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Learning to design collaboratively: Participation of student designers in a Community of Innovation

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Abstract Creativity researchers have drawn on cognitive principles to characterize individual innovation. However, few comprehensive frameworks have been developed to relate social innovation to social cognition research. This article introduces the Communities of Innovation (COI) framework and examines its applications in a culture designed to promote collaborative creativity. Findings included evidence for some aspects of the COI model (flow and hacker ethic, entrepreneurship, collaboration and mentoring, sense of community, and learning through design criticism), moderate support for others (dynamic expertise and idea prototyping), but no evidence for other components (developing adaptable knowledge and expertise, symmetrical expertise within the community, community reflection, shifting interpersonal roles, or benefiting from cultural/educational/skill/other diversity). The majority of the new ideas identified and shared by participants were developed through interaction with others. Implications for refinement of the COI framework and future research are discussed.

Keywords Communities of Innovation · Communities of Practice · Innovation · Creativity · Social cognition · Collaborative learning · Collaborative work

Creativity and innovation researchers have often adopted and adapted theoretical frameworks and research methodologies from cognitive science. For example, research in creativity has drawn on cognitive principles such as knowledge and memory structures, representations, interference, and social input (for example, see Smith et al. 1995; Ward et al. 1999) to support efforts to characterize the nature of individual human innovation.

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When cognitive scientists explored the potential social nature of cognition (Barab and Plucker 2002), researchers likewise described the relationship between individual innovation and the social system (Amabile et al. 1996; Anderson and West 1996; Csikszentmihályi 1999). However, we lack a comprehensive framework for studying social innovation that parallels those used in social cognition research.

One widely studied social cognition framework is Communities of Practice (COP) (Lave and Wenger 1991; Wenger 1998). Previously, Author (2009) extended COP theory to communities designed to promote shared innovation (i.e., innovation emerging within and distributed across a community) and identified principles of the Communities of Innovation (COIs) framework. Because c*reativity* is often defined as the initial spark or idea generated, *innovation* is used in this framework to represent the ability to both generate and develop/implement an idea in practice. In the current study, we investigated the nature and characteristics of COIs within a graduate student design community. We describe the relationship between Communities of Practice and Communities of Innovation, and report findings emerging from the experiences of participants within this community. We conclude with implications from this research for the design and research of Communities of Innovation within educational settings.

Communities of Practice

Lave and Wenger derived their theory of Communities of Practice from the frameworks of situated cognition (Brown et al. 1989) and cognitive apprenticeship (Collins et al. 1989), which were alternatives to traditional information processing models of cognition that often neglected social variables. These theories were based on ideas from anthropology, social psychology, sociology, and the Russian cultural–historical school of psychology (Cole and Engeström 1993). Wenger and Snyder (2000) later defined COPs as "groups of people informally bound together by shared expertise and passion for a joint enterprise" (p. 139). While COPs are often sources of new ideas, their primary focus is on the practices and expertise developed by and shared among the community members. Knowledge generated within COPs is presumed to improve the efficiency or effectiveness of this shared practice. Wenger (1998) described an example of a community among claims processors in which "you are good… when you can quickly find legitimate ways to get the charges reimbursed" (p. 31). Wenger and Snyder further explained that the purposes of COPs are "to develop members' capabilities" and "build and exchange knowledge" (p. 142). In their examples, communities were bound by passionate workers "learning together by focusing on problems that were directly related to their work" (p. 143).

Communities of Innovation

In contrast, the Communities of Innovation framework seeks to explain communities in which shared innovation, rather than shared practice, binds the community. These frameworks are not necessarily mutually exclusive, as a community focused on innovation often becomes engaged in building expertise and efficient practices when producing and developing the innovation. In addition, COPs may generate new ideas, although the creativity is usually limited to the domain of practice reinforcing the community structure.

Communities of Innovation have structures and characteristics that better engender innovative activity. In an earlier article, Author (2009) described the theorized elements

that could explain a COI. He began by reviewing research in psychology on group creativity, as well as elements in theories on individual creativity that could be extrapolated to group or community settings. He also reviewed research from the organizational development literature on the changing nature of effective and innovative groups in the twenty-first century. Research on innovative groups is found throughout diverse literature. Different scholars refer to wisdom networks (Benton and Giovagnoli 2006), group creativity (Paulus and Nijstad 2003), group genius (Sawyer 2008), distributed creativity (Sawyer and DeZutter 2009), expansive learning cycles (Engeström 1999), knowledge creating communities (Bielaczyc et al. 2006), team creativity (Anderson and West 1996), communities of networked expertise (Hakkarainen et al. 2004), and innovation laboratories (Lewis and Moultrie 2005). Particular principles tend to be emphasized more than others, but overlapping patterns are evident. In positing the COI framework, Author sought to identify principles most commonly cited as constituting the interpersonal characteristics of effective innovative communities. Future research and exploration may well uncover additional elements such as physical spaces where COIs innovate, tools that facilitate their communication and innovation, and leadership practices that promote COIs.

Author (2009) identified eleven initial characteristics of COIs. In contrast to stable communities that remain intact for years and focus on efficiently implementing specific actions, COIs are often *dynamic* (Hakkarainen et al. 2004), *improvised* (Sawyer 2008), and rapidly changing (even when self-organized) to *produce innovation*. *Interpersonal roles and expertise* change as the nature of the community structure evolves and needs arise for solving problems. To deal with complexity, many COIs have *symmetrical expertise and knowledge structures* (Benton and Giovagnoli 2006) that de-emphasize authority and strengthen incentives for equal participation. For example, Lewis and Moultrie (2005) studied three "innovation laboratories" within UK organizations—spaces where employees were encouraged to be innovative. They found that these laboratories created successful innovation incubators by removing people from regular daily activities and eliminating traditional organizational hierarchies through increased participation. The creativity of individuals within communities can be enhanced when they identify their own problems to work on (Mumford 2003).

This asymmetrical organizational structure requires leaders and experts to stimulate fresh ideas and guidance from *diverse perspectives* within the community (Justesen 2004; Bielaczyc et al. 2006). For example, Fixson (2009) wrote that "careful consideration of a team's characteristics, such as its diversity and interests, increases its creative ability to develop better products, and it enables the team to approach the development process in a more integrated fashion which in turn helps accelerate development projects" (p. 199). Kurtzberg (2005) verified the value of diversity in two empirical studies in which cognitive diversity improved team creative fluency on objective measures. Mostert (2007) emphasized that for creative thinking, diverse thinking is more critical than diverse people, and Bassett-Jones (2005) added that while management can be risky for any community, diversity can enhance creativity.

In addition, a critical characteristic for effective COIs is *flow*, which is participating in intense engagement and learning at the edge of one's competence (Csikszentmihályi 1990; Hakkarainen et al. 2004). Flow is often initiated by a *hacker-like motivation* to excel at innovation beyond the requirements for a job or monetary compensation (Himanen 2001). Raymond (2003) described this as being intrinsically "loyal to excellence" and willing "to explore." Hacker ethic and flow, which may exist as a function of a group rather than an individual (Sawyer 2008), typically emerge in response to intriguing and personally meaningful challenges where community members are given the *autonomy* to self-identify

through inquiry (Engeström 1999), and then assume ownership over solving these problems. As Carmeli et al. (2007) noted, "The extent to which organizations succeed in designing a challenging work environment has a significant influence on creativity" (p. 76). They defined job challenge as including an emphasis on work variety and autonomy support for individual members of the community. In their study of 175 employees and their managers in six (for-profit or public sector) organizations, they found strong positive relationships between task challenge and community identification and creativity. They concluded, "A challenging job augments employee identification with an organization, which in turn, results in creative behavior" (p. 86). While tackling challenging job problems, COI members typically engage in intrapersonal and interpersonal reflection (Hakkarainen et al. 2004; Sawyer 2008) where thay have "productive failure" (Kapur 2006) and learn from past mistakes until true innovation emerges. Bielaczyc et al. (2006) argued that reflection is "crucial to knowledge creation." In the COI framework, this emphasis on flow, hacker ethic, job challenge, and group reflection has been proposed to enable COI members to gain *new knowledge through creating* conceptual and physical artifacts, as well as developing dynamic expertise not solely confined to a particular domain (Hakkarainen et al. 2004).

Research design and questions

The purpose of this study was to examine the actions and perceptions of four graduate instructional design students involved in a design Studio emphasizing collaboration and innovative thinking. We investigated the common incidents, actual and psychological, that participants reported as influencing their innovation. We sought to determine the extent to which a COI framework might clarify the nature of collaborative innovation activities. Our purpose in the current study was to investigate whether and how the COI framework might be used to explain the experiences of participants under the best conditions, not to determine whether the framework could describe the experiences of all members of the community.

Because the research goals were largely exploratory and theory-building, we employed a qualitative case study approach, choosing cases from each of the three courses within an interconnected Studio context. Our specific research questions were:

1. What incidents were most critical to student designers' experiences?
2. Did elements of a Community of Innovation emerge through researcher observation and participants' own descriptions of critical incidents?
3. If so, how did members of this community describe those elements? If not, what did members report might have impeded the development of a COI in this setting?

Methods

Research setting

The design setting (or "Studio") was a required master's-level, three-course sequence focusing on developing skills of instructional design and development, offered to graduate students at a large university in the Southeastern United States. Each Studio course was taught by a different instructor, although they collaboratively determined objectives and strategies. In contrast to lecture-based approaches, instructors typically consulted and

mentored students across courses. During this semester-long study, 12 students enrolled in 6190: Design and Development Tools (focused on learning design technologies), 12 in 6200: Individual Instructional Design Project, (projects developed for clients), and eight in 6210: Group Design Project (larger projects developed for clients). A typical weekly Studio class session began with a whole-group meeting before the student groups divided into their own class sessions.

We purposively chose the Studio because of the emphasis on developing a student community (through required peer critiques, informal social events, project demonstrations, and a requirement that experienced students mentor newer ones and newer students serve as consultants on Studio 6210 projects). In addition, student creativity was encouraged through a Creative Interaction Award, demonstration of past creative projects, and class discussions on creativity in interaction design.

Definition of community

Building from previous work, we operationalized communities according to boundaries [e.g., physical (together in the same space), mental (members self-identify a unifying bond), functional (members are laboring towards the same goal), and emotional (a psychological sense of community)] (Author 2007). Accordingly, we selected the design studio due to the potential influence of physical boundaries (students belonged to the same course, meeting in the same place and time) and mental boundaries (while working on different projects, students had a feeling of working towards similar design end goals). This research sought to additionally determine the influence within this group of emotional bonds and psychological sense of community (Sarason 1974).

Participant selection

Because of the exploratory nature of the study, we sought participants likely to embody the COI characteristics so we could determine whether the framework might be effectively valid under ideal circumstances and so we could learn how to identify the COI principles in practice. If the COI framework described their experiences, future research could be conducted to study participants from a wider variety of backgrounds. We selected four participants that showed the initial likelihood of embodying COI principles by consulting with the course instructors and observing the first few class sessions. Within this framework, we also sought participants with varied prior experiences and perspectives.

The students chosen as case studies were given pseudonyms for this study: Jamie from Studio 6210; Lori from Studio 6200; and Boyd and Robin from Studio 6190 (see Fig. 1).

Data collection strategies

The main sources of data were generated by combining Seidman's (2006) process for conducting phenomenological interviews and Flanagan's (1952) Critical Incident Technique (CIT). Seidman's procedure involves conducting three 90-min interviews: the first focusing on the participants' prior histories, the second collecting descriptive details of the studied experience, and the third co-interpreting the experience.

CIT has been applied to collect and analyze specific incidents that defined a particular experience across multiple participants (Flanagan 1952). An *incident* is defined as "any observable type of human activity which is sufficiently complete in itself to permit

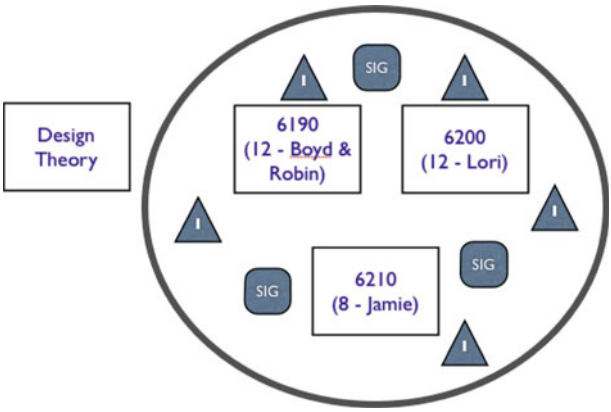

Fig. 1 A visual depiction of the instructional design studio that was the setting for this research. Each *square* represents a course within the community. The "design theory" course was not technically part of the Studio sequence nor was it a focus of this research, but it is shown here because students in 6190 often took the two classes concurrently and discussed how classmates in their design theory course influenced their designs in 6190. "I" represents the instructors and graduate assistants, shown more as floating consultants than direct lecturers, and "SIG" represents the various special interest groups that are often self-organized within the Studio for additional learning. The *numbers in each box* represent the course numbers as well as the number of enrolled students. The *names* represent the pseudonyms of participants selected for this research

inferences and predictions to be made about the person performing the act" (p. 61). The method has since been broadened to encompass psychological and cognitive constructs that impact a person's experience (Butterfield et al. 2005). This shift follows a trend towards using the CIT method for exploration within an "interpretive or phenomenological paradigm" (Chell 1998, p. 51). We adopted Kain's (2004) definition of an incident as any event, characteristic, trait, or perspective that influenced—positively or negatively—the design of the students' projects. Potential incidents included, for example, perceived lack of requisite skills, insufficient time to complete the work, or inability to request help from peers. We also stipulated that the incident make "a contribution, either positively or negatively" to successfully completing their design projects (Gremler 2004, p. 66).

We initially combined Seidman's (2006) interview procedure with CIT by conducting preliminary interviews related to participants' prior Studio experiences, including instructional design, creative thinking, and group project collaborations, as well as expectations for the semester. In lieu of Seidman's second interview, we used CIT to collect extensive data on weekly design experiences by asking participants to record short weekly voice memos describing the critical incidents relative to their project that week. We provided a digital voice recorder for each participant and sent weekly emails prompting them to submit their memos. To triangulate these data we also collected students' written design journals and personally observed weekly Studio sessions. For one participant who provided fewer voice memos, we conducted a second interview to elicit details and identify the incidents important to her project.

We then conducted a final individual interview with each participant near the end of the semester. During this interview, per Seidman's guidelines (2006), we queried for opinions and interpretations of the individuals' design experiences. In all interviews, the approach was semi-structured, allowing us to probe and explore emergent themes and ideas. We audio recorded and transcribed these interviews to document the participants' own words describing their experiences.

Data analysis procedures

Because our goals were to develop theory and to interpret the experiences of participants, grounded theory and related interpretive methodologies were relevant. Since the development of the grounded theory (Glaser and Strauss 1967; Strauss and Corbin 1998), researchers have argued that methods need to be used flexibly to reveal important patterns (Charmaz 2002; Merriam 1998). In this study, we adapted grounded theory analysis techniques as tools rather than strict procedures.

During analysis, we first examined the experiences within each case study as the unit of analysis, then considered broader potential themes for the Studio community at large. We analyzed concurrently with data collection (Merriam 1998) through persistent memoing, maintaining a research journal, and coding the transcripts as we received/completed them. Based on emergent findings, we moved from inductive, data-emergent analysis to deductive, reductionist thinking as we cycled between identifying emerging ideas and developing these ideas into a coherent framework. During initial coding, we used main categories from the COI framework, research questions, and definitions of terms. Within these categories, we used constant comparison techniques to generate subcategories and additional main categories as evidence warranted. After coding a substantial portion of the data, we analyzed the coding structure itself to identify overall patterns and areas of overlap. We then condensed and redefined the categories to consolidate patterns that emerged from the analysis. We continued analyzing and refining codes until all data were examined, then identified examples and narratives to epitomize the derived patterns.

Establishing trustworthiness of results

In qualitative research, emphasis is placed on the researcher's inductive interpretation of the data, including its significance, rather than solely numerical statistics. An effort is then made to present the data to ensure trustworthiness. Using Lincoln and Guba's (1985) criteria for qualitative trustworthiness to establish credibility, transferability, dependability, and confirmability, we were persistent and thorough in our immersion in the setting, observing nearly all of the Studio class sessions and following the class email listserv. We triangulated multiple data sources and methods (observations, interviews, and archival data), and we solicited input on analysis and findings from peers familiar with Studio or the research literature. We asked two independent qualitative researchers to review our coding categories and apply them to sample data, then discussed and compared our codes for the same data and found overall similar results. Discrepancies, usually attributed to limited familiarity of the independent coders with the COI literature, were discussed until mutually resolved. Finally, we shared our findings as well as theoretical and methodological frameworks with experts knowledgeable with the research setting or research topic to assess the veracity of our assertions.

Findings

In this study, after coding all data, we analyzed the code frequencies to determine those trends that were mentioned most frequently. In instances where categories overlapped to the degree that it was not possible to distinguish different trends and patterns, frequencies were combined. Following interpretivistic research traditions, we also considered whether some events held high significance for individual participants independent of the frequency

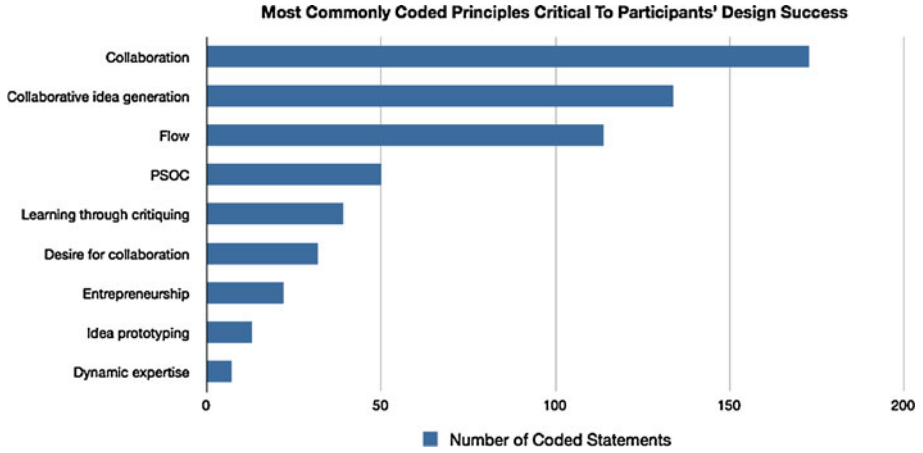

Fig. 2 Summary of the most commonly coded principles critical to the success of the participants' designs within the studio community

of coded responses. This analysis of the most frequently-coded categories across all participants produced the main findings (see Fig. 2), including the emergence of several elements of the Community of Innovation framework in the experiences of the participants: flow and hacker ethic, entrepreneurship, and dynamic expertise. In addition, new themes emerged representing potential new candidates to be considered for the working framework: collaboration and mentoring, sense of community, learning through design criticism, and idea prototyping. Of particular interest, for generating ideas interactive approaches were dominant over non-interactive idea approaches. Finally, some proposed COI elements were not evident in this study. These findings are summarized and interpreted according to the COI framework (see Fig. 3). In reporting these findings, we share the number of total statements coded as representing each pattern. Unless otherwise indicated, these patterns were representative of the experiences of all four participants.

Theorized COI elements supported by the data

Flow

Flow was defined and coded when participants reported being completely engaged to the point of losing consciousness of their surroundings and of time because they reported competence to complete the task, understood the bounds and rules of the activity, and found it personally enjoyable. Participants mostly reported experiences of individual flow (30 statements), which seemed to be enabled by the flexible and agentive nature of the community structure. Additionally, students sometimes discussed an interactive and interdependent kind of flow (12 statements), representative of Sawyer's (2008) theory of group flow.

Robin, who engaged in flow often as she worked on her projects, reflected, "I was kind of working *in that zone* yesterday, and I woke up and I had spent two and a half hours just on Photoshop *playing* with a page to make it *good, or appealing* to me" [emphasis added]. During a project work day, Robin exclaimed, "I could see myself get sucked into playing with this for a while." Boyd also reported flow-like experiences while learning the

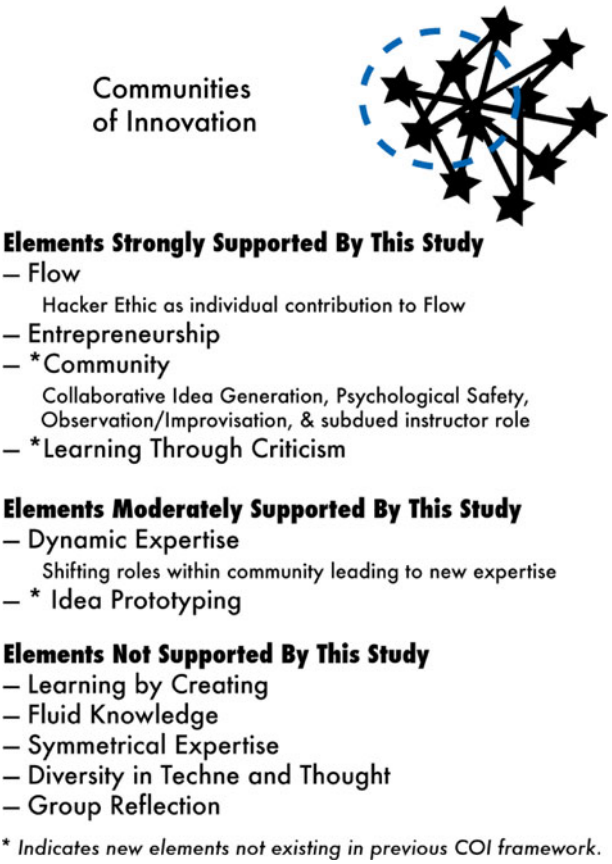

Fig. 3 COI theoretical elements found in the experiences of Studio participants

technologies. "You get lost in the flow… and so that does happen a lot it seems," he said in his final interview. Reflecting on learning computer coding, he stated,

> I'm a dork like that. I like digging into the code and… learning what affects what, and so *I would just get lost in that*. Of course, my job duties suffered because of that, but… (laughter)… that was one time when *I got absorbed in that* [emphasis added].

During interviews Lori and Jamie also indicated flow experiences. Jamie said,

> I think for me it did [happen]…. I was working on the various animations…. There were moments when *I would spend hours on it and not realize that it was actually hours* [emphasis added] that I was spending on it. So, there were… quite a few times that I experienced that.

Similarly, Lori said,

> It probably happens to me a lot more than it happens to some others because I'm pretty much at it all day…. So… *all of a sudden, you look up at the clock and you're like, oh, I missed lunch*. It's almost dinner time.

Jamie, a member of a 6210 team working on a group project with three other students, experienced some situations of group flow, particularly as the group discussed and

improvised on possible ideas for the main design of their project. While not working with an assigned team, Robin and Boyd also reported group flow in their individual projects as they gave or received desk critiques from other Studio members. Robin identified where conversations engaged multiple people in solving a design problem: "It was just other people's ideas that kept on bouncing and bouncing and bouncing and bouncing."

Hacker ethic

Hacker ethic was evident when participants described work as interesting or playful, indicating that it involved high levels of enthusiasm or was completed because of a desire for quality or satisfaction rather than a grade. Although it is similar to the concept of flow, we define hacker ethic separately. Based on published literature and this research, flow was defined as an experience that happens *to* people engaged in design, whereas hacker ethic *is* an individual persistence and motivation that a person brings to an experience. Although participants often indicated both flow and hacker ethic simultaneously, data in this study coded by separate coders supported this distinction.

All four participants described a hacker ethic for learning the skills needed to complete high quality projects, although Jamie did so less frequently (six coded statements compared with an average of 22 statements for each of the other three). Robin and Boyd described being highly motivated by the freedom to select their own project and referred to their instructor's advice to choose projects based on "passion," "entertainment," or personal importance and "not just for a grade." Among three possible projects, Robin selected the one that was the most personally meaningful, which propelled her to overcome her fear of learning Photoshop. "I am ready now to break that fear… to make something… meaningful," she said. Her hacker ethic led her to become so immersed in Photoshop that she experienced flow and lost sleep, tackled advanced features outside of her learning contract, and became preoccupied with the software: "Photoshop has consumed my life," she admitted.

Likewise, Lori and Boyd chose to go beyond project requirements. Lori stated, "After careful consideration, I have decided to create more work for myself!" Boyd explained, "I'm considering doing some video. Even though that wasn't part of my contract, I think it would just kind of help round out the site." Boyd explained, "I'm considering doing some video. Even though that wasn't part of my contract, I think it would just kind of help round out the site." He also noted, "getting caught up in the tiniest of details" in his quest for high quality in his project. Jamie reported similar desires when working on her favorite part of the group project—the graphic design of the main project screen—and said she was very excited about that aspect of the project ("I can't wait to see the progress") and wanted it to look "more professional."

Entrepreneurship and autonomy

Entrepreneurship/autonomy was evident when participants reported the ability to make their own design choices and take personal responsibility for those choices. In total, 22 statements were coded with this theme. All participants reported that Studio encouraged innovation by providing autonomy in selecting and designing their projects. Boyd remarked, "[Studio] lets you have your own goals not compared to somebody else" and "they really give you free reign" over tools, learning design/theory, etc. He continued, "Really the only thing that can impede you… would just be your own limitations." Robin agreed that autonomy fostered creativity: "The fact that everybody was working on something totally different allowed you to… be creative with what you were doing." Jamie explained that

because her team "had the liberty to basically do what we wanted, it helped… foster creativity." Boyd stated that the Studio structure provided a "safety net" for students to fail, but it was "up to you between Point A and Point B to use that time wisely to create." However, Boyd ("I've spent a great deal of time mulling over the design"), Lori ("[I'm] in a state of confusion"), and Robin ("paralysis caused by a lack of plan") also struggled to manage individual autonomy while envisioning how to produce their project. This may indicate a need within a COI to scaffold or provide boundaries for new designers to define projects while affording them freedom over how to execute their ideas.

Dynamic expertise

The proposed COI element dynamic expertise generated limited supporting evidence. Typically, researchers have characterized expertise as becoming "outstanding" at accomplishing a particular task (see, for example, Ericsson and Smith 1991). Hakkarainen et al. (2004) noted that many studies on expertise have been cross-sectional, measuring expertise by presenting problems that were challenging for novices but easy for experts, indicating that expertise involves the ability to solve some problems routinely. However, in dynamic organizations like COIs, both expertise and the problems to be solved are fluid. Expertise in COIs, may be most evident in progressively pushing the edge of competence to solve new and challenging problems: to "be able to continuously expand one's current cognitive competencies" (Hakkarainen et al. 2004, p. 37).

In the current study, dynamic expertise was coded only seven times, when participants indicated gaining new expertise in unfamiliar areas or adapting previous expertise to fit new situations. For example, Robin entered Studio with some design and technology skills (Dreamweaver and PowerPoint, for example), but the nature of her project required that she gain expertise in new areas that she later demonstrated in an award-winning project. The remaining participants, however, only presented limited evidence for this theme.

New candidate COI principles supported by the data

Our analysis also indicated several candidate principles critical to emerging collaborative innovation. Other scholars have discussed these ideas and so they were not necessarily unexpected. Evidence from this study indicated that these elements might be included in future research on the COI framework.

Collaboration and mentoring

Collaboration, defined as repeated interactions focused on achieving a goal such as developing a project component or learning new skills, was evident in 173 comments. While the working COI framework emphasized innovation within a community structure, it did not specify the directness and collaborative nature of these interactions. In contrast, other scholars have noted that close proximity to others enables more effective collaboration leading to innovation (Kraut et al. 2002), and that innovations flow from building communities (Hargadon 2003). Thus, the COI framework may require revision to include collaboration and mentoring.

All four participants reported that collaboration was crucial to developing or refining their projects, although they defined collaboration differently and benefited from different

collaborative relationships. Overall, participants indicated a desire for even more collaboration (32 statements). Although participants reported being very comfortable with Internet technologies and two resided a significant distance from the university, only Lori indicated collaborating on the Internet, while the others strongly preferred face-to-face collaborations.

Some of the reported collaborations involved occasional interactions with other community members that either contradicted or reinforced a particular decision or gave emotional support for a chosen action. Among these 34 minor interactions, Boyd explained that while the required desk critiques given by peers in the class often did not provide new ideas, they motivated him to continue in his chosen direction: "A lot of times… I was thinking about doing that anyway. Somebody else just validated that I probably should go that direction." Similarly, while Jamie did not initially like her design for her group project's main screen, "I sent the design to the rest of the team, and they seemed to like it a lot, so maybe I just needed to take a break from it to see its true beauty." She decided to keep that design.

On occasion, however, the participants identified dedicated, consistent, and one-on-one collaborations that were coded as mentoring (30 statements). All participants reported some mentoring, usually to support their technical skill development. Lori, who had a dedicated mentor, reported, "I got a tremendous amount of help from [her]." Lori was also mentored outside of Studio: "I had a lot of trouble with my layout, until I got help… through my mentor and a friend who is a Web designer."

Interactive idea generation

Many scholars have surmised that ideas are more likely to develop from interactions rather than individual genius (Hargadon 2003; Sawyer 2008), and our research provided evidence for this hypothesis. When participants mentioned a new idea, we coded the idea as having originated from the participants themselves, through interactions with others, or from materials such as textbooks or tutorials. In general, participants received ideas through interactions with others. Most were stimulated by other Studio members (134 coded statements, see Fig. 4), but some were from outside Studio connections (37 statements). Participants gained ideas from assigned textbooks (eight statements), from searching on the Internet (41 statements), and occasionally from their own cognition (11 statements); however they reported that most ideas were generated interactively. This suggests that the creativity within the Studio setting was distributed throughout the Studio group, as well as through networks outside of Studio, and that ideas most often emerged through interactions with these networks.

Ideas from Studio members

Students frequently mentioned receiving ideas from their peers, instructors, and clients within the Studio community. Some ideas were related to understanding technical issues and learning new technologies, but most were related to minor design changes, usability issues, and aesthetic improvements. Robin eventually changed the entire template for her project because Boyd, in a desk critique, questioned the viability of her previous design. In return, Robin and others offered ideas to Boyd about adding interactive elements to his Web site and improving his font and color choices. Boyd noted,

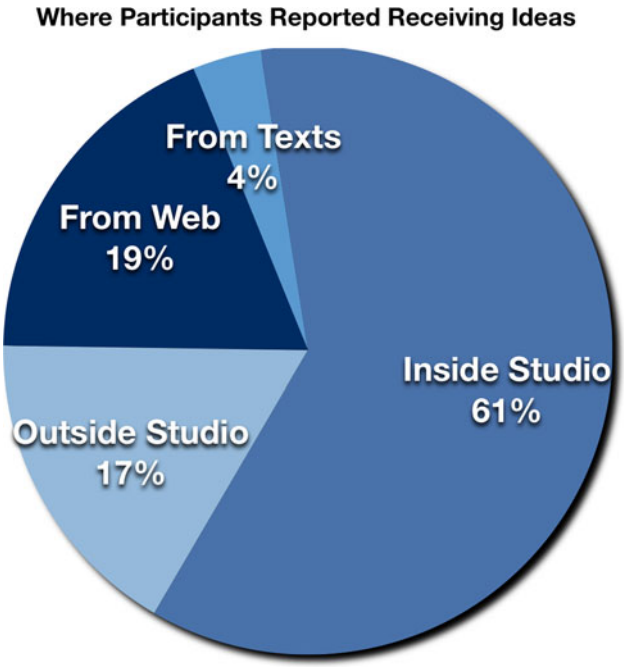

Fig. 4 Summary of where participants reported receiving ideas

> I received some really great feedback,… which led directly to changes in… colors, background, content, and also [other] great ideas that I'm going to work on this weekend…. I think that every comment has enhanced both the design and usability of my site.

Jamie received ideas from peers about the appearance of her project, including the placement of pictures and animations, and Lori mentioned receiving advice on her animated guide as well as ideas from a studio peer's public design journal.

Participants also received ideas from peers to improve their entire project design. Robin explained that when working on her own, it was "minor stuff," but when she went to Studio "[I] knew I was going to get probably an idea." She described being able to brainstorm ideas regarding her own and others' projects:

> You would throw out a pebble, and like ripples other people would… come back and say, "Well, what about this?"… Somebody's going to have an opinion about something. They… don't just think it looks nice. They're going to talk about it… a little bit more in depth.

Robin noted that this made Studio "more creative for me." Similarly, Lori identified major direction shifts for her project through ideas generated during collaborative discussions with both a friend and her Studio instructor. Boyd indicated receiving important design ideas from peers for the content and structure of his project. He reflected,

> [Studio] participants begin to see that self-directed learning is not about "going it alone," but instead about making choices… [from] social learning activities with peers and instructors. A lot of my decisions regarding project changes and contents

> have been born out of social episodes of criticism [desk critiques] and review [dress rehearsal].

Ideas from outside Studio

To varying degrees, participants also drew on input from friends, family, and even strangers outside of Studio. For Robin, Boyd, and Jamie, the feedback was usually minor, although Jamie recalled receiving "a lot of input from friends just to find out like how does this look? What do you think? Is this needed?" Lori received the most ideas from her out-of-Studio network. To overcome technical and design hurdles, she often asked for assistance from individuals with specific expertise, including a neighbor with expertise in information technology and friends with expertise in instructional design and Web development. She also sought advice from people she had never previously met with whom she communicated on the Internet (through email, Twitter, and other networks). For example, she was rescued at one time when she said she "was just pulling my hair out" over a technical hurdle:

> So I just put a question out to Twitter… and like five people replied back within five minutes. And one guy was just like, add me to your Skype, I'll walk you exactly through what you need to do. And sure enough it was fixed in like 10 minutes.

Lori's reliance on her out-of-Studio network for new ideas likely emerged because she had established a personal network through previous work projects. Thus it was natural to seek support from her personal network.

Sense of community

Rogers (1954) suggested that creativity was supported by a psychological sense of community (PSOC). He defined sense of community as acceptance of the individual, a lack of external evaluation, and empathetic understanding. In our data, evidence for a strong sense of community was coded a total of 50 times. Although collaboration could be another indication of the strength of a community, collaborative events were coded separately to permit analysis of those interactions.

Robin and Boyd noted a greater sense of community than did Jamie and Lori. As Robin explained, "The Studio created a safe environment of camaraderie that allowed you to open up your projects for review and criticism and not feel anxious about being shut down." Robin described being able to relate to other Studio members and "talk and vent with other people who are going through the same process." She described how Studio "encouraged the idea [that you] should look at other people's work and see what they're doing and maybe help them if they're stumped to come up with some ideas." Similarly, Boyd reported, "Everybody knows what everybody else is going through, and everybody else knows that we can rely on each other for help. That's understood almost implicitly from the beginning." Boyd noted that the Studio community particularly supported innovative thinking: "It forces people… like myself… to step out of the box a little and start thinking in different ways about how to do things." In Studio, Boyd noted the trust needed for effective design feedback, stating, "It's hard to separate yourself from the artifact." But he continued,

> Once you become comfortable with that process and can separate some of the emotion from it, then I think you realize there is a greater community of people

involved even though this is a self-organized learning environment. The "we're all in it together" mentality begins to take shape, and that community becomes a readily available resource of support.

Lori and Jamie both reported negative feelings about the Studio community, although their actions at times seemingly contradicted their perceptions. Lori, for example, reported her experience in Studio 6190 in the summer as "cliquey," and her concerns over bothering other students deterred her from seeking help. However, this condition may have been partially due to Studio 6190 being the first of the three Studio courses and being more compacted over summer term. Similarly, Jamie remarked that while she had perceived herself as being part of the Studio community in the past when she had worked on individual projects, "With a group project it's kind of like you're detached from everything else that's going on in the Studio." Although both reported this lack of community, Lori and Jamie each sought and received help within Studio that proved critical to their projects. Thus their sense of community may have been stronger in practice than they perceived or reported.

Learning through critiquing

Learning through critiquing, coded 39 times, was evident when participants described learning or gaining insights from the peer feedback process or from evaluating others' designs. For example, during a discussion of a friend's prototype, Lori contributed advice that caused her to reflect on her own project: "In just some of the things I suggested to her I was like—wait a minute, I could be doing that for my project."

Boyd reflected that learning in Studio was effective because of the engagement and interactivity:
We are learning by making, interacting, evaluating, etc. We are not just listening to someone lecture every week and digesting that information. We are creating our own products and helping others with their process as well. A very dynamic system.

Boyd reported looking forward to the end-of-semester showcase to engage in design discussions. Robyn wrote in her design journal that she planned "to search through colleagues' pages as well as other Web sites to try to figure out the design of my page." She quoted Nelson and Stolterman (2002), "It is also possible to develop design skills by critiquing existing designs" (p. 217).

Idea prototyping

Several scholars identified prototyping as a key to innovation. Schrage (2000) stated, "the ability to manage prototypes creatively becomes synonymous with effectively managing innovation" (p. 33), Thomke (2001) reported that prototyping radically effected the development of design-related knowledge. In our study, participants described prototyping as an important method to facilitate idea generation through observation and improvisation. However, evidence for this COI element was tentative (13 coded statements), perhaps due to the short nature of the one-semester experience which limited prototyping opportunities. This concept is supported by models of rapid prototyping, which is an approach to design that emphasizes a "rapid, iterative series of tryout and revision cycles… until an acceptable version is created" (Baek et al. 2008, p. 660). Whereas rapid prototyping often involves

user testing, this study indicated that it was also necessary to engage members of a COI in developing innovative ideas. Participants suggested that prototyping might be most influential when it begins early in the design process and when it facilitates one-on-one or small-group discussions about the prototype.

Challenges to implementing a COI

Several challenges to implementing a Community of Innovation in an educational setting were evident: Lack of time and focus on tasks, lack of prerequisite skills, and superficial collaboration outside of peer groups.

Lack of time forcing a focus on tasks instead of innovation

The lack of sufficient time to cultivate the community, in part due to course requirements and the academic calendar schedule, often caused the participants to focus on completing tasks rather than cultivating innovation. Time pressures and slow turnaround times from clients limited participation in the Studio community and opportunities to pursue innovative ideas.

Lack of prerequisite technology skills

Students also identified limited technology skills as a challenge, particularly Boyd and Lori, who identified innovative ideas but were not able to implement them. Thus while Hakkarainen et al. (2004) noted the importance of dynamic expertise that is adaptable to changing problems, in the current context of technology skills domain-specific expertise may be prerequisite to innovative collaboration and improvisation.

Collaboration only within small peer groups

Participants reported receiving ideas, social support, and feedback from peers, but much of this support was superficial unless offered by a member of their close peer group. Lori, who described working closely with a dedicated and skilled mentor, reported almost no collaborations with anyone else. Robin and Boyd formed a group with Studio friends who provided quality feedback and support. Like Lori, however, they collaborated little with anyone else. Jamie worked closely with her immediate team but reported few interactions beyond her team. Thus COI support and collaboration may influence innovation mainly among members of local, helpful community peer groups. If so, connecting community members with "innovation champions" (Coakes and Smith 2007) or developing expert networks (Hakkarainen et al. 2004) may prove especially important.

Limitations and implications of the study

Because this study was exploratory and interpretive, there were several limitations related to the theoretical constructs and the research methodology. Also there are important implications that warrant future study.

Theoretical limitations

In the past, the constructs under study, including innovation, have proven difficult to define and operationalize. Thus in the present study, supporting claims about the "innovativeness" of ideas being generated and refined proved difficult. Similarly, there were concerns over some of the defined categories, such as flow, hacker ethic, community, and others, which may have influenced some of the lack of support for a few of the COI elements. Finally, it proved difficult to distinguish the influence of individual versus group contributions on innovation. This was particularly challenging in identifying the influence of the course instructors on the students' innovativeness.

Methodological limitations

Transferability of the findings is limited by the minimal diversity in the sample and the fact that we purposefully recruited participants who likely would be successful COI members. Of the four case studies, three were women and three were Caucasian-Americans, and all participants were relatively young (under 40).

Implications for future research

The study was an initial attempt to clarify and operationalize the attributes of the COI framework. Support for some components was apparent in this study, but several unanswered questions remain.

What is the nature of group flow and how can it be developed?

Sawyer (2008) posited that group flow is a precursor to group innovation. Although common across participants, flow was usually manifest individually rather than within groups. Future research is needed to investigate the differences between individual and group flow, articulate their common and unique characteristics, and identify what influences flow among individuals versus groups. To address these questions, conversation analysis—a methodology designed to rigorously capture routine, everyday activities occurring in naturalistic settings in a manner that is reproducible and defensible (Psathas 1995)—might provide a useful approach. This methodology typically involves analysis of verbatim transcripts, but it could be extended to the analysis of video recordings. Researchers could apply approaches of conversation analysis to verbal and nonverbal interactions in order to identify specific patterns in the interactions and environment that promote group flow and help document when individual and/or group flow occurs.

How do COI designers balance structure and scaffolding with autonomy?

Future research is needed to investigate an effective balance between structure and scaffolding, especially for novices, and the autonomy needed to promote innovation. Quasi-experimental studies with control and experimental groups might help account for varying levels of scaffolding and structure. Results could be compared according to expert judgments of the innovativeness of the final products or via a metric such as the Torrance Test for Creative Thinking (TTCT) (Kim 2007) or a similar measure of divergent thinking (Runco 1993). Complementary qualitative methods could be used to describe the

scaffolding found to be most effective and to examine how participants perceived, used, experienced, and benefited from this scaffolding.

What is the nature of the community within a COI?

This study examined the potential influence of different community boundaries, including how participants generated ideas, perceived psychological safety within the Studio, and observed and improvised on the ideas shared. While the findings provided some insights, research is needed to characterize the nature of a COI community and its similarities to and differences from other communities, such as learning communities and Community of Practice. Since some evidence of creativity seemed to flow through out-of-Studio networks, it is unclear whether students considered the Studio their design community or identified more, psychologically, with outside design collaborators. These issues could be examined via social network analysis (Wasserman and Faust 1994) to quantify the strength of communicative links between different persons to develop a more inclusive assessment of collaborative patterns and the key individuals within different communities. This methodology could also help to identify and detail patterns of collaboration, interaction, and knowledge flow in innovation communities (Dahlander and Wallin 2006).

How are knowledge and expertise acquired in a COI?

This study provided tentative findings related to how innovation develops through the peer critiquing process and how dynamic expertise influences innovation. However, research is needed to verify and extend this understanding. Several approaches may prove useful. Additional case study methods along with video/conversation analysis could document how dynamic expertise is developed, relying on a combination of critical incident recall and close researcher observation with a small participant sample.

What is the value of COIs?

A significant, and largely unanswered, question concerns whether COIs stimulate time-tested innovation more or less than other social structures. Again, mixed-methods research may be useful in addressing this overarching question. Historical approaches can be used to first identify major innovative ideas in order to retrace emergence over time using archival data concerning the social structure surrounding the innovation. Experts could review the products generated by a COI in order to contrast them with artifacts from other communities to analyze the contributions of group ideas to assess fluency, originality, elaboration, abstraction, and resistance to closure for group versus individual ideas.

Conclusions: reexamining the formative COI framework

In this study, we employed a formative Communities of Innovation framework to describe the innovative potential of adult groups. Not all of the theorized COI elements were evident in the data. Findings included evidence for some aspects of the proposed COI model (flow and hacker ethic, entrepreneurship, collaboration and mentoring, sense of community, and learning through design criticism), moderate support for others (dynamic expertise and idea prototyping), and no evidence in this context to support other proposed

components (developing adaptable knowledge and expertise, symmetrical expertise within the community, community reflection, shifting interpersonal roles, or benefiting from cultural/educational/skill/other diversity). This distinction is helpful for designing and researching COIs, as it creates priorities for emphasizing specific elements in a given community.

In addition, we found that the majority of the new ideas identified and shared by participants were developed in part through interactions with others (77% of reported ideas). Our findings regarding the interactive nature of idea generation appear to support Sawyer and DeZutter's (2009) theory of distributed creativity, which describes distributed creativity as comparable to the *social cognition* branch of distributed cognition (Moore and Rocklin 1998). Sawyer and DeZutter wrote that collaborative emergence, or the unpredictable and unexpected emergence, of distributed creativity occurs when activities have unpredictable outcomes; interdependency exists within the group such that a person's actions are influenced and constrained by the actions of others; and collaboration (equal member contribution) is fostered. Future research needs to extend self-report data to characterize how distributed creative thinking emerges within a community and which community structures and constraints affect creative thinking.

Greeno (1997) noted that our instructional institutions need to understand "which combinations and sequences of learning activities will prepare students best for the kinds of participation in social practices that we value most" (p. 9). Because collaborative innovation is emerging as a crucial characteristic of successful workers (Banahan and Playfoot 2004; Ogunleye 2006) as well as an effective form of learning (Barrett 1998; Turvey 2006), understanding how collaborative creativity can be successfully fostered in higher education communities has always been critical, but has now become paramount in educating future citizens.

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