to words of encouragement. Others even sent information about non-crowdfunding funding sources, highlighting how feedback from supporters can encourage novice crowdfunders to participate in the broader entrepreneurial work of pivoting when encountering barriers. One participant described how feedback from supporters in his first unsuccessful campaign helped him redesign his relaunched campaign.

FIGURE 4. Example of someone seeking feedback for their beauty-related Kickstarter Project through Reddit ("REDDIT," 2016). Posting requests for feedback on public online forums allows people to get advice and feedback from feedback outside one's immediate social circle. Given this page is publicly available online, permission to use this image for research falls under the FAIR USE Act of 2007.



> I also, you know, made some tweaks and things about the rewards. Part of that was in response to feedback I had from people interested in the campaign the first time. So, I listened to that feedback. I thought about what might be reasonable to change or tweak, and I tweaked those things. (P40)

P40 lowered his funding goal from $8000 to $6000 in the relaunched campaign and ended up raising over twice as much the second time around to reach his goal of $10,000.

However, seeking feedback was not always easy. Participants described difficulty in motivating people to spend time giving in-depth feedback and feedback before campaign launch. In order to address the challenge of seeking timely advice, Kickstarter launched a feature called Kickstarter Campus, which allows crowdfunders to post their work and receive feedback and advice (Kickstarter Campus, 2015).

We find that novice crowdfunders more often seek process feedback from domain experts (e.g., professional videographers) and peers (e.g., other crowdfunders), and product/service feedback from supporters (e.g., people who provide funding). The ability to receive coaching depended on novice crowdfunders' ability to build and manage their social networks in order to access relevant information and resources at the right time.

Explain Process to Maintain Relationships

Explaining work to supporters, such as describing one's product manufacturing process in social media updates, provides an opportunity for novice crowdfunders to develop skills through *articulation*. Articulation involves any method of getting novices to describe their knowledge, reasoning, and problem-solving processes (Collins, 2014). Unlike in cognitive apprenticeship, where articulation is initiated by a pedagogical domain expert (e.g., teacher), articulation in distributed apprenticeship is initiated by a *distributed network* of *supporters*, such as people who request updates and detailed project descriptions in return for investing financial or social support.

Because crowdfunding work is done in a *workplace context* where activity is public and held accountable by real consumers, crowdfunders are expected to develop relationships with their supporters by answering questions about product designs, elaborating on their production processes, and posting frequent updates—responsibilities typically outside the scope of selling products in traditional brick-and-mortar stores or online marketplaces, like Amazon. For instance, one participant who raised funds for a local bee-keeping venture described the amount of time she dedicated to managing communication and social media in addition to designing and producing the final product.

> I respond to every question or comment, almost every comment on the Kickstarter page & You have to be prepared to devote 4-5 hours a day just making sure that you are promoting it or following up on it you know, or anything like that. (P10)

Previous work on funder motivations finds that many supporters want to know more about the design process because they see themselves as investors rather than just consumers (Gerber & Hui, 2013; Kim, Shaw, Zhang, & Gerber, 2017). Because crowdfunding supporters are giving funds months in advance, they tend to feel more personally invested in the project's success and final design (Gerber & Hui, 2013).

Having supporters provides a way to *scale articulation* because supporters are inherently motivated to request articulation activity through pitches, updates, and Q&A. Participants found the act of pitching to be a useful way to think through and articulate their project goals. For instance, a participant raising funds to build an urban garden described,

> You have to be able to talk to people and explain what you're doing & You're always figuring out different ways to explain your story or your plot or your project to people so they can understand it. So, I would say I definitely learned communication skills a lot more and it was very helpful. (P40)

However, not all pitches include articulation. Articulation requires getting novices to describe their knowledge, reasoning, and problem-solving processes (Collins, 2014), while pitching requires using certain rhetorical strategies to effectively describe one's work to increase the likelihood of a response (Arguello et al., 2006). In analyzing

crowdfunding pitches in campaign project descriptions and videos, we found that they often included articulation activity (e.g., explaining design processes, production processes, budget plans) in addition to pitching activity (e.g., describing design features, why their product is better than others). For instance, on a crowdfunding campaign page that raised $71,000 to launch a new brewery, the crowdfunders included traditional pitch information—"Phenomenal beer, mind-blowing technology. Become a Braxton Builder and help create the taproom of the future," and articulated their reasoning and problem-solving process in the Risks and Challenges section (Rouse, 2014):

> With all new business ventures some degree of risk does exist and as responsible business owners, we feel obligated to explain them & Many of our rewards rely on vendors for fulfillment: a problem with any one of them could lead to delays or a change of plans. We would seek new vendors as soon as a problem arose, but there are no guarantees we could produce identical rewards in some cases. (Rouse, 2014)

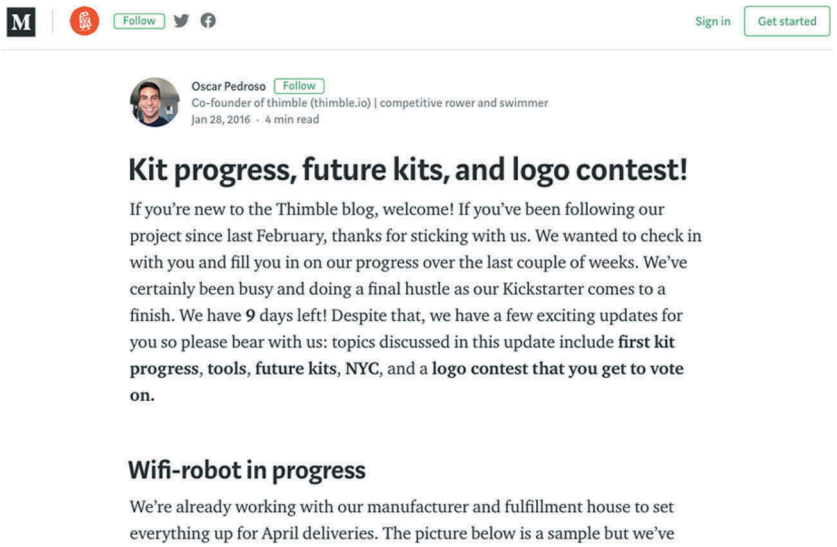
We find similar articulation activity in project updates (e.g., Figure 5). For instance, one creator of a tabletop game project described how he uses a combination of videos, blogging, campaign page feeds, and social media to verbally and visually share his design process and give updates on his progress:

> I will make sure that I send updates on how it's going & I'm able to share like say real time or a timeline of videos of how I layout a book or something or design a logo. And so I can share the process as it goes through, and the backers appreciate that and that seems to kind of build up, again, trust that I can fulfill on these projects. (P35)

Articulation does not always happen in real time, especially in work where voicing one's thought process interferes with work in the moment. Yet, with advances in live video technology, we see an increase in live articulation on Facebook Live, Instagram Live, Snapchat, and most recently, Kickstarter Live. These live videos are often used for Q&A sessions, where supporters post questions on a live comment thread or via social media channels (e.g., Twitter), and crowdfunders respond. For instance, in a live Q&A by a crowdfunding team raising funds to design a new backpack ("Livefree backpack live Q&A," 2017), they explain why they chose Kickstarter over other funding options, why they chose certain product materials, why they chose a certain manufacturing company, and how they plan to ship rewards on time. All these activities fall under articulation actions of describing knowledge, reasoning, and problem-solving processes.

However, the expectation to develop relationships with one's supporters may hinder novice crowdfunders to perform articulation effectively because they are at risk of being judged negatively, and therefore not funded. While we do not have data showing

FIGURE 5. Example of explaining one's project progress to supporters through a public article (PEDROSO, 2016). Posting these updates not only helps maintain supporter relationships but also provides an opportunity to articulate one's decision and work process. Permission to use this image granted by blog author, Oscar Pedroso.



if and how participants censor what they share about their projects, it is likely that novice crowdfunders feel more comfortable articulating their thought process on "safer" topics, like design, rather than issues with their budget plans. Articulation on these riskier topics often happens in campaign updates when supporters demand explanations after certain issues surface, such as reward delays (Kim et al., 2017).

Being able to articulate one's work is necessary for learning how to seek feedback from coaches, communicate project plans to supporters, and think through one's assumptions. The public nature of performing entrepreneurship on crowdfunding platforms is different from other online marketplaces (Kim et al., 2017), like Amazon, where people go to buy a product with little interest in knowing who the designer was and why something was designed in a certain way. Instead, crowdfunding supporters often expect to have design and business decisions explained to them in order to motivate them to fund the project (Gerber & Hui, 2013). This demand for regular contact with supporters drives opportunities for articulation by forcing crowdfunders to repeatedly describe the state and purpose of their work.

Share Reflection to Support Community Well-being

After running the campaign, novice crowdfunders **reflect** on their work experience in written and video posts summarizing challenges they faced, lessons for

others, and plans for future work. Reflection is a key component of the learning process because it provides an opportunity to improve one's mental models and develop self-efficacy by assessing improvements in performance and determining what to change in order to meet or exceed a certain standard (Collins et al., 1991; Van Merriënboer & Kirschner, 2012; Zimmerman & Schunk, 2011). Unlike traditional cognitive apprenticeship where reflection is prompted by an expert instructor, reflection in crowdfunding is prompted by a *distributed network* of *nonexpert instructors*, including peers and supporters. *Peers* drive opportunities for reflection by asking for feedback and advice on their own crowdfunding work, while *supporters* drive reflection by expecting an overview of the crowdfunding experience in exchange for potential future financial or social support.

By providing advice and feedback to peers through blog posts, YouTube videos, and online forums, crowdfunding entrepreneurs must reflect on their experience, make sense of it, and communicate lessons so that novices can apply them to their own work. For instance, one participant, who has raised $100,000 over four successful crowdfunding campaigns, described how he provides advice through e-mail to the many crowdfunding peers who reached out to him:

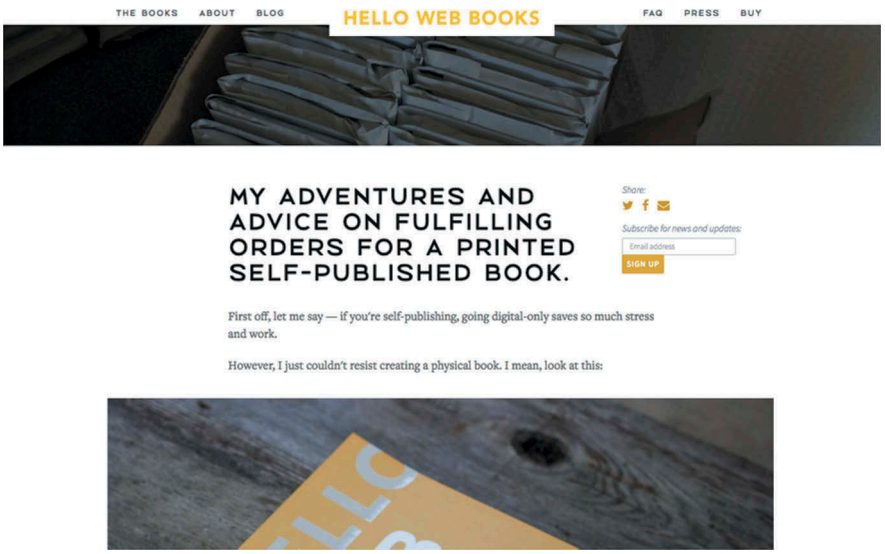
> Every week or so somebody emails me asking questions about Kickstarter like, "My project got rejected by Kickstarter, how do I redo it?" And I'm like, "You need to change this, this and this in your proposal, or you need to add this." (P6)

As described in earlier sections, lessons shared by more experienced crowdfunders serve as models and coaching for novices. In observations of online crowdfunding activity, we find various examples of reflection in public blogs written to support crowdfunding peers (e.g., Figure 6). For instance, one crowdfunder wrote an article titled, "How we failed in our first Kickstarter campaign, only to nail it with the second," in which he describes identifying and addressing initial mistakes to inform future strategy changes, such as how to build a community, set a funding goal, format images and video, organize publicity, and manage shipping and rewards (Habich, 2015):

> I can't emphasize enough how vastly we underestimated this aspect [of community] the first time we tried Kickstarter. We didn't have a big user base, or a good variety of contacts, quite the opposite to be honest & You need to start with people that are thrilled about your product. They can give you feedback to perfect your campaign before launch and they will help create traction once you are live & This how to do it. (Habich, 2015)

In addition to providing advice and feedback through direct messages, sharing public posts through social media and online publishing platforms allow experienced crowdfunders to make sense of their own experiences in the process of helping peers. This public reflection process supports "socialization" of newcomers by having more experienced members of the community teach new members community

FIGURE 6. Example of a blog post describing what they learned from running a crowdfunding campaign to fund a self-published book (OSBORN, 2015). Posting these reflections not only benefits novices in the crowdfunding community but also provides an opportunity to reflect on one's experiences, a key part of skill development. Permission to use this image granted by blog author, Tracy Osborn.



norms and behaviors (Wenger, 1999), a practice shown to help sustain online communities (Kraut & Resnick, 2012).

This growing pool of novice crowdfunders provides a way to *scale reflection* as they seek and consume advice, motivating other crowdfunders to continue posting reflections for community benefit. Participants who have launched multiple successful crowdfunding campaigns described becoming well-known mentors in the crowdfunding community (P6, P9, P32, P35) and that the number of people reaching out to them for help has increased exponentially over the years. While they hope to support those who reach out for advice, these experienced members often become overwhelmed with requests. Some participants described using social media to scaffold advice giving. For example, P35 described directing people to a Pinterest page in which he curates and shares blog posts and articles before agreeing to speak with them one-on-one:

> I've put [advice] on a Pinterest board that I try to share when people come to me now and ask, "How do I do a Kickstarter?" & Kickstarter itself actually documents some of these answers, but I think people just look at it and kind of get a little, I don't know, glassy-eyed? And so, to an extent, they're just looking for, "Well, where do I start trying to figure out what I want to do here," and that's what the pin board was for.

Since then, Kickstarter has launched its own guide to walk novice crowdfunders through this process ("Kickstarter Guide," 2017). Because crowdfunding takes place in a *workplace context*, novices are responsible for maintaining relationships with those who invested in their development. Supporters often expect to be updated on the state of the project and plans for the future (Gerber & Hui, 2013). Following their failed campaign, P22 and her project partner chose to keep their supporters informed by posting a video post on the campaign page in which they reflected on mistakes made and plans to potentially relaunch. In the video, P22's project partner attributed their failure to the fact that they tried to raise funds for multiple products at once. He explained that in the next iteration of the campaign, they would focus on the design and implementation of one product, a vending machine to promote healthy eating among children, rather than trying to raise funds for a series of machines at multiple schools. As described in the previous section on seeking advice and feedback from extended networks, these posted reflections also allow supporters a chance to provide further social support to overcome failure. In response to P22's video, supporters sent words of encouragement and introductions to schools that would benefit from the project, as well as alternative sources of funding.

Continued participation from crowdfunding peers and supporters can promote reflection by informing strategies for adjustment and stronger self-efficacy. While reflection often occurs naturally, the social nature of crowdfunding makes it possible for people within the crowdfunding community to help initiate and promote reflection.

5. DISCUSSION

While the learning sciences literature argue that one-on-one instructional guidance from an expert is one of the most effective ways to learn (Collins, 2014), it is difficult to scale, especially in an online workplace community as large and diverse as crowdfunding. Our findings contribute to efforts in HCI to develop theory as new technologies inform new practice and visa versa. We add to literature on how the Internet has allowed traditionally solo activities to become more social, and in effect, creating greater opportunities for social learning.

5.1. Distributed Apprenticeship as an Emergent Theory

Through an in-depth qualitative study of a large informal workplace community, we provide evidence for an emergent theory of online instruction—*distributed apprenticeship*. Distributed apprenticeship describes how novices are experiencing apprentice-like instruction by interacting with a distributed community of nonexpert instructors across multiple platforms. Specifically, distributed apprenticeship articulates the role of community expectations in shaping how people use social technologies to document, share, and produce knowledge.

Distributed apprenticeship draws from a long history of learning theories that describe the role of external agents in the learning process. Broadly, Piaget's constructivism describes how people make meaning through their experiences (Piaget & Cook, 1952), while others expanded on this by emphasizing how social interactions provide opportunities to become aware of and practice skills (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Rogoff, 2003; Vygotsky & Cole, 1978). While these previous theories describe the role of social interactions in the learning process, we believe online informal workplace communities, like crowdfunding, present unique challenges to skill development not articulated in previous literature.

As today's workforce continues to shift towards nontraditional jobs outside corporations (Florida, 2004), the nature of work becomes increasingly distributed with heavy reliance on social technologies. Members of these informal workplace communities are now expected to develop skills where (1) there is often no dedicated instructor, (2) there are increased expectations of public transparency and social support, (3) there are thousands of examples of peer work to view and make sense of, and (4) the work is often more complex in that is nonroutine, difficult to plan, and involves various subgoals and diverse expertise. While more recent theories of learning in the digital age emphasize the role of networks as distributed structures of knowledge organization (Hollan et al., 2000; Siemens, 2014), they inadequately discuss how social expectations within these networks influence who performs instruction and how. An incomplete understanding of skill development and the stakeholders in this process limits our ability to inform and evaluate platforms created to meet the changing professional development needs of an increasingly informal workplace.

In the context of crowdfunding, we find that community expectations of social support and transparency drive people to provide advice, content, and explanations of their work in addition to the basic requirement of creating a campaign page. This motivation to post additional content and help others in the community might stem from the types of people who participate in the crowdfunding community, such as makers, who have been shown to exhibit values of social support (Toombs et al., 2015). Given that informal workplace communities increasingly exist outside corporate structures, it is also possible that the people drawn to these professions understand the need to build and join communities where people are motivated to share knowledge, advice, and other forms of support. We also find that the public nature of performing work online influences community expectations of the work process itself. For instance, because crowdfunding is publicized as a way to engage the "crowd" in entrepreneurship, supporters expect crowdfunders to explain their process and, in some cases, even allow them control over certain design decisions. This is heightened expectation of transparency motivates members of the crowdfunding community to inadvertently perform instructional activities, like requesting crowdfunders to articulate their work.

While we present distributed apprenticeship as an emergent theory, we emphasize that it is *in no way* meant to replace traditional apprenticeship but rather extend it to a new growing area of professional development. In many ways, traditional

apprenticeship is still considered a gold standard of instruction *if* novices are able to find someone who has the right skills and is motivated to provide long-term guidance. However, this is becoming increasingly challenging as the knowledge required for most modern day jobs is rapidly evolving and requiring increasingly diverse skillsets (Pew Research Center, 2016). Therefore, the chances of finding someone who has the specific set of interests and expertise, as well as time, to be a mentor is slim, causing people to turn to more distributed sources of instruction. Over the years, HCI researchers have described how online technologies, such as messaging systems, chat rooms, shared document editing tools, and online version control systems, are starting to address how people communicate with a distributed workforce. While these technologies allow people to more easily connect with geographically distributed people, they also introduce new challenges of coordination, expert identification, and establishment of trust.

5.2. Contributions to Human–Computer Interaction

We identify how expectations of social support and transparency in informal workplace communities influence how people leverage social technologies for skill development. Because people are motivated and expected to post their work and explain their process, crowdfunders are able to consult examples of peer work (like modeling), seek feedback from extended networks (like coaching), explain process to maintain relationships (like articulation), and share reflection for community well-being (like reflection). Through this work, we expand how theories of informal learning are instantiated in online contexts and compare and contrast these findings with other models of learning in HCI literature.

The growing amount of work on leveraging social technologies for learning in online communities has primarily focused on describing modeling and feedback in single platforms, like design platforms (Marlow & Dabbish, 2014), fan-fiction platforms (Campbell et al., 2015; Evans et al., 2017; Fiesler et al., 2017), university project-based learning platforms (Rees Lewis et al., 2015), and MOOCS (Kulkarni et al., 2013). We argue that a distributed approach to skill development is particularly important for learning skills where each project needs a different set of instructions from different sources.

Previous frameworks describing how novices learn in online communities have been discussed in the context of newcomer socialization (Kraut & Resnick, 2012) and moving from peripheral to central participation (Preece & Shneiderman, 2009). Kraut and Resnick (2012) describe how newcomers "must struggle to make sense of how to contribute on their own" and argue that online communities generally use individualized socialization tactics, where newcomers are provided limited guidance by more senior members of the community (Kraut & Resnick, 2012). Similarly, crowdfunders also face difficulties finding long-term mentors who could guide them through the crowdfunding process and found that they too had to "learn-on-the-job" by performing crowdfunding tasks with little guidance. We build on research of newcomer

socialization in online communities by describing how novices combine instruction from different community stakeholders to mimic hard to find expert instructional guidance.

Others describe learning in online communities from a "reader-to-leader" perspective where novices become increasingly involved in online communities by moving from marginally contributing to leading online collaborations (Preece & Shneiderman, 2009). Similarly, in our data, we encountered people who worked on friends' crowdfunding projects before developing their own. Opportunities to do so can be inspired by related work performed by Morris et al. (2017), which describes a system to support microtasking in crowd work as a potential initial activity for novice workers to perform skills in an authentic environment before committing to full-scale tasks (Morris et al., 2017). Most recently, Kickstarter launched a new initiative called "Kickstarter Commissions" that "invites backers into your creative process." Inviting others to provide input and expertise into one's campaigns is one way official crowdfunding platforms are initiating opportunities for online situated learning opportunities (Lave & Wenger, 1991), like in the "reader-to-leader" framework. Further work needs to be done to better understand how these peripheral opportunities to participate are initiated, how relationships are managed over the course of a project, and what specific aspects about these interactions foster skill development.

We further theoretical understanding of instruction in online communities by describing how novices leverage emergent social interaction with different community sources to develop complex work skills. While our framework describes how online community members perform apprenticeship instruction in the context of crowdfunding, the way in which instruction methods occur may differ in other contexts like crowdwork (Gray et al., 2016), online creative communities (Campbell et al., 2015; Evans et al., 2017; Fiesler et al., 2017; Marlow & Dabbish, 2014), freelance crowdsourcing marketplaces (Hannák et al., 2017; Parigi & Ma, 2016; Suzuki et al., 2016), and MOOCS (Dillahunt, Ng, Fiesta, & Wang, 2016; Kulkarni et al., 2013). To describe how distributed apprenticeship applies to other online workplace contexts, we describe its attributes and mechanisms in the context of crowd work.

Implications for Crowd Work

Crowd work—where distributed workers perform tasks posted online by requestors in exchange for financial compensation—is considered one of the most promising opportunities to support social mobility on a global scale through on-demand employment (Kittur et al., 2013). We align ourselves with crowd work literature to identify ways to better support the worker, such as promoting ethical employment practices (Bederson & Quinn, 2011; Irani & Silberman, 2013; Salehi et al., 2015), career growth (Kittur et al., 2013), and skill development (Suzuki et al., 2016). We believe distributed apprenticeship can provide a useful framework to

identify where support tools are succeeding and lacking in supporting instruction within online workplace communities, like crowd work.

Despite rich online interactions between members (Gray et al., 2016), crowd workers typically work without in-person contact with peers, making crowdwork an ideal context to apply online socially based instructional methods (Coetzee, Lim, Fox, Hartmann, & Hearst, 2015), like distributed apprenticeship. Unlike crowdfunding, the work of crowd work is requestor defined (not worker defined), and work tasks are typically less complex (e.g., transcribing an audio file) than those described in crowdfunding (e.g., filming a publicity video). However, this often depends on who is performing the work and their set of expertise. We believe that as crowd work continues to advance and expand, the type of work being performed will continue to grow in complexity and new models of learning the complex skills will be needed.

In order to benefit from social learning opportunities, crowd workers describe connecting with peers via phone, online forums, chat, social media, and in person (Ding, Shih, & Gu, 2017; Gray et al., 2016). These social interactions allow crowd workers to develop relationships with people who have platform expertise (e.g., how to set up an account) and people with expertise on certain tasks (e.g., copy editing). By connecting with others in the community, people with more expertise can develop more stable careers as community managers, while novices can establish relationships with those who might point them toward promising jobs or tasks (Ding et al., 2017). For instance, crowd workers describe choosing tasks that allow them to practice skills, such as writing in English (Martin, O'Neill, Gupta, & Hanrahan, 2016). Others describe balancing choosing tasks that fall within their skillsets and tasks that allow them to try something new (Gupta, Martin, Hanrahan, & O'Neill, 2014).

While there has been much work to develop tools that support social learning in crowd work, distributed apprenticeship can provide a framework by which to identify gaps in instruction. For instance, the method, *seek feedback from extended networks*, highlights the opportunity to seek feedback from a wide stakeholder network, including peers, domain experts, and supporters (in this case, requesters). Related work describes the benefits of pairing novices with dedicated experts (Suzuki et al., 2016), hiring people to be community managers (Kulkarni et al., 2012), and supporting peer-to-peer connections (Dow, Kulkarni, Klemmer, & Hartmann, 2012; Whiting et al., 2016), to encourage coaching activity. Similar work could also be done to facilitate timely feedback from task requestors, which would allow another avenue to develop positive relationships between workers and requesters, a key issue in supporting healthier crowd work environments (Irani & Silberman, 2013; Martin et al., 2016).

The instructional method of *share reflection to support community well-being* highlights an opportunity to develop tools that motivate reflection as part of the work process. While previous studies (Dow et al., 2012; Zhu, Dow, Kraut, & Kittur, 2014) describe how crowd work platforms can require reflection activity to participate, we suggest designing communities in a way that encourage crowd workers to reflect as motivated by social expectations. For instance, Kulkarni et al. describe a system where they hire managers, who are particularly experienced members in the community, to recruit

workers and perform coaching responsibilities like giving feedback and managing conflict (Kulkarni et al., 2012). Crowdwork platforms could motivate people to post reflections for the benefit of others' in order to gain status and the opportunity to become managers, who are paid more and have greater career stability.

We found fewer examples of tools that supported *explaining work to maintain relationships* and *consulting posted examples of peer work* in crowd work. Researchers found that crowd workers who participated in discussions were more likely to arrive at the right answer to a problem (Coetzee et al., 2015). Yet further work needs to be done to understand to what extent these discussions foster articulation activity, and whether that has a significant impact on skill development. Further work could also be done to identify whether greater articulation activity in these discussions leads to better peer relationships. *Consulting posted examples of peer work* would also help novice crowd workers develop skills through the apprenticeship method of modeling. While posting examples of work poses problems with privacy, certain requestors and workers might be interested in volunteering to share their work in order to benefit novices in the community, or at least those working on the same task.

In addition to crowd work communities, we believe distributed apprenticeship can be applied to other related online workplace communities, such as gig economy platforms where people develop skills through requests for crowdsourced freelance work (Parigi & Ma, 2016; Suzuki et al., 2016), creative work platforms where amateur designers and artists develop skills by posting work and receiving feedback (Campbell et al., 2015; Evans et al., 2017; Fiesler et al., 2017), and even MOOCS where an increasing number of people are taking project-based courses to learn how to develop their own products and services ("Design Kit: The Course for Human-Centered Design," n.d.). Using the instructional framework of distributed apprenticeship to analyze existing work in these online workplace contexts helps to identify particular instances where skill acquisition is most likely to occur and where it needs support.

5.3. Contributions to Crowdfunding and Entrepreneurship

The public nature of crowdfunding has changed how entrepreneurship is performed in an online context. We find that the addition of these platforms provides a repository of peer work from which to take inspiration, a large network from which to seek feedback, and community of dedicated peers and supporters who drive opportunities for articulation and reflection-like activity. Unlike previously studied entrepreneurial communities, the transparent nature of crowdfunding work influences how members of this community acquire entrepreneurial skills.

While entrepreneurship researchers have studied the types of skills needed, few have studied *how* entrepreneurs acquire these skills (Cope, 2005). The overarching skills needed to perform entrepreneurship typically refer to the cognitive processes by which entrepreneurs transform their experiences into different forms of knowledge and action (Baron, 1998; Kolb, 1984). For instance, entrepreneurship researchers have argued that inconsistencies between individuals' existing knowledge (Ardichvili,

Cardozo, & Ray, 2003; Shane, 2003) and their behavior are rooted in cognition, which could explain why some people are able to recognize and exploit venture opportunities, while others with similar backgrounds and experiences do not (Corbett, 2005; Shane, 2003). The majority of literature has focused on knowledge sources, such as social networks, first-hand experience, and formal schooling (Sexton, Upton, Wacholtz, & McDougall, 1997; Slotte-Kock & Coviello, 2010). While formal approaches to entrepreneurial skill acquisition, such as business roundtables, seminars, videos, and books, (Sexton et al., 1997) are still heavily used ("Common Teaching Materials," 2014), informal sources, like one's position in a social network and first-hand experience, have been argued to be more effective (Kauffman Foundation, 2008).

More recently, entrepreneurship researchers have focused on understanding the experiences that entrepreneurs endure as a source of entrepreneurship knowledge (Chen et al., 1998; Corbett, 2005; Kauffman Foundation, 2008). This experiential learning perspective highlights the importance of trial-and-error, learning from failure, and authentic environments (Cope & Watts, 2000; Deakins & Freel, 1998; St-Jean & Audet, 2012). We expand the literature on understanding entrepreneurial experiences by studying the process of apprenticeship in online entrepreneurship communities where novices leverage social technologies to overcome challenges with finding consistent mentorship. In a way, performing crowdfunding can be seen as an introductory activity to larger scale entrepreneurship activity because crowdfunding is often performed by novices who use the online platform and support tools to develop their initial consumer base and publicity material (Gerber & Hui, 2013; Hui et al., 2014).

Crowdfunding entrepreneurs often describe their relationship with peers as more supportive than competitive (Hui et al., 2014). While entrepreneurship does involve collaborating with teammates and other firms, previous literature emphasizes that entrepreneurs must maintain information asymmetry to maintain competitive advantage for a greater likelihood of opportunity exploitation (Shane, 2003). This behavior is different from much of observed crowdfunding behavior where crowdfunders post their work publicly online, and volunteer to give advice and feedback to each other (Hui et al., 2014). Similarly, others have found that the public nature of crowdfunding promotes greater opportunities for social support and the development of entrepreneurial self-efficacy (Harburg, Hui, Greenberg, & Gerber, 2015). Such cooperative competition has been observed in artisan entrepreneurial communities as well, like Etsy, where people are motivated to provide support to other members despite competing for the same customers (Kuhn & Galloway, 2015).

Entrepreneurship is experiencing a revolution through crowdfunding, as these entrepreneurs must learn to interact not just with a handful of team members and investors, but also with members of an entire online community of peers, experts, and supporters to perform a wide range of work. Unlike crowdfunding, entrepreneurial researchers have found that less than 30% of entrepreneurs typically maintain direct or indirect ties with customers (Bhide, 2000). Conversely, crowdfunding entrepreneurs are often motivated to build lasting relationships with their supporters

by following online community building practices (Kraut & Resnick, 2012), such as engaging with supporters directly, explaining the value of their project (Kazanjian, 1988), coordinating efforts with supporters (Hui et al., 2014), and motivating activity via extrinsic tangible rewards or intrinsic rewards of gratitude (Gerber & Hui, 2013). We argue that in order to support skill development in online workplace communities with limited access to dedicated expert instructors, these communities should design and adopt systems that provide a diversity of avenues to apprentice-like instruction, including access to representations of each others' work, opportunities to seek relevant advice and feedback, and ways to communicate process and reflections to different stakeholders.

6. DESIGN IMPLICATIONS

Our study provides insight into how we can better leverage the social nature of online communities to support professional skill development online. These implications are intended to describe specific ways that social technologies can be improved or implemented so that novices have greater opportunities to experience instruction through interactions with other community members. Figure 7 summarizes these design principles. We describe how these design implications could be carried out in the online workplace context of crowdfunding.

6.1. Support Search via Instructional Attributes

Unlike traditional and cognitive apprenticeship where there are dedicated instructors who create and share examples for the purpose of instruction, such as in classrooms (Collins et al., 1991) and MOOCs (Gulwani, 2014), crowdfunders must identify and make sense of examples provided by nonexpert instructors. Similar to other online workplace communities (Kuznetsov & Paulos, 2010; Marlow & Dabbish, 2014), people in crowdfunding communities find it useful to observe projects with similar goals in order to inspire their own ideas and identify successful strategies. Although crowdfunding platforms have significantly improved their search functionality in the last few years (see Figure 8 for Kickstarter's current search features), it is still difficult to identify projects and people from which to learn and take inspiration. We suggest opportunities to expand search functionality by adding attributes particularly useful for instruction.

Crowdfunding platform search tools could help crowdfunders pinpoint successful strategies controlling for other mediating factors. For instance, if crowdfunders specifically wanted to identify useful communication strategies, platforms could identify projects of similar type, funding goal, reward structure, and social network of the crowdfunder, but with different communication formats and success outcomes. Learning via modeling often involves comparing successful to failed models in order to identify which actions to mimic and which to avoid (Bandura, 2001).

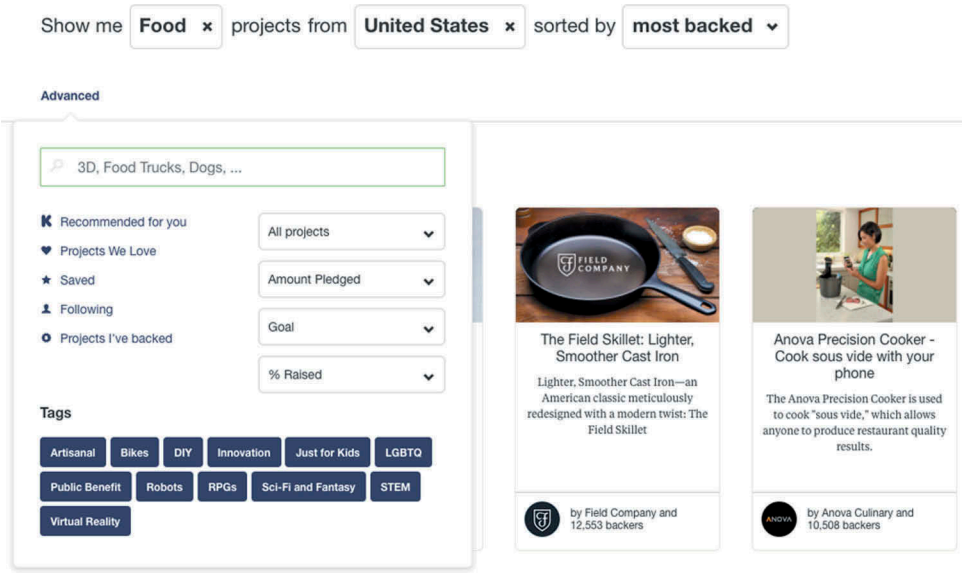
FIGURE 7. Design implications for improving learning opportunities in distributed apprenticeship.

Design implication		Distributed apprenticeship method supported	Crowdfunding Example
1	***Support search via instructional attributes***	- Consult posted examples of peer work - Seek direct feedback from extended networks	Provide ability to search for successful and unsuccessful projects run by similar others.
2	***Facilitate feedback from multiple stakeholders***	- Seek direct feedback from extended networks - Explain process to maintain relationships	Facilitate relationships with feedback providers by suggesting ways to present work and timelines for updates.
3	***Support process documentation***	- Explain process to maintain relationships - Share reflection to support community wellbeing	Provide opportunities to share progress on a pre-launch page in order to build a consumer following.

Hiding failed projects limits opportunities to learn from "negative models" and may cause people to have unrealistic expectations of success. Previous work finds that 43% of relaunched crowdfunding projects are successful the second time around (Greenberg & Gerber, 2014). Yet, if crowdfunding entrepreneurs fail to reach their funding goal, they might have lower self-efficacy to overcome failure if they do not see others who have experienced and overcome similar challenges. While it may be against the interests of crowdfunding platforms to highlight failed projects among the general public, platforms could provide tools specific for novice crowdfunders to help them identify successful and failed campaigns that serve as particularly useful instructional models.

Platforms could also facilitate search of potential models by making important invisible factors of success more visible. Identifying successful practices is difficult because much of crowdfunding success depends on one's initial social capital (Mollick, 2013), a measure typically absent on campaign pages. In our interviews, we encountered many people who believed achieving success would be simple after seeing the ease by which others raised funds, not knowing how their social capital compared. Social capital is the extent to which people can leverage their social connections for resources (Coleman, 1988; Putnam, 2001). Being able to find campaigns run by people with similar social capital would help crowdfunders set more realistic expectations of success based on their own network. Currently, Kickstarter allows people to search for successful projects by project type, location, amount pledged, funding goal, % raised, and related topic tags. In order to better support novice skill development, search functionality could also help crowdfunders find people in similar networks to oneself (e.g., similar number of social media connections, student or employed, local groups active in). Being able to search for similar others would not only help to identify useful work examples, but also people who could serve as feedback and advice providers. The growing number of crowdfunding projects online provides a rich repository from which novices could learn. Providing search functionality to identify relevant models would help novices better plan their work and develop useful mentor relationships.

FIGURE 8. Kickstarter's search primarily allows users to search for successful projects by general project type, location, and certain success factors.



6.2. Facilitate Feedback From Multiple Stakeholders

Scaffolding interactions to receive advice and feedback is particularly important for novices who need extra guidance on performing the many complex aspects of crowdfunding work. In order to receive and benefit from online feedback, requesters must determine their need for feedback, identify feedback providers, effectively present work, incentivize feedback providers, make sense of feedback, and adapt it to their revisions (Foong, Dow, Bailey, & Gerber, 2017).

Computer science researchers have created multiple tools to identify feedback providers and facilitate the feedback process, such as on Q&A sites (Bouguessa, Dumoulin, & Wang, 2008), social networking sites (Horowitz & Kamvar, 2010; Liu & Jansen, 2013), and enterprise platforms (Guy, Ur, Ronen, Weber, & Oral, 2012). Systems to facilitate online feedback have been created to support timely feedback (Cambre, Kulkarni, Bernstein, & Klemmer, 2014; Dow et al., 2012; Greenberg, Easterday, & Gerber, 2015; Kulkarni, Bernstein, & Klemmer, 2015), structured feedback (Xu et al., 2014), higher quality feedback (Hicks, Pandey, Fraser, & Klemmer, 2016; Hui, Glenn, Jue, Gerber, & Dow, 2015; Xu, Rao, Dow, & Bailey, 2015), and more accurate feedback (Kulkarni et al., 2013) from crowds and peers. We find that crowdfunders who were not part of an immediate network of people willing to offer and help, such as a school or creative community, had difficulty collecting advice and feedback. Expert recommender systems could be implemented in

crowdfunding platforms to help novices identify specific members of the community who might be particularly motivated to provide feedback, such as those who are most active (Liu & Jansen, 2013) or those that have run similar projects. However, our data also show that those who have come to be mentors in the crowdfunding community are also inundated with requests for help, especially as crowdfunding continues to grow in popularity. Algorithms to efficiently distribute feedback requests or organize peer feedback (Staubitz, Petrick, Bauer, Renz, & Meinel, 2016) could be adopted by crowdfunding platforms to reduce the burden on those who are experienced but have limited time. Those who do end up providing significantly more help to peers could be acknowledged by crowdfunding platforms for their service, a suggestion made in MOOC contexts to reduce anti-reciprocal peer review (Kotturi, Du, Klemmer, & Kulkarni, 2017).

Unlike crowds, which need to be paid, crowdfunding supporters are motivated to provide feedback because they have invested financially and socially in the work (Gerber & Hui, 2013). This relationship is not unidirectional as supporters often see themselves as investors and consumers and expect frequent and detailed descriptions and updates in return for their support (Kim et al., 2017). Crowdfunding support tools could provide schedules or reminders for frequency of communication, what questions or topics to address, and guidance on how to structure these updates in a way that presents work clearly. Explaining one's work and providing updates helps both fulfill requirements for receiving feedback (i.e., effectively presenting one's work (Foong et al., 2017)) and also provides opportunities to perform articulation, a key aspect of apprenticeship instruction.

6.3. Support Process Documentation

Unlike traditional forms of modeling where an expert performs an entire task for the purpose of instruction, there are limited opportunities for observing work process online. This is a problem in related contexts, like graphic design communities where members primarily post only their finished products to maintain a professional reputation (Marlow & Dabbish, 2014). HCI researchers and practitioners have begun to develop various online platforms that encourage people working on design and engineering projects to elaborate on their process (Rees Lewis et al., 2015; Tseng & Resnick, 2014). However, many find that people are wary of posting their process because they have little motivation to spend the extra time and do not want to be judged on early versions of their work (Marlow & Dabbish, 2014; Tseng & Resnick, 2014).

In order to overcome fear of judgment, HCI researchers have studied how sharing parallel prototypes (Dow et al., 2010) and anonymous feedback (Hui et al., 2015) can encourage sharing early versions. Parallel prototypes reduce design fixation (Jansson & Smith, 1991), making designers more receptive to feedback, while anonymity of the designer hides their identity from people who might judge them by their work. Implementing parallel prototyping in crowdfunding might involve designing the ability to make multiple versions of one's landing page for feedback

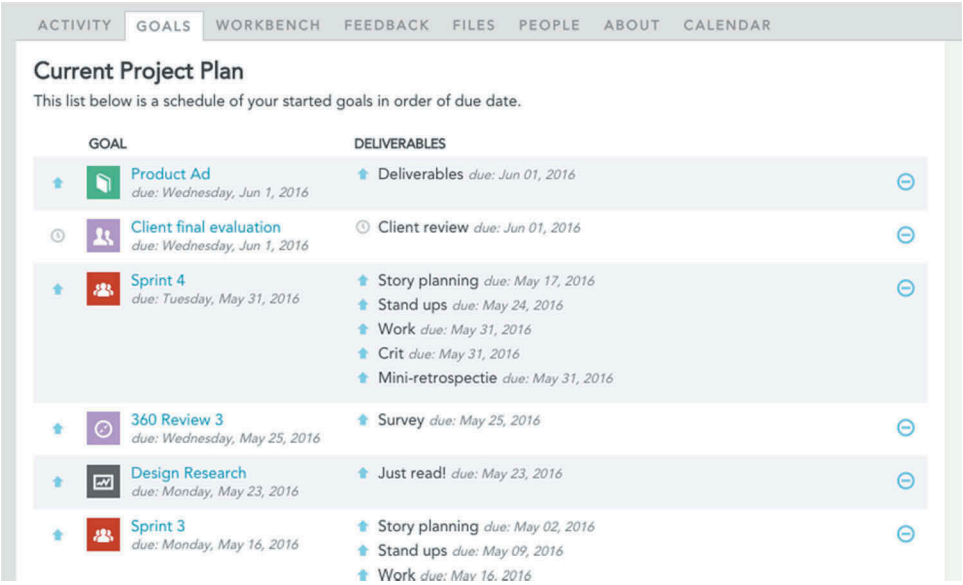
and sharing these prototypes during early stages of campaign preparation. Related work in marketing describes the value of building anticipation by updating consumers about product progress before product launch (Mahajan, Muller, & Bass, 1991). Furthermore, work on motivation to give funds in crowdfunding includes the desire to participate in the overall design process (Gerber & Hui, 2013).

While process documentation can be time consuming, it can support in-the-moment assessment and documentation during complex fast-paced work like entrepreneurship (Shane, 2003). Related work on checklists (de Vries et al., 2010; Haynes et al., 2009; Wu et al., 2014) and version control systems (Brindescu, Codoban, Shmarkatiuk, & Dig, 2014; Mikami, Sakamoto, & Igarashi, 2017) have shown how tools that support process documentation can help manage complexity, help error recovery, and support more efficient collaboration in high-stress complex work environments. For instance, similar to Loft (Figure 9) which outlines key project goals and provides places for students to upload work so that coaches and peers can provide feedback, crowdfunding platforms could perform similar functionalities and outline key responsibilities before, during, and after the campaign to share with domain experts, peers, and supporters. Similarly, blogs that host crowdfunding reflections could provide questions to help crowdfunding entrepreneurs reflect on different parts of their process, such as "What was most difficult during the first week of the campaign?" or "What are three things you would change if you were to crowdfund again?" which could support reflection that can be easily shared with peers looking for advice. Such supports could reduce cognitive burden for novice crowdfunders, allowing them greater time to concentrate on performing tasks well.

7. LIMITATIONS

As crowdfunding becomes increasingly popular, the community and technological space constantly changes. Because data collection occurred between 2011 and 2017, it is possible that social technologies that launched this year already address some of the challenges participants described in the past. While we interviewed 62 participants from 16 different crowdfunding project categories, both failures and successes, it is hard to tell whether we achieved a representative sample. Other factors, such as gender, race, and socioeconomic status of participants play a large role in how they experience crowdfunding (Marom, Rob, & Sade, n.d.; Rhue & Clark, 2016). We initially attempted random sampling by randomly following up with people who had recently launched a campaign, but we were limited by platforms' terms of use of sending out more than 10 message requests per day. Furthermore, many crowdfunding entrepreneurs do not provide outside contact information on their crowdfunding profile. Primarily contacting those who connected their profile to social media accounts or were responsive online would bias our participants to those who were tech-savvy. Therefore, in order to recruit people with a wide range of backgrounds, social technology capabilities, from various project categories and funding goals, we started with a random sampling seed paired with snowball sampling to achieve a representative sample. We also acknowledge that

FIGURE 9. Loft (REES LEWIS ET AL., 2015) scaffolds performance and documentation work by laying out project goals and providing places to upload work coaches and peers to view. Permission to use this image granted by study author, Daniel Rees Lewis.



our data do not provide concrete evidence that skill acquisition is actually occurring. Rather, we use this framework to map out instances where skill acquisition is most likely to occur based on existing learning theory.

8. CONCLUSION

We develop an emergent theory of distributed apprenticeship, which describes the process by which social interactions in informal online workplace contexts, like crowdfunding, foster opportunities for apprenticeship. We argue that in order to mimic the benefits of dedicated instructional guidance, these communities should provide a diversity of avenues to apprentice-like instruction, including consulting posted examples of peer work, seeking feedback from extended networks, explaining process to maintain relationships, and sharing reflection to support community well-being. These findings provide implications for how community design and technologies can be improved to provide novices greater opportunity to experience apprentice-like instruction in online informal workplace communities.

NOTES

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REFERENCES

Ackerman, M. S. (1998). Augmenting organizational memory: A field study of answer garden. *ACM Transactions on Information Systems (TOIS)*, *16*(3), 203–224. doi:10.1145/290159.290160

Adamic, L. A., Zhang, J., Bakshy, E., & Ackerman, M. S. (2008). Knowledge sharing and yahoo answers: Everyone knows something. In *Proc. of the Conference on World Wide Web* (pp. 665–674). ACM.

Ahlers, G. K., Cumming, D., Günther, C., & Schweizer, D. (2015). Signaling in equity crowdfunding. *Entrepreneurship Theory and Practice*, *39*(4), 955–980. doi:10.1111/etap.12157

Alexa.com. (n.d.). Retrieved October 15, 2011, from http://www.alexa.com/

Ardichvili, A., Cardozo, R., & Ray, S. (2003). A theory of entrepreneurial opportunity identification and development. *Journal of Business Venturing*, *18*(1), 105–123. doi:10.1016/S0883-9026(01)00068-4

Arguello, J., Butler, B. S., Joyce, E., Kraut, R., Ling, K. S., Rosé, C., & Wang, X. (2006). Talk to me: Foundations for successful individual-group interactions in online communities. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 959–968). ACM.

Audet, J., & St-Jean, E. (2007). Factors affecting the use of public support services by SME owners: Evidence from a periphery region of Canada. *Journal of Developmental Entrepreneurship*, *12*(02), 165–180. doi:10.1142/S1084946707000629

Bain, A. (2012). *The learning edge: What technology can do to educate all children*. New York, NY: Teachers College Press.

Bandura, A. (2001). *Self-Efficacy: The exercise of control*. New York, NY, USA: W. H. Freeman and Company.

Baron, R. A. (1998). Cognitive mechanisms in entrepreneurship: Why and when enterpreneurs think differently than other people. *Journal of Business Venturing*, *13*(4), 275–294. doi:10.1016/S0883-9026(97)00031-1

Bederson, B. B., & Quinn, A. J. (2011). Web workers unite! addressing challenges of online laborers. In *Extended abstracts on human factors in computing systems* (pp. 97–106). Vancouver, BC, Canada: ACM.

Belleflamme, P., Lambert, T., & Schwienbacher, A. (2013). Crowdfunding: Tapping the right crowd. *Journal of Business Venturing*. *29*(5), 585–609.

Bennett, R. (2008). SME policy support in Britain since the 1990s: What have we learnt? *Environment and Planning C: Government and Policy*, *26*(2), 375–397. doi:10.1068/c07118

Bennett, R. J., & Robson, P. J. (1999). The use of external business advice by SMEs in Britain. *Entrepreneurship & Regional Development*, *11*(2), 155–180. doi:10.1080/089856299283245

Bhide, A. (2000). *The origin and evolution of new businesses*. New York, NY, USA: Oxford University Press.

Blau, P. M., Falbe, C. M., McKinley, W., & Tracy, P. K. (1976). Technology and organization in manufacturing. *Administrative Science Quarterly*, *21*(1), 20–40. doi:10.2307/2391876

Bouguessa, M., Dumoulin, B., & Wang, S. (2008). Identifying authoritative actors in question-answering forums: The case of yahoo! answers. In *Proc.of the International Conference on Knowledge Discovery and Data Mining* (pp. 866–874). ACM.

Bransford, J. D. (1997). *The Jasper project: Lessons in curriculum, instruction, assessment, and professional development*. New York, NY, USA: Routledge.

Brindescu, C., Codoban, M., Shmarkatiuk, S., & Dig, D. (2014). How do centralized and distributed version control systems impact software changes? In *Proc. of the International Conference on Software Engineering* (pp. 322–333). ACM.

Brooks, C., Thompson, C., & Teasley, S. (2015). A time series interaction analysis method for building predictive models of learners using log data. In *Proc. of the Conference on Learning Analytics And Knowledge* (pp. 126–135). ACM.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–42. doi:10.3102/0013189X018001032

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues*, *8*(2), 5–21. doi:10.2307/1511637

Cambre, J., Kulkarni, C., Bernstein, M. S., & Klemmer, S. R. (2014). Talkabout: Small-group discussions in massive global classes. In *Proc. of the Conference on Learning@Scale* (pp. 161–162). ACM.

Campbell, J. A., Aragon, C., Davis, K., Evans, S., Evans, A., & Randall, D. P. (2015). Thousands of Positive Reviews: Distributed Mentoring in Online Fan Communities. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing*. ACM.

Chen, C., Greene, P. G., & Crick, A. (1998). Does entrepreneurial self-efficacy distinguish entrepreneurs from managers. *Journal of Business Venturing*, *13*(4), 295–316. doi:10.1016/S0883-9026(97)00029-3

Coetzee, D., Lim, S., Fox, A., Hartmann, B., & Hearst, M. A. (2015). Structuring interactions for large-scale synchronous peer learning. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing* (pp. 1139–1152). ACM.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, S95–S120. doi:10.1086/228943

Collins, A. (2014). Cognitive Apprenticeship. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (2nd ed., pp. 47–60). Cambridge, England: Cambridge University Press.

Collins, A., & Brown, J. S. (1988). *The computer as a tool for learning through reflection*. New York, NY, USA: Springer.

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator*, *15*(3), 6–11.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser*, *18*, 32–42.

Collinson, S., & Gregson, G. (2003). Knowledge networks for new technology–Based firms: An international comparison of local entrepreneurship promotion. *R&D Management*, *33* (2), 189–208. doi:10.1111/1467-9310.00292

Colombo, M. G., Franzoni, C., & Rossi-Lamastra, C. (2015). Internal social capital and the attraction of early contributions in crowdfunding. *Entrepreneurship Theory and Practice*, *39*(1), 75–100. doi:10.1111/etap.2015.39.issue-1

Common Teaching Materials. (2014). Retrieved from http://www.nationalsurvey.org/survey-findings/

The Contender. (2015a). The contender: The game of political debate. Retrieved from https://www.kickstarter.com/projects/contender/the-contender-the-game-of-political-debate

The Contender. (2015b, November 4). Step-by-step guide on how we made over $142,000 in our campaign. Retrieved from https://www.kickstarter.com/projects/541979290/the-contender-the-game-of-political-debate/posts/1404456

Cope, J. (2005). Toward a dynamic learning perspective of entrepreneurship. *Entrepreneurship Theory and Practice*, *29*(4), 373–397. doi:10.1111/etap.2005.29.issue-4

Cope, J., & Watts, G. (2000). Learning by doing-An exploration of experience, critical incidents and reflection in entrepreneurial learning. *International Journal of Entrepreneurial Behavior & Research*, *6*(3), 104–124. doi:10.1108/13552550010346208

Corbett, A. C. (2005). Experiential learning within the process of opportunity identification and exploitation. *Entrepreneurship Theory and Practice*, *29*(4), 473–491. doi:10.1111/etap.2005.29.issue-4

Davidsson, P., & Honig, B. (2003). The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, *18*(3), 301–331. doi:10.1016/S0883-9026(02)00097-6

de Vries, E. N., Prins, H. A., Crolla, R. M., den Outer, A. J., van Andel, G., & van Helden, S. H.; others. (2010). Effect of a comprehensive surgical safety system on patient outcomes. *New England Journal of Medicine*, *363*(20), 1928–1937. doi:10.1056/NEJMsa0911535

Deakins, D., & Freel, M. (1998). Entrepreneurial learning and the growth process in SMEs. *The Learning Organization*, *5*(3), 144–155. doi:10.1108/09696479810223428

Design Kit: The Course for Human-Centered Design. (n.d.). Retrieved from http://www.designkit.org/resources/5

Dew, N., Velamuri, S. R., & Venkataraman, S. (2004). Dispersed knowledge and an entrepreneurial theory of the firm. *Journal of Business Venturing*, *19*(5), 659–679. doi:10.1016/j.jbusvent.2003.09.004

Dillahunt, T. R., Ng, S., Fiesta, M., & Wang, Z. (2016). Do massive open online course platforms support employability? In *Proc. of the Conference on Computer-Supported Cooperative Work & Social Computing* (pp. 233–244). ACM.

Ding, X., Shih, P. C., & Gu, N. (2017). Socially embedded work: A study of wheelchair users performing online crowd work in China. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing* (pp. 642–654). ACM.

Dow, S. P., Glassco, A., Kass, J., Schwarz, M., Schwartz, D. L., & Klemmer, S. R. (2010). Parallel prototyping leads to better design results, more divergence, and increased self-efficacy. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *17*(4), 18. doi:10.1145/1879831.1879836

Dow, S. P., Kulkarni, A., Klemmer, S., & Hartmann, B. (2012). Shepherding the crowd yields better work. In *Proc. of the ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 1013–1022).

Drake, D. (2016, October 22). 2,000 global crowdfunding sites to choose from by 2016: Top 5 growth indicators. *The Huffington Post*. Retrieved from http://www.huffingtonpost.com/david-drake/2000-global-crowdfunding-_b_8365266.html

Evans, S., Davis, K., Evans, A., Campbell, J. A., Randall, D. P., Yin, K., & Aragon, C. (2017). More Than Peer Production: Fanfiction Communities as Sites of Distributed Mentoring. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing*.

Fiesler, C., Morrison, S., Shapiro, R. B., & Bruckman, A. S. (2017). Growing Their Own: Legitimate Peripheral Participation for Computational Learning in an Online Fandom Community. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing* (pp. 1375–1386). ACM.

Florida, R. (2004). *Rise of the creative class*. New York, NY, USA: Basic Books.

Foong, E., Dow, S. P., Bailey, B. P., & Gerber, E. M. (2017). Online feedback exchange: A framework for understanding the socio-psychological factors. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 4454–4467). ACM.

Gerber, E. M., & Hui, J. S. (2013). Crowdfunding: Motivations and deterrents for participation. *Transactions on Human-Computer Interaction*, *20*(6), 34:1–34: 32. doi:10.1145/2530540

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, *17*(S2), 109–122. doi:10.1002/smj.4250171110

Gray, M. L., Suri, S., Ali, S. S., & Kulkarni, D. (2016).The crowd is a collaborative network. In *Proceedings of computer-supported cooperative work and social computing*. ACM.

Gredler, M. E. (1992). *Learning and instruction: Theory into practice*. New York, NY: Macmillan.

Greenberg, M. D., Easterday, M., & Gerber, E. M. (2015). Critiki: A scaffolded approach to gathering design feedback from paid crowdworkers. In *Proceedings of ACM Conference on Computer-Supported Cooperative Work and Social Computing*. San Francisco, California, USA: ACM.

Greenberg, M. D., & Gerber, E. M. (2014). Learning to fail: Experiencing public failure online through crowdfunding. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 581–590). ACM.

Gulwani, S. (2014). Example-based learning in computer-aided stem education. *Communications of the ACM*, *57*(8), 70–80. doi:10.1145/2632661

Gupta, N., Martin, D., Hanrahan, B. V., & O'Neill, J. (2014). Turk-life in India. In *Proc. of the Conference on Supporting Group Work* (pp. 1–11). ACM.

Guy, I., Ur, S., Ronen, I., Weber, S., & Oral, T. (2012). Best faces forward: A large-scale study of people search in the enterprise. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 1775–1784). ACM.

Habich, J. (2015, November 25). How we failed in our first Kickstarter campaign, only to nail it with the second. Retrieved from https://medium.com/the-crowdfunding-bible/how-we-failed-in-our-first-kickstarter-campaign-only-to-nail-it-with-the-second-f72d163dd881

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. *Handbook of Self-Regulation of Learning and Performance*, *30*, 65–84.

Hannák, A., Wagner, C., Garcia, D., Mislove, A., Strohmaier, M., & Wilson, C. (2017). Bias in online freelance marketplaces: Evidence from taskrabbit and fiverr. In *Proc. of the Conference on Computer-Supported Cooperative Work and Social Computing (CSCW 2017). He, K.*

Harburg, E., Hui, J. S., Greenberg, M. D., & Gerber, E. M. (2015). The effects of crowdfunding on entrepreneurial self-efficacy. In *Proc. of the ACM Conference on Computer Supported Cooperative Work & Social Computing* (pp. 3–16). ACM.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*(1), 81–112. doi:10.3102/003465430298487

Haynes, A. B., Weiser, T. G., Berry, W. R., Lipsitz, S. R., Breizat, A.-H. S., & Dellinger, E. P.; others. (2009). A surgical safety checklist to reduce morbidity and mortality in a global population. *New England Journal of Medicine*, *360*(5), 491–499. doi:10.1056/NEJMsa0810119

Hicks, C. M., Pandey, V., Fraser, C. A., & Klemmer, S. (2016). Framing feedback: Choosing review environment features that support high quality peer assessment. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 458–469). ACM.

Hite, J. M. (2005). Evolutionary processes and paths of relationally embedded network ties in emerging entrepreneurial firms. *Entrepreneurship Theory and Practice*, *29*(1), 113–144. doi:10.1111/etap.2005.29.issue-1

Hite, J. M., & Hesterly, W. S. (2001). The evolution of firm networks: From emergence to early growth of the firm. *Strategic Management Journal*, *22*(3), 275–286. doi:10.1002/(ISSN)1097-0266

Hoang, H., & Antoncic, B. (2003). Network-based research in entrepreneurship: A critical review. *Journal of Business Venturing*, *18*(2), 165–187. doi:10.1016/S0883-9026(02)00081-2

Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation for human-computer interaction research. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *7*(2), 174–196. doi:10.1145/353485.353487

Hollingshead, A. B., Fulk, J., & Monge, P. (2002). Fostering intranet knowledge sharing: An integrated of transactive memory and public goods approaches. In P. Hinds & S. Kiesler (Eds.), *Distributed work*. Cambridge, MA, USA: The MIT Press.

Horowitz, D., & Kamvar, S. D. (2010). The anatomy of a large-scale social search engine. In *Proc. of the Conference on the World Wide Web* (pp. 431–440). ACM.

Hui, J. S., Gerber, E., & Gergle, D. (2014). Understanding and leveraging social networks for crowdfunding: Opportunities and challenges. In *Proc. of the ACM Conference on Designing Interactive Systems* (pp. 677–680). ACM.

Hui, J. S., Gerber, E. M., & Dow, S. P. (2014). Crowd-Based design activities: Helping student connect with users online. In *Proc. of the ACM Conference on Designing Interactive Systems* (pp. 875–884). ACM.

Hui, J. S., Glenn, A., Jue, R., Gerber, E. M., & Dow, S. P. (2015). Using anonymity and communal efforts to improve quality of crowdsourced feedback. In *Proc. of the AAAI Conference on Human Computation and Crowdsourcing*. AAAI.

Hui, J. S., Greenberg, M. D., & Gerber, E. M. (2014). Understanding the role of community in crowdfunding work. In *Proc. of the ACM Conference on Computer Supported Cooperative Work & Social Computing* (pp. 62–74). ACM.

Hwang, E. H., Singh, P. V., & Argote, L. (2015). Knowledge sharing in online communities: Learning to cross geographic and hierarchical boundaries. *Organization Science*, *26*, 6. doi:10.1287/orsc.2015.1009

Irani, L. C., & Silberman, M. (2013). Turkopticon: Interrupting worker invisibility in amazon mechanical turk. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 611–620). ACM.

Jansson, D. G., & Smith, S. M. (1991). Design fixation. *Design Studies*, *12*(1), 3–11. doi:10.1016/0142-694X(91)90003-F

Kaish, S., & Gilad, B. (1991). Characteristics of opportunities search of entrepreneurs versus executives: Sources, interests, general alertness. *Journal of Business Venturing*, *6*(1), 45–61. doi:10.1016/0883-9026(91)90005-X

Kauffman Foundation. (2008). *Entrepreneurship in American higher education*. Retrieved from http://www.kauffman.org/what-we-do/research/2013/08/entrepreneurship-in-american-higher-education

Kazanjian, R. K. (1988). Relation of dominant problems to stages of growth in technology-based new ventures. *Academy of Management Journal*, *31*(2), 257–279. doi:10.2307/256548

KickSpy. (2015). Retrieved November 13, 2014, from https://web.archive.org/web/20141113030253/http://www.kickspy.com/top

Kickstarter Campus. (2015). Campus. Retrieved from https://www.kickstarter.com/campus

Kickstarter Guide. (2017). Retrieved from https://www.kickstarter.com/guide-to-funding?ref=fb_ads_guide_to_funding_julia&utm_source=facebook&utm_medium=cpc-mgb&utm_campaign=ft-L2&banner=cta-launch01

Kickstarter Stats. (2016). Retrieved February 12, 2015, from http://www.kickstarter.com/help/stats

Kim, Y., Shaw, A., Zhang, H., & Gerber, E. (2017). Understanding trust amid delays in crowdfunding. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing* (pp. 1982–1996). ACM.

Kittur, N., Nickerson, J., Bernstein, M., Gerber, E., Shaw, A., Zimmerman, J., … Horton, J. (2013). The future of crowd work. In *Proc. of the ACM Conference on Computer Supported Cooperative Work and Social Computing* (pp. 1301–1318).

Knowledge @ Wharton. (2010, December 8). Can you spare a quarter? Crowdfunding sites turn fans into patrons of the arts. Retrieved from http://knowledge.wharton.upenn.edu/article.cfm?articleid=2647

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Kotturi, Y., Du, A., Klemmer, S., & Kulkarni, C. (2017). Long-Term peer reviewing effort is anti-reciprocal. In *Proc. of the Conference on Learning@ Scale* (pp. 279–282). ACM.

Krause, M., Mogalle, M., Pohl, H., & Williams, J. J. (2015). A playful game changer: Fostering student retention in online education with social gamification. In *Proc. if tge Conference on Learning@Scale* (pp. 95–102). ACM.

Kraut, R. E., & Resnick, P. (2012). *Building successful online communities*. The MIT Press.

Kuhn, K. M., & Galloway, T. L. (2015). With a little help from my competitors: Peer networking among artisan entrepreneurs. *Entrepreneurship Theory and Practice*, *39*(3), 571–600. doi:10.1111/etap.2015.39.issue-3

Kulkarni, A., Gutheim, P., Narula, P., Rolnitzky, D., Parikh, T., & Hartmann, B. (2012). MobileWorks: Designing for quality in a managed crowdsourcing architecture. *IEEE Internet Computing*, *16*(5), 28–35. doi:10.1109/MIC.2012.72

Kulkarni, C., Wei, K. P., Le, H., Chia, D., Papadopoulos, K., Cheng, J., … Klemmer, S. R. (2013). Peer and self assessment in massive online classes. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *20*(6), 33. doi:10.1145/2505057

Kulkarni, C. E., Bernstein, M. S., & Klemmer, S. R. (2015). PeerStudio: Rapid peer feedback emphasizes revision and improves performance. In *Proc. of the Conference on Learning@ Scale* (pp. 75–84). ACM.

Kuznetsov, S., & Paulos, E. (2010).Rise of the expert amateur: DIY projects, communities, and cultures. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction*. Reykjavik, Iceland: ACM.

Lampe, C., Wohn, D. Y., Vitak, J., Ellison, N. B., & Wash, R. (2011). Student use of Facebook for organizing collaborative classroom activities. *International Journal of Computer-Supported Collaborative Learning*, *6*(3), 329–347. doi:10.1007/s11412-011-9115-y

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leonardi, P. M. (2015). Ambient awareness and knowledge acquisition: Using social media to learn" who knows what" and" who knows whom". *MIS Quarterly*, *39*(4), 747–762. doi:10.25300/MISQ/2015/39.4.1

Leonardi, P. M., & Meyer, S. R. (2015). Social media as social lubricant how ambient awareness eases knowledge transfer. *American Behavioral Scientist*, *59*(1), 10–34. doi:10.1177/0002764214540509

Liu, Z., & Jansen, B. J. (2013). Factors influencing the response rate in social question and answering behavior. In *Proc. Conference on Computer Supported Cooperative Work and Social Computing* (pp. 1263–1274). ACM.

Livefree backpack live Q&A. (2017). Retrieved from https://live.kickstarter.com/knomo/live-stream/live-q-and-a-livefree-backpack

Long, W. (1983). The meaning of entrepreneurship. *American Journal of Small Business*, *8*(2), 47–59. doi:10.1177/104225878300800209

Mahajan, V., Muller, E., & Bass, F. M. (1991). New product diffusion models in marketing: A review and directions for research. In N. Nakicenovic & A. Grübler (Eds.). *Diffusion of technologies and social behavior* (pp. 125–177). New York, NY, USA: Springer-Verlag Berlin Heidelberg.

Marlow, J., & Dabbish, L. (2014). From rookie to all-star: Professional development in a graphic design social networking site. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing* (pp. 922–933). ACM.

Marom, D., Rob, A., & Sade, O. (n.d.). Gender dynamics in crowdfunding (Kickstarter): Evidence on entrepreneurs, investors, deals, and taste-based discrimination. Retrieved from https://ssrn.com/abstract=2442954 doi:10.2139/ssrn.2442954

Martin, D., O'Neill, J., Gupta, N., & Hanrahan, B. V. (2016). Turking in a global labour market. *Computer Supported Cooperative Work (CSCW)*, *25*(1), 39–77. doi:10.1007/s10606-015-9241-6

Massolution. (2015). *2015CF: The crowdfunding industry report*. Retrieved from Massolution.com

McDonald, D. W., & Ackerman, M. S. (2000). Expertise recommender: A flexible recommendation system and architecture. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing* (pp. 231–240). ACM.

Mikami, H., Sakamoto, D., & Igarashi, T. (2017). Micro-versioning tool to support experimentation in exploratory programming. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 6208–6219). ACM.

Miles, M. B., & Huberman, M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publications.

Miner, J. B. (1990). Entrepreneurs, high growth entrepreneurs, and managers: Contrasting and overlapping motivational patterns. *Journal of Business Venturing*, *5*(4), 221–234. doi:10.1016/0883-9026(90)90018-O

Mitra, T., & Gilbert, E. (2014). The language that gets people to give: Phrases that predict success on kickstarter. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing* (pp. 49–61). ACM.

Mod, C. (2010, August). Kickstartup: Successful fundraising with Kickstarter.com & (re) making art space Toyko. Retrieved from http://craigmod.com/journal/kickstartup/

Mollick, E. R. (2013). The dynamics of crowdfunding: An exploratory study. *Journal of Business Venturing*, *29*(1), 1–16. doi:10.1016/j.jbusvent.2013.06.005

Morris, M. R., Bigham, J. P., Brewer, R., Bragg, J., Kulkarni, A., Li, J., & Savage, S. (2017). Subcontracting microwork. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 1867–1876). ACM.

Morris, M. R., & Horvitz, E. (2007). SearchTogether: An interface for collaborative web search. In *Proc. of the Symposium on User Interface Software and Technology* (pp. 3–12). ACM.

Muller, M., Geyer, W., Soule, T., Daniels, S., & Cheng, L.-T. (2013). Crowdfunding inside the enterprise: Employee-initiatives for innovation and collaboration. In *Proc. of the Conference on Human Factors and Computing Systems* (pp. 503–512).

Muller, M., Geyer, W., Soule, T., & Wafer, J. (2014). Geographical and organizational distances in enterprise crowdfunding. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing* (pp. 778–789). ACM.

National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington D.C.: The National Academy Press.

Olsen, G. M., & Olsen, J. S. (2000). Distance matters. *Human-Computer Interaction*, *15*, 139–178. doi:10.1207/S15327051HCI1523_4

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science*, *3*(3), 398–427. doi:10.1287/orsc.3.3.398

Osborn, T. (2015, July 28). My adventures and advice on fulfilling orders for a printed self-published book. Retrieved from https://hellowebbooks.com/news/my-adventures-and-advice-on-fulfilling-orders-for-a-printed-self-published-book/

Ozcan, P., & Eisenhardt, K. M. (2009). Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Academy of Management Journal*, *52*(2), 246–279. doi:10.5465/AMJ.2009.37308021

Parigi, P., & Ma, X. (2016). The gig economy. *XRDS: Crossroads, the ACM Magazine for Students*, *23*(2), 38–41. doi:10.1145/3026779

Pedroso, O. (2016, January 28). https://blog.thimble.io/kit-progress-future-kits-and-logo-contest-10843d17f638. *Medium*. Retrieved from https://blog.thimble.io/kit-progress-future-kits-and-logo-contest-10843d17f638

Pew Research Center. (2016). *The State of American Jobs*. Washington, D.C.

Pfeffer, J., & Salancik, G. R. (2003). *The external control of organizations: A resource dependence perspective*. Palo Alto, CA, USA: Stanford University Press.

Piaget, J., & Cook, M. (1952). *The origins of intelligence in children* (Vol. 8). New York: International Universities Press.

Preece, J., & Shneiderman, B. (2009). The reader-to-leader framework: Motivating technology mediated social participation. *Transactions on Human-Computer Interaction*, *1*(1), 13–32. doi:10.17705/1thci.00005

Putnam, R. D. (2001). *Bowling alone: The collapse and revival of American community*. New York, NY, USA: Simon & Schuster.

Reddit. (2016). *Reddit*. Retrieved October 29, 2017, from https://www.reddit.com/r/kickstarter/comments/47m0u2/hi_reddit_could_you_please_give_me_some_feedback/

Rees Lewis, D., Harburg, E., Gerber, E., & Easterday, M. (2015). Building support tools to connect novice designers with professional coaches. In *ACM Conference on Creativity and Cognition* (pp. 43–52).

Reiser, B. J. (2004). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. *The Journal of the Learning Sciences*, *13*(3), 273–304. doi:10.1207/s15327809jls1303_2

Ren, Y., & Argote, L. (2011). Transactive memory systems 1985–2010: An integrative framework of key dimensions, antecedents, and consequences. *The Academy of Management Annals*, *5*(1), 189–229. doi:10.1080/19416520.2011.590300

Rhue, L., & Clark, J. (2016). Who gets started on kickstarter? Racial disparities in crowdfunding success. Retrieved from https://ssrn.com/abstract=2837042 doi:10.2139/ssrn.2837042

Rittel, H. W., & Webber, M. M. (1973). Planning problems are wicked problems. *Polity*, *4*, 155–169.

Rogoff, B. (2003). *The cultural nature of human development*. Oxford, England: Oxford University Press.

Rosner, D. K. (2012). The material practices of collaboration. In *Proceedings of the ACM 2012 conference on computer supported cooperative work* (pp. 1155–1164). ACM.

Rouse, J. (2014). Braxton Brewing Company: Building the taoproom of the future. Retrieved from https://www.kickstarter.com/projects/1860927270/braxton-brewing-company-building-the-taproom-of-th/description

Rulke, D. L., & Galaskiewicz, J. (2000). Distribution of knowledge, group network structure, and group performance. *Management Science*, *46*(5), 612–625. doi:10.1287/mnsc.46.5.612.12052

Salehi, N., Irani, L. C., Bernstein, M. S., Alkhatib, A., Ogbe, E., & Milland, K., & others. (2015). We are dynamo: Overcoming stalling and friction in collective action for crowd workers. In *Proc. of the Conference on Human Factors in Computing Systems* (pp. 1621–1630). ACM.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action* (Vol. 5126). New York, NY, USA: Basic books.

Sexton, D. L., Upton, N. B., Wacholtz, L. E., & McDougall, P. P. (1997). Learning needs of growth-oriented entrepreneurs. *Journal of Business Venturing*, *12*(1), 1–8. doi:10.1016/S0883-9026(96)00037-7

Shane, S. (2003). *A general theory of entrepreneurship: The individual-opportunity nexus*. Northampton, MA: Edward Elgar Publishing Limited.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. doi:10.3102/0013189X015002004

Siemens, G. (2014). *Connectivism: A learning theory for the digital age*. Retrieved from http://www.itdl.org/journal/jan_05/article01.htm

Simon, H. A. (1973). The structure of ill structured problems. *Artificial Intelligence*, *4*(3–4), 181–201. doi:10.1016/0004-3702(73)90011-8

Slotte-Kock, S., & Coviello, N. (2010). Entrepreneurship research on network processes: A review and ways forward. *Entrepreneurship Theory and Practice*, *34*(1), 31–57. doi:10.1111/etap.2010.34.issue-1

Smith, M. K., Wood, W. B., Adams, W. K., Wieman, C., Knight, J. K., Guild, N., & Su, T. T. (2009). Why peer discussion improves student performance on in-class concept questions. *Science*, *323*(5910), 122–124. doi:10.1126/science.1165919

Solomon, J., Ma, W., & Wash, R. (2015). Don't wait! How timing affects coordination of crowdfunding donations. *Proc. of the ACM Conference on Computer Supported Cooperative Work and Social Computing*.

Staubitz, T., Petrick, D., Bauer, M., Renz, J., & Meinel, C. (2016). Improving the peer assessment experience on MOOC platforms. In *Proc. of the Conference on Learning@ Scale* (pp. 389–398). ACM.

St-Jean, E., & Audet, J. (2012). The role of mentoring in the learning development of the novice entrepreneur. *International Entrepreneurship and Management Journal*, *8*(1), 119–140. doi:10.1007/s11365-009-0130-7

Strauss, A. (1988). The articulation of project work: An organizational process. *The Sociological Quarterly*, *29*(2), 163–178. doi:10.1111/j.1533-8525.1988.tb01249.x

Su Yin, M., Haddawy, P., Suebnukarn, S., & Rhienmora, P. (2016). Toward intelligent tutorial feedback in surgical simulation: Robust outcome scoring for endodontic surgery. In *Proceedings of the 21st International Conference on Intelligent User Interfaces* (pp. 402–406). ACM.

Suzuki, R., Salehi, N., Lam, M. S., Marroquin, J. C., & Bernstein, M. S. (2016). Atelier: Repurposing expert crowdsourcing tasks as micro-internships. In *Proc. of the Conference on Computer Supported Cooperative Work*. ACM.

Toombs, A. L., Bardzell, S., & Bardzell, J. (2015). The proper care and feeding of hackerspaces: Care ethics and cultures of making. In *Proc. of the ACM Conference on Human Factors in Computing Systems* (pp. 629–638). ACM.

Tseng, T., & Resnick, M. (2014). Product versus process: Representing and appropriating DIY projects online. In *Proc. of the Conference on Designing Interactive Systems* (pp. 425–428). ACM.

Van Merriënboer, J. J., & Kirschner, P. A. (2012). *Ten steps to complex learning: A systematic approach to four-component instructional design*. New York, NY, USA: Routledge.

Von Hippel, E. (1988). *Sources of Innovation*. New York, NY, USA: Oxford University Press.

Von Hippel, E. (2005). *Democratizing innovation*. Cambridge, MA: MIT Press.

Vygotsky, L. S., & Cole, M. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wash, R., & Solomon, J. (2014). Coordinating donors on crowdfunding websites. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing* (pp. 38–48). ACM.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. New York, NY, USA: Cambridge University Press.

Whiting, M. E., Gamage, D., Gaikwad, S. S., Gilbee, A., Goyal, S., & Ballav, A., … others. (2016). Crowd guilds: Worker-led reputation and feedback on crowdsourcing platforms. *ArXiv Preprint ArXiv:1611.01572*. Retrieved from https://arxiv.org/abs/1611.01572

Williams, J. J., Kizilcec, R. F., Russell, D. M., & Klemmer, S. R. (2014). Learning innovation at scale. In *Extended Abstracts in the ACM Conference on Human Factors in Computing Systems* (pp. 131–134). Toronto, ON, Canada: ACM.

Williams, J. J., Renkl, A., Koedinger, K. R., & Stamper, J. C. (2013). Online education: A unique opportunity for cognitive scientists to integrate research and practice. In *CogSci*.

Woodward, J. (1958). *Management and technology*. Indiana, USA: HM Stationery Off.

Wu, L., Cirimele, J., Leach, K., Card, S., Chu, L., Harrison, T. K., & Klemmer, S. R. (2014). Supporting crisis response with dynamic procedure aids. In *Proc. of the Conference on Designing interactive systems* (pp. 315–324). ACM.

Xu, A., Huang, S.-W., & Bailey, B. (2014). Voyant: Generating structured feedback on visual designs using a crowd of non-experts. In *Proc. of the Conference on Computer Supported Cooperative Work and Social Computing*. ACM.

Xu, A., Rao, H., Dow, S. P., & Bailey, B. P. (2015). A classroom study of using crowd feedback in the iterative design process. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing* (pp. 1637–1648). ACM.

Xu, A., Yang, X., Rao, H., Fu, W.-T., Huang, S.-W., & Bailey, B. P. (2014). Show me the money! An analysis of project updates during crowdfunding campaigns. In *Proc. of the ACM Conference on Human Factors in Computing Systems* (pp. 591–600). ACM.

Yarosh, S., Matthews, T., Zhou, M., & Ehrlich, K. (2013). I need someone to help!: A taxonomy of helper-finding activities in the enterprise. In *Proc. of the Conference on Computer supported cooperative work* (pp. 1375–1386). ACM.

Zhang, H., Easterday, M. W., Gerber, E. M., Lewis, D. R., & Maliakal, L. (2017). Agile research studios: Orchestrating communities of practice to advance research training. In *Proc. of the Conference on Computer Supported Cooperative Work & Social Computing*.

Zhu, H., Dow, S. P., Kraut, R. E., & Kittur, A. (2014). Reviewing versus doing: Learning and performance in crowd assessment. In *Proc. of the Conference on Computer supported cooperative work & social computing* (pp. 1445–1455). ACM.

Zimmerman, B. J., & Schunk, D. H. (2011). *Handbook of self-regulation of learning and performance*. New York, NY, USA: Taylor & Francis.