



Completely online group formation and development: small groups as socio-technical systems

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Abstract

Purpose – This paper has two purposes. First, to provide insight into the formation of completely online small groups, paying special attention to how their work practices develop, and how they form identity. Second, to pursue conceptual development of a more multi-level view of completely online group experience, which can be made visible through analysis of the unique interaction logging system used in this study.

Design/methodology/approach – The authors conduct a mixed methods study that integrates interviews, grounded theory analysis, case study methods and social network analysis to build a multi-layered view of completely online group and community development.

Findings – Completely online group formation is explicated as a socio-technical system. The paper identifies themes of tool uptake and use, and patterns of interaction that accompany group formation and development of completely online group practices. These patterns show little respect for the boundaries of space and time. It then shows how groups who are paired together for two non-sequential activities develop a common internal structural arrangement in the second activity, and are viewable as groups in the larger course context in four of six cases.

Research limitations/implications – The time bounded nature of the group and community, combined with the educational context limit the generalizability of these findings.

Practical implications – The study shows how completely online group development can be made visible. Managers of work teams and teachers who work with classrooms in completely online contexts need to recognize the dynamic structure and interaction practices of completely online teams.

Originality/value – First, little research has been conducted on completely online group formation. Second, a conceptual understanding of how group members relate to one another and how groups interact with other groups in the same socio-technical context is not explored in prior work. Third, the paper performs this analysis including data from rich, contextualized usage logs, which enables greater insight into online group interactivity than prior research.

Keywords Sociotechnical change, Communities, Social capital, Human capital, Team working

Paper type Research paper



1. Introduction

Small groups are powerful engines for getting work done. When small work groups are formed, members must get to know each other, make sense of their tasks and coordinate task progress and completion. Completely online small groups may never meet face to face. And this means they face at least two unique challenges when they are starting out. First, no technology available today recreates the experience of a shared, physical work space (Heath and Luff, 1992; Teasley *et al.*, 2002; Birnholtz *et al.*, 2007). Second, when completely online groups form, members must make sense of available technology, each other and the work at hand simultaneously (Laffey *et al.*, 2006). In this study we describe how one small group meets this challenge in the context of a completely online graduate level software design course. We then compare the evolution of interaction patterns for that group with other groups assigned the same tasks and using the same tools. Our comparisons make group development in a completely online context visible, and the deep case study informs our analysis of the common patterns that emerge from the data.

By describing patterns of completely online group formation and development we illustrate the smallest and arguably most productive social unit in a new form of organization; those built through distributed and networked connections instead of physical co-location. Such virtual group behavior is hard to anticipate or identify in many prominent settings like Facebook, but occurs with some regularity in online graduate level courses, where the diversity of member experience and background is similar to what we find in virtual work groups. Prior studies of virtual work group formation describe patterns of high early expectations, followed by the cyclical movement between individual and group identity oriented behaviors, similar to studies of physically co-located groups (Smith, 2005).

While studies of online learning groups offer a window into patterns of group formation, sustained evolution of group work practices in virtual organizations are studied in a range of traditional organizational contexts and newer, more technologically mediated organizational forms. Watson-Manheim *et al.* (2002) explore the nature of virtual work as an array of continuities and discontinuities across time, space, organization and culture, referencing online learning groups as one example. Lamb *et al.* (2003) conclude that external contingencies are a prime driver of ICT uptake and use within firms, further noting that, in the absence of such external contingencies, managers tend to gather only data that supports their decisions. Elliott and Scacchi (2008) present an extensive virtual ethnography of free and open source software as a social movement whose goal is no less than the institutionalization of a new social order through computerization. Socio-technical examinations of Wikipedia consistently highlight the disciplined practices that evolve in this virtual space (Kittur, Chi, Pendleton, Suh and Mytkowicz, 2007; Kittur, Suh, Pendleton and Chi, 2007; Priedhorsky *et al.*, 2007; Kittur and Kraut, 2008). Each of these examples explicates depth and variance in the emergence of organizational practices in specific socio-technical contexts.

In spite of this extensive study, organizations of all kinds maintain a strong preference for collocation over virtualization (Kiesler *et al.*, 2005). Kling and Courtright (2003, 2004) note the rarity of community formation in completely online settings. Powell *et al.* (2004) describe 47 studies examining virtual work teams, which individually and collectively do not build a clear picture of how virtual organizations

might work most effectively. Group formation online has been predominantly studied in the aforementioned contexts like Wikipedia or FOSS, where there is a task orientation, or in online social networks, where there is a social-emotional orientation (Adamic and Adar, 2005; Backstrom *et al.*, 2008; Lazer *et al.*, 2009). This research is exciting because it explains new forms of socio-technical organization; but it does not address the more common situation where new technologies influence existing modes of organization.

We work to close this gap by describing completely online group formation where such phenomena presently exist, while drawing on literature from communities of practice (Wenger, 1998) and small group development (McGrath, 1984; Mcgrath, 1991; McGrath and Hollingshead, 1993; Arrow *et al.*, 2000; McGrath *et al.*, 2000), which describe how organizational and group practices emerge and are reified. We present a single, revelatory case study analysis of one group, showing how they simultaneously make sense of their work, each other and collaborative technology (Yin, 2009). We then analyze the unique, bi-directional interaction logs produced by the collaborative technology the groups work in (explained in section 3) using time-sliced social network analysis. The changes in network structure within and between groups in this course reinforce our findings from the case study, and reveal that patterns of completely online group formation and development can be made visible.

1.1 Purpose of study: completely online groups as socio-technical systems on two levels

The purpose of this paper is to provide a detailed explication of how groups cooperate and develop characteristics of community as described by Wenger in a tool facilitated, virtual environment. The first focus of this case study is one small group assigned to work together in the context of an online graduate school course. The second focus is the online graduate student course community. This setting is chosen because the duration of engagement, tasks and expectations are stable, which allows us to focus our examination on the effect of tools on the undertaking and completion of tasks, and the corresponding formation of group identity and community. We describe how member cooperation evolves into a shared repertoire, which includes tools as a salient dimension of the community itself.

1.2 Research questions

The three research questions that guide this work are:

- RQ1.* How do members of a small group experience cooperation in a completely online environment?
- RQ2.* How do members of a small group participate in completely online communities?
- RQ3.* How and to what extent are the experiences of a small cooperative group, and other groups in the same context, revealed through analysis of the social structure derived from bi-directional (read and post) trace data?

The rest of this paper has the following structure: In section 2 we discuss theories of community and group formation. In section three we describe the context of this study, the participants and the research methods. Results are presented in sections 4 and 5. Section 6 includes discussion and directions for further research.

2. Theoretical framework

Our work is framed in theories that help us to be clear about often confused units of analysis like “group”, “community” and “network”. Our central theoretical waypoints in this regard are Brown and Duguid (1991), Wenger (1998) and Rohde *et al.* (2004). In Table I the high level perspectives of each theory for each type of social aggregation are shown. In the remainder of this section we elaborate on each theory, and related theories to provide a thorough overview of how our work was guided.

2.1 Social theory of learning

Recent theoretical analysis by Stahl (2006) suggests that small groups of 3 to 5 are “where the action is” for understanding online group cooperation. Stahl points out the need to develop a theory of mediated cooperation through a design based research agenda of analysis of small group cognition. Stahl’s focus on small group cognition in online cooperation is compelling, as it extends existing notions of organic systems of knowing, as suggested by Hutchins (1995). A socially grounded theory of group behavior in general is posited by Wenger (Lave and Wegner, 1991; Wenger, 1998), who observes that practice is the construction of meaning in everyday life, and that our understanding of that meaning construction in any context – online or in person – must reconcile the duality of established protocols (what Wenger references as reification) with the participation of actors who apply and transform those protocols in the context of community. These systems are, in Wenger’s theory, dynamic and social.

What makes communities function well in the physical world is some combination of mutual engagement, joint enterprise and shared repertoire (Brown and Duguid, 1991; Wenger, 1998). The challenge of community formation in a virtual world includes these same dimensions, as well as new challenges. These challenges are the same as those faced by online cooperative work in general, most notably the context poor nature of the tools used. Social awareness in an online environment makes mutual engagement in general more likely, and the sort of rebelliousness that can demonstrate commitment to community possible. Similarly, Wenger’s notion of joint enterprise can be managed or assigned in most online cooperative environments with great efficiency, and is therefore more readily manufactured in the virtual world than it is in the physical world.

	Brown and Duguid (1991)	Wenger (1998)	Rohde <i>et al.</i> (2004)
Groups	Canonical. Individual and assigned	Exist within communities of practice	Task oriented
Communities	Non-canonical	Progression from legitimate periphery to full participation. “Reification of practice”.	Shared culture
Networks	Amorphous	Legitimate periphery	Lower barriers to membership, compared with community. Fewer rules, compared with community

Table I.
Central theoretical
influences

Shared repertoire is the socially negotiated component of a community of practice, and in a completely online setting, is therefore highly dependent on the types of tools available for interaction. In a shared physical setting, this includes the ability to work through many different problems at once, taking advantage of the richness of verbal and non-verbal communication people use when situated around the same table.

Wenger describes the effect of communities of practice on individual identity. There is a powerful set of dynamics at play between the individuals who belong to communities, how those individuals participate (or “non-participate”) in those communities, the negotiation of identity within the context of a particular community and the juxtaposition of membership in different communities with an individual’s identity. Participation in a community and contribution to the reification of different aspects of that community affect individual identity, and vice versa. As members take up and use ICTs in one context, they develop a set of practices that influence their use of those ICTs in future online contexts. The development of community and identity in completely online groups incorporates constraints of the present tools, tasks and people with practices that may have been developed elsewhere. The notion of an online group incorporates social and technical dimensions. Social theories like Wenger’s must, then, be revisited for the socio-technical landscape.

2.2 Groups and communities of practice

There are two challenges when studying online, collaborative learning groups. First, the definition and continuum between group and community is neither clear nor consistently applied. Second, there is wide variation in the meaning of “online”. Regarding the first challenge, we agree with Kling and Courtright (2003, 2004), who argue there is extensive misuse of the term community by researchers examining online behavior. Frequently, community is used as an aspirational construct or without consideration of the criteria for identifying community, like those outlined by Brint (2001). At the same time, completely online small groups display characteristics described in Wenger’s (1998) explication of communities of practice, such as the reification of practices, shared repertoire and mutual engagement, which makes CoP an important and relevant framework for the study of group formation and development. As a matter of definition, McGrath’s (Mcgrath, 1991; McGrath and Hollingshead, 1993) enumeration of the purposes of small groups: meeting member needs, sustaining the group and completing group work, surely apply. From this core definition of the small group hundreds of studies using different methodological and theoretical foundations emerge.

Powell *et al.* (2004) reviews 47 studies of virtual teams, concluding that the development of such virtual teams is complex, multivalent and in need of extensive additional study to determine how to design social and technical mechanisms leading to successful virtual teams. McGrath *et al.* (2000), speaking of group research more generally, observed that after over 100 years of investigation of small groups in social psychology, we still know very little about the antecedents to highly effective and cohesive groups; and, surely, more phenomenological studies of small groups are needed. More recently, small groups have begun to be characterized as small, complex systems (Arrow *et al.*, 2000). This framing enables researchers to recognize and address the challenges of connecting laboratory experiments to real world phenomena, but it also further blurs the boundary between small groups and the communities

within which they are inevitably situated. Our incorporation of theories of communities with theories of small groups reflect the diminished parsimony of these two theories in a completely online environment.

The second challenge to the study of online, collaborative learning groups is the wide variation in the meaning of words like “online” and “computer supported collaborative learning”. In some studies online groups occasionally gather in face-to-face settings (Johnson *et al.*, 2002; Michinov *et al.*, 2004; Cress *et al.*, 2005; Cho *et al.*, 2007; Michinov and Michinov, 2007, 2008) and in other studies the groups are framed as geographically distributed subgroups (Cadima *et al.*, 2010). Examination of the completely online case is rare (Goggins *et al.*, 2010a; Goggins and Erdelez, 2010). Variations in socio-technical context are widely understood to have a material effect on group experience (Dourish, 2004; Nardi, 2010), but consideration of these effects is glossed over in much work that examines these different constructions of “online group”. These social, technical and methodological challenges are addressed in a handful of previous studies.

Blanchard and Markus (2002) examine community formation and practice in a virtual community, finding that, as with physically connected communities, virtual sense of community is enhanced by mutual recognition among members, informational and socioemotional support and identification with the community. In virtual communities, however, their research suggests that identification and recognition of individual group members is actually more important to sustaining the community than the items related to the sense of community that members report.

Sense of community is an aspect of the social nature of online learning explicated by Laffey *et al.* (2006), who specify the construct of “social ability” in an online setting as “the person’s capacity to associate with fellows and use the members, resources and tools of the social context to achieve something of value”. They further identify social presence and social navigation as critical determinants of social ability. Social navigation is the awareness of what others are doing combined with the subsequent use of that awareness information to make choices about how and when to participate in an online community (Laffey and Group, 2005; Laffey *et al.*, 2006). Laffey *et al.*’s notion of social ability and its critical determinants of social presence and social navigation help to explain how relations are built in an online learning community.

Blanchard and Markus’s examination of a less time-bound and thus less canonical community also suggests that community emerges in the virtual world more through the explicit relations between individuals than in the more difficult to discern legitimate peripheral participation (Lave and Wenger, 1991) of physically bound COPs or NOPs. Rohde *et al.* (2004) contrasts COPs with NOPs by characterizing NOPs as more amorphous, having lower barriers to membership and fewer coordinative rules. The online aspect of the community in their study does not allow access by members of other schools in the university or faculty. The closed nature of the community increases the social capital among group members; consistent with Coleman’s (1988) observation that social capital rises within a group when membership is restricted.

As the world becomes increasingly virtual, the likelihood of needing to develop and maintain virtual relationships with individuals whom one has never met and likely will never meet goes up. At the same time, human expectations about what is required to form satisfying community membership in an online setting seems remarkably unvaried from expectations people have for a more physically bounded community. These expectations

create an opportunity for disappointment in online cooperative work, and impedance to the development of tool-facilitated (virtual) communities. They also create opportunity for new forms of community to emerge around the uptake and use of these tools.

2.3 Summary

Groups represent a more canonical, task oriented and identifiably bounded combination of people than communities, which are characterized by Wenger as having the distinguishing features of mutual engagement, joint enterprise and shared repertoire among members. Communities represent a less explicitly defined set of norms than groups.

Online learning and work environments embody some aspects of groups, insofar as these groupings are typically made by management or instructor decree. Online learning and work environments also embody the characteristics of what the literature understands as community, insofar as a pattern of mutual engagement, joint enterprise and shared repertoire evolves among participants as they move from group to group within a common toolset or “virtual world”.

In this study we present the case of one small group emerging through the uptake and use of technology in an online learning setting at two levels of analysis. First, we describe the participation, cooperation and group identity formation in a small online group during the course of a time-bounded set of cooperative activities. Second, we describe the structure, development and evolution of the online community within which the group is situated.

In this study, online tools that are common, including Skype, Skype chat, discussion boards and wikis, mediate member participation. All participants in this study post intermediate work products to a shared file area and as attachments in a discussion board over the course of their interactions. Our analysis of one small group provides a revelatory case study of digitally mediated group formation. Our wider view of the formation of community in a completely online setting examines the structure of social engagement in a completely online community.

Community formation in a setting that includes physical interaction among participants is well explicated by Wenger. Here, we examine those ideas to a completely online setting. Wenger focuses on the formation and ongoing negotiation of community membership among longstanding, physically co-present communities of practice. We attend to the early stages of group and community formation in a tool facilitated, virtual context. Communities form, change and disband at a much faster rate in the virtual world than in the physical world. In cases where the group is previously engaged in a common physical setting, there is evidence that the rate of change among virtual groups is lower (Gloor, 2005). Such groups are also more commonly sustained than when the interactions are “completely online”.

Completely online groups where members never meet (and have mostly never met) in person are the focus of this study. We believe study of completely online groups situated within a larger virtual community provides two advantages for gathering insights about small groups as socio-technical systems. First, at the small group level of analysis there is no established shared repertoire unique to the group. These members are new to the socio-technical context, and new to each other. In contrast, studies of online groups who are part of a larger community with established practices may produce as much insight about a particular group and its member’s personalities

or the virtual community's established practices as it does about the interplay of tools, cooperative work and the development of community. Second, at the community level of analysis, we describe the variance of structure and interaction in six completely online groups who share the same tools, tasks and socio-technical context. (Our case study group is one of the six.) This knowledge of the socio-technical context is methodologically novel, but contributes to understanding of the relationship between small groups and wider communities in completely online environments.

For the purposes of this study, completely online groups are defined as those where the participants never meet, and have never met previously face to face. All members of the online course in this study fit these criteria.

3. Study context and methods

3.1 *Setting*

This study is conducted at a large, Midwestern US university, using an online learning environment composed of an open source course management tool called Sakai and another open source tool, the Context Aware Notification System (CANS). CANS provides awareness of each member's activity within the course management system for all members, and logs all activity with reference to the course context, activity, and members. CANS records both read and post behaviors. Members use Sakai wikis, discussion boards, chat rooms and file storage areas during the course, and receive daily e-mail digests of fellow member activity from CANS. There are 16 students in the online course in this study.

3.2 *Activities and participants*

The course activities centered on software design for performance support systems. For example, the help and tutorial system in the popular US Tax preparation software "Turbo Tax" was evaluated, and students designed changes based on the principles taught in the class in one activity. The course was divided into seven modules, enumerated in Table II. Each module included course readings, discussion among the class and varying types of activities, including small group, peer to peer and individual activities. Each module contains activities. For example, module one will contain activities 1.1, 1.2, 1.3, etc.

Module	Activity type	Description
One	Individual	Getting started with performance support systems and goals for interaction design
Two	Individual	Online interaction and participation: a framework for designing for online activity
Three	Group	What is PSS? Review examples and identify approaches
Four	Peer to peer	Performance analysis – requirements
Five	Group	Scenarios and use cases
Six	Individual and peer to peer	Interface specifications
Seven	Individual and peer to peer	Usability

Table II.
Course modules

Three of the students are in the core group we build our case study around. Each of the three group members is interviewed three times. The first author interviews the three group members before they become a group, and then once again following each of two, three week cooperative tasks. The two cooperative tasks are a software evaluation task for activity one and an actual software design task for activity two. In addition, discussion board activity and assignments completed by each group during cooperative activity are observed on a daily basis, with field notes recorded during that process. Assignments and work products produced by the small group are also reviewed and coded.

3.3 Method

Small groups and virtual organizations are sometimes studied using experiments in controlled settings. In socio-technical systems research, behavior is more often studied using ethnographic methods, case studies, social network analysis and surveys. Each method exchanges different degrees of depth for generalizability. We focus first on a case study because the depth and breadth of completely online group formation is not adequately explored in prior work, and an empirical understanding of the fine grained details from one setting will inform the development of theories which may be tested in other settings (Eisenhardt, 1989). Social network analysis is selected as a complementary method so that comparisons between our case study group and the other groups in this context may be drawn. Here our goal is to uncover how interactions are correlated with a deep case study for the purpose of making the invisible processes and structure of online group formation visible.

The methodology of this study is guided by Wenger's social theory of learning. Wenger's social theory of learning and explication of communities of practice form a foundation for investigation of how communities of practice may be enabled in a context poor, online environment. This study examines the role tools play in the negotiating and shaping of a small online group. A case study method (Stake, 1995) is employed to explicate how participants experience the online community under investigation. Interviews, observations, course deliverables and activity logs are collected and analyzed. We use social network analysis to build sociograms of member interactions from electronic trace data produced by CANS. All member names and codes reported here are pseudonyms with identifying data removed.

3.4 Data analysis

Three types of data are collected to address the research questions of this study. The first type of data are verbatim interview transcripts constructed from audio recordings with our informants. These transcripts are imported into NVivo 8.0 and coded. We also import our field notes, taken during our observations of the course into NVivo for analysis.

The second type of data we collect is made up of written deliverables, discussion board posts and field notes related to discussion board posts from the entire class. These are reviewed for quality and alignment with the stated objectives of the work. We analyze these first two types of data using transcript analysis and coding techniques adapted from grounded theory (Coffey and Atkinson, 1996; Charmaz, 2003) to expose themes related to small group online cooperation. Grounded theory analysis is used because, although we approached our analysis with an understanding of

existing theory on communities of practice and group development, the kinds of highly virtual, completely online configurations studied here may not be fully explained with those theories. Therefore, we thought it important to drive our analysis out from the data. Open coding of the interviews and discussion board data revealed 71 unique codes, which were refined down into 14 categories. Additional refinement by a second rater revealed four major codes that the first author and a research assistant axially coded against the full corpus of data. Through this coding and review of participation data, we develop a description of this group's cooperative experience, and chronicle how one small group becomes part of an online community in case study format.

The third type of data analyzed is log data produced by CANS. These data provide a complete record of the reading and posting behavior of each online community member over the 16 week period that makes up this study. Previous research by the authors (Goggins *et al.*, 2010b) establishes that the bi-directional, contextualized logs produced by CANS reveal a more accurate representation of membership structure than common weblogs. We use this data in the second part of our results to explicate the structural development of all six groups. Our CANS Trace data is divided up according to both time period, and module activity. If an event occurs during the time period for a module and in that module's discussion area, then it is preserved as evidence of interaction during that module. In contrast, connections between members in a previous module, made during the time of a subsequent module, are not counted within either module, but are counted across the entire course. This ensures that when we are talking about group behavior within a module, and during a specific activity type, we are clear about what we are discussing. While in some of our research we do not let groups see each other's private work areas, in this course all discussions and resources are visible to all members.

We follow Yin's (2009) tactics for ensuring reliability and validity in a single, revelatory case study. We use multiple sources of evidence to ensure construct validity, pattern matching and explanation building to ensure internal validity and apply theories of group and community development for external validity. Reliability is ensured through strict adherence to our protocol for conducting case study research with completely online groups.

4. Small group case study results

Data analyses make clear three patterns and two themes, which we discuss in this section. First, we identify macro themes of tool use and cooperation. Next, we describe the behavior and context of the community as it is forged in the crucible of online cooperative work. Finally, we identify salient patterns of engagement that distinguish community formation in a completely online environment from similar events chronicled by Wenger and others in non-virtual and semi-virtual worlds.

4.1 Themes of tool use and cooperation

Two core themes emerge from discussion with all of our informants and subsequent coding of transcripts:

- (1) Members demonstrate explicit politeness and are cautious about risking social capital.
- (2) Members are frequently multi-tasking.

4.1.1 Politeness and risk taking. Sproull and Kiesler (1992) note the behavior of flaming in discussion lists early in the age of the networked organization. In contrast with their findings, participants in completely online cooperative groups consistently describe a strong drive to ensure that their peers perceive them as polite. As a result, the emergence of low risk, cordial communication, even in the face of general disagreement is common. Comments like “I don’t disagree with people online . . . I just think in a face to face setting that you have a lot more opportunity to interact back and forth and ultimately get to the point” are common in our discussion with members.

The absence of disagreement in an online community, particularly in a learning community, is associated with low levels of engagement and learning. This is a consequence of attempts to transfer metaphors of the physical world, such as a classroom, directly to designs for the virtual world, as in the application of physical classroom constructs into a virtual classroom (Hughes and Daykin, 2002; Wise *et al.*, 2004).

The absence of earnest disagreement among members of virtual environments like ours reflects a failure of tool designers to distinguish the behaviors in the physical world, which enable learning, and subsequently build tools that support those behaviors in the virtual world. In this case, the tools are simply not attending to the specific needs of participants, who seem to miss some of the physical props of coordination and group formation they rely on for context in the physical world. The ICTs members use do not support structured argumentation, which results in constraints on the negotiation process and diminished capacity for cooperation in the virtual environment.

4.1.2 Multi-tasking. Multi-tasking is the second theme that emerges. Unlike in regular classrooms where students’ physical and mental engagement with the process of learning is visible, our members are frequently engaged in other tasks while they participate in synchronous or asynchronous aspects of the community. “I’ve actually been driving down (the highway), talking to my husband and posting to my team” and “sometimes I get distracted when my boyfriend saws something up in Gears of War while I’m chatting with my team online” are representative of the measures of multi-tasking our informants describe.

Participants in online communities are often simultaneously engaged with people who are not part of their online world, but who are physically present with the online learner. We speculate that there is an emotional component of belongingness that people require when they are participating in an online community, but which may not be met well in the medium they are using for the course. There is no way to physically interact with other real people who are in the course, but participants do choose to interact with people who are in their physical environment, with whom they have an emotional bond, while they are working online. Interacting with one set of individuals in the physical world while simultaneously interacting with people in the virtual world is a common theme across the participants in this study. Multi-tasking transcends the boundaries of the physical and digital worlds.

4.2 Cooperation and group formation in the small

There are three members in the small group that is the focus of our case study. All three are currently living in North America, and participating in an online graduate program in educational technology at a large public research university in the Midwestern part of the USA. They have never met, and report that they have not worked together in a group prior to this experience.

4.2.1 Kelly. Kelly is from Nova Scotia in Canada. She currently spends a lot of her time consulting with organizations around North America, and will frequently find herself on an airplane several days during the week. Kelly is an experienced online collaborator. She participates in a number of online work groups, and has some positive and not so positive experiences in those settings. In a previous online learning workgroup, Kelly was one of three members, one of whom (not Kelly) was not pulling their weight. This kind of social loafing can occur in online communities, and for Kelly, like for many people, dealing with this issue is a particularly awkward burden in the online environment. When she is unable to provide her collaborators with relevant non-verbal social cues about their poor participation patterns, Kelly becomes frustrated: “well, we’re more mature than this and we can work together and so forth”. Kelly is sensitive to her obligation to contribute, and sensitive to other group members’ perceptions of her.

4.2.2 Rachel. Rachel is from Portugal and relatively new to the USA. She is a doctoral candidate at the university. Though she lives and works on campus, and knows many of the professors who teach online courses, she is participating in some courses online because that is the only mode of delivery they are offered in. Rachel does not enjoy online learning. Rachel is relatively new to online group work, and has a strong preference for interactive, social experiences. During a discussion on ways to improve online tools, she volunteers several observations about online work, which reflect her strong preference for face-to-face experiences. Despite the implicit challenges of online work, Rachel does not distinguish between these two cooperation modes in terms of the difficulty she experiences providing constructive feedback, which several informants describe as particularly difficult in an online setting.

4.2.3 Marge. Marge lives in Pittsburg, PA (USA) and is near completion of an online masters degree. Marge is an experienced online learner who previously belonged to a group who moved from course to course together. Marge maintains an online identity with this past cohort, and misses the consistency of their collaborations. Marge is also a veteran of more interpersonally challenging online experiences. In one case, Marge’s online group develops what Wenger calls a shared repertoire. In this case, the social cues and modes of interaction for the group are established and identifiable by the members. At a later point in this cooperation, the composition of the group is altered by the addition of a fourth member, resulting in a “good group going bad”. Marge views online groups as more prone to difficulty when their makeup or practices change unexpectedly.

4.2.4 Pre-cooperative discussion. Each member of this group has experience being part of another completely online group in the past. Kelly and Marge bring both positive and frustrating experiences with online cooperation. Rachel is not “against” online work, but clearly has a preference for face-to-face interaction, if only as a supplement to the online modality.

Each informant expresses a consistent desire to impress their collaborators with dedication to the group, and willingness to contribute. They also identify communication within the group as an important element of the overall success of the group effort, based on their past online group experiences. Kelly and Marge both share “online cooperation horror stories” during our discussions. When Kelly and Marge describe their past, bad online experiences, they are passionate in their storytelling. They describe the experience as one that is emotionally painful, and express a desire to avoid even the slightest chance of a future bad experience.

4.3 Group formation, cooperation and community – the Alpha Group

The group's first cooperative activity serves as both an introduction to the work, and an introduction to the other members of this cooperative group. Joint enterprise emerges early in their interactions, and centers on the construction of an understanding of their assigned work, followed by its completion. The "alpha group" produces four different work products of different types, and two reviews of other teams work over the course of this first three week "module", which is one module of eight that constitute the online course. Several themes related to small online community formation emerge during this module.

Group cooperation and tool interaction are initiated during activity 1.3 and activity 2.2 in Alpha Group's first module together. In activity 1.3, the group is tasked with creating a performance support system for TurboTax, a popular US tax processing software package. In activity 2.2 the members are asked to develop a detailed report about an existing performance support system. To coordinate their work, the members use a Sakai discussion board thread as a central command. Analysis of the other five groups in the course shows that some use the discussion board as a secondary communication channel and rely on e-mail or instant messenger for primary communication. This demonstrates an absence of technologically deterministic behavior in this structured virtual environment. The completely online circumstance pre-determines that work will occur through technology, but the choice of technology is negotiated within each small group.

The other technology channels that Alpha Group uses have a greater impact on their negotiation of community practices than the primary discussion channel. For example, during the performance support design activity (1.3), instant messaging is used to discuss the specific content that is put into the groups work product. The work product itself is in a document-based format – PowerPoint – that Marge initiates. This is distinct from alternative choices, which include the use of collaborative editing tools (wikis). There are two significant elements of community and individual identity that are represented by these choices. First, chat is a social, interactive communication channel, over which the members report being able to get to know each other and understand details of their personal lives. Rachel's remote family issues, Marge's baby and Kelly's frequent flier nightmare stories add levity and a social bond to the Alpha Group's cooperative work oriented discussions. These personal stories, shared in the context of a required cooperative task, build a social bond in the group.

Second, the use of a document-based tool for constructing the final deliverable mutes the opportunity for the work itself to be actively negotiated by the group. In the performance support design activity (1.3), the PowerPoint only goes through three changes from the time it is drafted to the time it is finished. This change is negotiated during a series of Skype IM chats over the course of two days (we have these communications in our data corpus). Marge and Rachel describe chat and the use of PowerPoint for the production of the deliverable for the performance support design activity (1.3) using positive terms. These two group members are the more socially motivated of the three. In contrast, Kelly's choices are more pragmatic. Kelly's view of the activity is that it takes a great deal of coordination to arrange the chat session, and while she expresses satisfaction with the results, she also describes a lower sense of ownership than the other two members, who play a more active role. Marge and Rachel feel their ideas are adopted in the results of the performance support design activity (1.3). Kelly is satisfied with the result, and also feels that her ideas are adopted.

Kelly is a contributor, but not a driver in this activity, which is a different role than she usually plays. The performance support design activity is an important marker in the development of the Alpha Group. It represents their first successful completion of a task, the application of specific tools to the completion of that task, and evidence of compromise of individual points of view and style in the interest of maintaining a harmonious group. With rapport established, the movement of the group into module 2.2 (performance support evaluation) is a turning point in the evolution of their cooperation, and the development of their sense of community. The selection of a synchronous tool (chat) for creative cooperation helps to strengthen the bonds within this small group, and allows the performance support evaluation to be executed with some efficiency.

The trust established and success perceived during the performance support design activity gives the alpha group confidence to be adventurous and choose a wiki for creative cooperation in the performance support evaluation activity (2.2). All three group members describe the choice of a wiki as disruptive. None of the members of this group have previous wiki experience. Most other groups in this same class did not use the wiki at all on this module or any other module. This is probably because the tool is not promoted within the class. In fact, it is obvious from Alpha Group's discussion board that Kelly, in effect, "discovered" the wiki and inspired her team, in fits and starts leading up to the performance support evaluation activity, to experiment with and ultimately use it for creative cooperation. Kelly's reasons for identifying and pushing the use of the Wiki within the alpha group are pragmatic – it allows for the completion of work in an asynchronous manner, and does not require the group to coordinate a time to chat about their work. For a heavy traveler like Kelly, this is a major convenience. Alpha group members describe themselves as flexible and comfortable with risk. They do not perceive themselves as having anything to lose by trying the wiki. This makes it easier for the group to choose a completely new tool after previous success using the discussion board. Alpha group is imaginative and flexible enough to try new things.

In Wenger's terms, what the group does by making these choices is called negotiating a shared repertoire, which is then reified through practice. In other models, this reification is considered a starting point from which the group either strengthens their alignment around a joint enterprise (purpose) or deviates from it. In an online environment, this negotiation is more fluid. If the group is physically co-present, physical infrastructure will grow up around the shared repertoire. Physical infrastructure is hard to move once it is in place. In this online community, the prior choice to use chat for cooperative activity is unceremoniously done away with in favor of a tool set that requires less coordination effort.

In contrast with the limited editing and evolution of the work product for the performance support design activity, the work product for the performance support evaluation activity changes 11 times. There are four major changes, and seven minor iterations. This reflects the difference in the nature of tools selected by the group. When the changes are negotiated in chat during the performance support design activity, time is spent on a single item, and the resulting change to the final version is small. The blocking behavior that is well documented in synchronous collaboration limits the exchange of ideas. The evolution of the final deliverable is observable with the asynchronous tools, and the resulting dimensions of change are more profound. New

sections are added, sections are completely modified or altered and each member visibly contributes. Though there is early confusion about how to use the wiki, the group does figure it out, and the result for that activity is a more well thought out and complex deliverable, compared with those produced by other groups in the same class. The effect of the change in tools for this group is a lower level of social engagement, but a higher degree of quality in the final product of their cooperative effort.

Alpha group makes pragmatic choices for coordinating their activity, and the results of their work evolve from beginning to end. They express a developing identity as a group through the contents of their discussion board posts (“aren’t we a great group”) and through subsequent discussion with us, where they comment on the strength of their group from several points of view. Alpha Group also demonstrates more coordination of group activity as their work together moves through time. From the point of view of group members, their choice of tools influences the development of this interaction, and tools themselves serve as the objects of the group’s actions. From the cooperation of Alpha Group, and through their development as a small online tool-mediated community, several interaction patterns emerge.

4.4 Pattern one: instant shared repertoire

Based on our analysis of discussion board activity and work products, a shared repertoire develops quickly among the members of Alpha Group. Communication to coordinate work follows a pattern for the each of the six activities in this module:

- Organizing pleasantries.
- Suggested course of action.
- Tacit acceptance of the course of action.
- Deliverable drafting.
- Nominal discussion of drafts.
- Posting of final version, occasionally following a “last call” message for input from other team members.

In addition to this regular flow, exchanges regarding logistics and reassurance are laced throughout many of the messages exchanged by this group.

An example of this shared repertoire, which Wenger says includes routines, words, ways of doing things, stories, gestures, symbols, genres, actions or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice (Wenger, 1998, p. 83) is presented below. It is the opening discussion for module three, and includes the organizing pleasantries as well as a suggested course of action:

Hi guys. I read through the module 3 work and saw that we would need to post a flow chart by Thursday the 15th. I will be traveling with my job and so won't have access to the internet Monday (12th) or Tuesday (13th). (I will look around to see if there's any connections where I'm going, but I can't guarantee it.) I will have access later that day on the 13th and then won't be traveling after that for a little while.

I can help with creating/drawing the flowchart if you'd like, too.

For the next activity, the same user – Kelly – initiates a more concise introduction, which nonetheless, repeats the described repertoire:

Hey guys, I'm working on getting us started on the next step (our report). Once I get that done, I'll post it and you guys can take a look, edit/add, etc. K? I'm hoping of getting the start of it up by tonight or tomorrow morning so we can all take a look and have time to add things.)

Critical consideration of such a rapid formation of shared repertoire by a small group of people previously unknown to each other begs the question of whether or not the members brought this repertoire with them to the group. Perhaps their participation in this community extends or leverages a repertoire that already exists among participants in these types of virtual communities. Does compliance with this simple "way of doing things" constitute shared repertoire, or is it, rather, a simple and prudent adaptation the group makes in the pragmatic interest of meeting the objectives of their "joint enterprise"?

There is evidence in our subsequent discussion with group members that the application of this repertoire is negotiated based on three main factors: past successful and non-successful online group experiences, patterns of engagement used in prior experiences online and a mutual desire to become a group through this experience. Our members intuit or have learned from past experiences that it is simply more enjoyable to work in a group that develops a respect laden, conscientious repertoire. For this group, the development of this repertoire is a high "out of the gate priority" once they are "thrown into the fire" together.

4.5 Pattern 2 – flavors of online negotiation – tool negotiation

The adoption (selection) and adaptation (how they use and make their own) of tools in this online environment is interwoven with Alpha Group's meaning making activities. Wenger asserts that meaning arises out of a process of negotiation that requires participation in a community, as well as the reification of the constructs of that community. In turn, the reification of practices, words, etc. is a natural outcome of ongoing community participation. In an online environment, participation is as much an engagement of tools, as it is of a common purpose or meaning. The shared repertoire, which develops among the group, includes the language and signaling (semiotic) system that is part and parcel of the tools the group is using. Whereas, in the communities Wenger studies, these shared repertoires evolve using well-understood modes of interpersonal communication, in the case of this small online community, the course tool, Skype and e-mail are all important tools to consider, because they in fact are what is used to negotiate meaning.

Alpha Group's community is constructed through ICT use. For example, there are occasions early in the cooperation where tools are being used incorrectly, and the misapplication of them caused problems for Alpha Group, as in Kelly's accidental "ruining" of the discussion thread:

Okay, shoot. I didn't think it would show the whole thing and ruin the thread!

Another example is Rachel's confusion about where to look for another team's assignment during a feedback component of the course:

I only see Team one's Activity 1.3 – Team 1 will examine the Performance Support System (PSS) of Turbo Tax. I'm confused.

Alpha Group's negotiation of how to use the Wiki to complete their task is another example of how tool use is negotiated at the same time as content and task oriented meaning. The negotiation process Alpha-Group goes through includes not only cooperation around the work, but active experimentation with the boundaries of the tools in order to allow cooperation. In the case of creating an activity summary (a group deliverable), Kelly identifies the Wiki as a tool resource, and subsequently pursues its use for the team to work together on one "collective" piece of feedback:

Hey guys, I'm so excited I don't know why, but I've been ignoring that whole wiki thing we have here. Anyhoo, I transferred our paper into the wiki. I put a Home Page wiki for Team 3, with a link to our Mod 3 summary for Turbotax. Just click "edit" and you can edit whatever you would like! Maybe we can do that and then when we get together tonight we can just discuss what each of us have added and tweaked?

(Kelly;0)

The other team members join in, but have difficulty. On the same day, Marge initiates this post:

I'm not able to reply to the wiki. Kelly's response is pretty straightforward:

Do you see a list of links at the top, one of which is "edit"? If you don't, perhaps there is a permissions issue that Dr. Kennedy can fix . . . Oh, if you do see "edit", then just click on the link that goes to the Turbotax page, and then click "edit".

If you want to make a reply or comment, then you can click on "comment" down below where the comments are.

If you don't see anything of what I'm talking about, then there must be a permissions issue if some sort.

Marge responds that she has effectively worked around the tool issue, as Kelly suggested:

I couldn't ever get the turbo tax sheet to edit . . . so I just added comments. I think kelly has done a really solid job.

From this point forward in the module (about another two weeks), the team uses the wiki for cooperation with great effectiveness. The adoption of the wiki has an effect on the quality of work product evolution and negotiation, because of the more frequent, easy iterations.

4.6 Pattern three – post type taxonomy

Alpha team's discussion board posts can be classified into one or more of four categories:

- (1) Pleasantries – statements like, "Really having fun", "this group is great"
- (2) Logistics – statements like, "I'll be available at 7 and 9 p.m. Wednesday" or "I'll be traveling to Vancouver"
- (3) Pseudo-synchronous communication – These types of posts are usually related to cooperative work production and "finishing" something. What differentiates these types of posts from others is the rather rapid exchange of communication, with times between posts being less than 15 minutes for two or more team members over at least one full exchange (a minimum of three total posts). These types of posts actively evolve the shared repertoire of alpha group.

-
- (4) Idea generation – Sometimes these are also pseudosynchronous communication, but they are differentiated from other post types by the creation of new ideas, which address meaning negotiation, task completion or other group dilemma. They are focused on the joint enterprise of the alpha-group.

These categories reveal that the discussion board is used primarily as a coordinating tool. Nonetheless, there are aspects of the discussion board, particularly when posts occur pseudosynchronously, where the group gropes through the tools at their disposal and builds a shared repertoire in the context of their limited toolset. In the next section, we describe how the structure of Alpha Group and the other five groups in this online community emerge through trace data, and analysis of discussion board communication.

5. Network analytical results: emergent structures

We described one group's formation and interaction in an online course using an in depth case study. We now turn to understand the extent to which group structure is visible through analysis of the bi-directional (read and post) trace data generated by CANS.

We learned three things from this analysis. First, during the first group exercise, group formation is not consistently discernable from trace data in our groups. Second and most significantly, during the second exercise the trace data reveal clear group structure for four groups, and a consistent coordination and leadership structure for all groups. Third, once group activities complete, the trace data shows no groups remain clustered together, although our qualitative analysis of Alpha Group suggests they maintained a level of group interaction. Before we explain our results in detail, we will review our methodological approach for this section.

5.1 Network analysis methods

We show how members cluster in groups and connect with other individual members using sociograms. The connecting lines in our sociograms show both strength and direction. The distance between nodes is a spatial representation of the distance between the people (nodes) in the course. People who communicate more frequently with each other are closer together.

The thickness of the lines connecting any two nodes reflects the relative number of communication instances between those nodes during the time period reflected by the graph. The thickness reflects strength of connection based on instances of communication recorded in our unique trace data. Line thickness is not normalized across all modules, but within each module. This helps to contextualize our sociograms temporally.

The arrows connecting any two nodes indicate whether the connection is uni-directional or bi-directional. If there is an arrow touching Bill's vertex and My vertex, that I read and/or respond to Bill's contributions, and that Bill reads and responds to mine. If there is only an arrow on my vertex of a line between Bill and I, that indicates a unidirectional (non-reciprocal) connection – In this case, Bill is reading my posts, but I am not reading his.

We calculate salient social network analysis (SNA) statistics for the social network in this course in tables, and the network positional characteristics of each group and each member using sociograms that reflect the network structure that emerges during different types of course activities. We present the sociograms in this section because

they illustrate the salient grouping of course members, and the relative positions of those members during different activities. We also validate the sociograms through calculation of social network statistics from the trace data. The sociograms we present are consistent with the network statistics we calculated, but we leave display of these statistics out in the interest of space. Specifically, we calculated network density, freeman degree centrality, betweenness and closeness statistics. We also performed our analysis using both UCI*NET and the iGraph within the R open source statistical software package. The sociograms presented here were generated using iGraph + R.

5.2 Group visibility during formation

First, we are interested in how group formation is visible through analysis of our interaction logs. Figure 1 shows how each of the six groups in this course are clustered together (or not) during the first collaborative module. Two groups, Group One and Group Two, are clustered together (Alpha Group is Group Three, and are represented with the names you are familiar with). The other four groups are not, suggesting that group formation, at least at the very beginning, is inconsistently observable through analysis of CANS logs. Each member is represented with a two character prefix

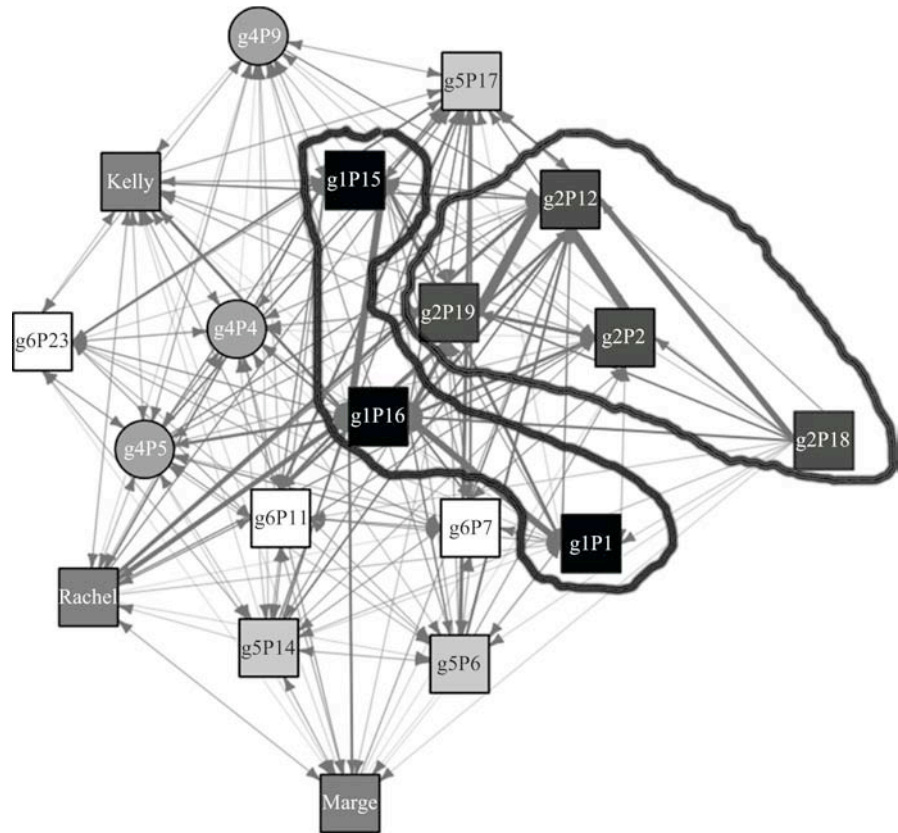


Figure 1.
Module three clusters by
group, showing groups
one and two are in a
cluster, while the other
four groups are not

Note: In this view, groups assigned colors based on their a priori assignment as a group

indicating group membership, and a two to three character suffix indicating their unique anonymized person number in the course. All group + person combination identifiers are consistent across all sociograms.

Group One and Group Two, while both clustered together in module three, show different tie strengths between them. We know from this structural attribute that the volume of communication within Group Two is high, and primarily within that group. We know from the relatively thin lines connecting Group One's cluster that its members are connected more weakly than those in Group Two. Further, the central position of Group One member "G1P16" in the overall course network is unique among the two groups; this member is both closely connected to other members of the course and her own group. We see that how the groups are connected within each other and across the course network are different in this first teamwork module, module three; And that four of the six groups have structures (or, non-structures) that are similar to those of Alpha Group (Group Three). It is also clear that by examining these small groups as networks instead of clusters that the nature of their connections, when they do cluster, is not homogeneous.

5.3 Group development – analysis of the second group activity

The actions of group members during the first group activity suggest a reticence to fully engage group membership. Reflections about the group work by the members of the course indicate that concerns about relying on people who are not known, performing tasks that are new and challenging limits their willingness to rely exclusively on their own group. The sociogram in Figure 1 shows that one-third of the groups in the course cluster together and two-thirds do not during the first module of teamwork. Figure 2 shows us that, during module five, the second group work module in the course, four of six, or two-thirds of the groups are clustered together. In Figure 1 and Figure 3 shading corresponds to a priori group membership. In Figure 2 and Figure 4, shading corresponds to network structural similarity measures of members, determined by an analysis of their actual interactions with each other, derived from CANS data (Reichardt and Bornholdt, 2006; Barabasi, 2009). In modules three through five, these measures of network similarity are corroborated by our analysis of discussion content and student reflections.

The four groups connected with their a priori members and connected to similar networks in our analysis of trace data do not create "tight clusters". Members are simply more connected to each other and closer to each other than other course members not in their group. In Figure 1, members of most groups are most closely grouped with other course members not in their assigned group. In Figure 2, most of the groups are mostly closely clustered together. Even Alpha Group (Group Three) appears more tightly clustered around its members than it did in module three (Figure 1). In a second group activity, the groups in this course are closer together than during the first group activity. This suggests that, through working together, they learn how to "work together" and rely on each other.

In addition to these clusters, there are other indicators of evolved community behavior in the second group activity. The coordinating role that we describe for Alpha Group member Kelly during module five is identifiable in the sociogram for module five, for every group. Figure 3 shows that each group has one member closely clustered around the instructor, who is circled in the middle of Figure 3. This same coordinating

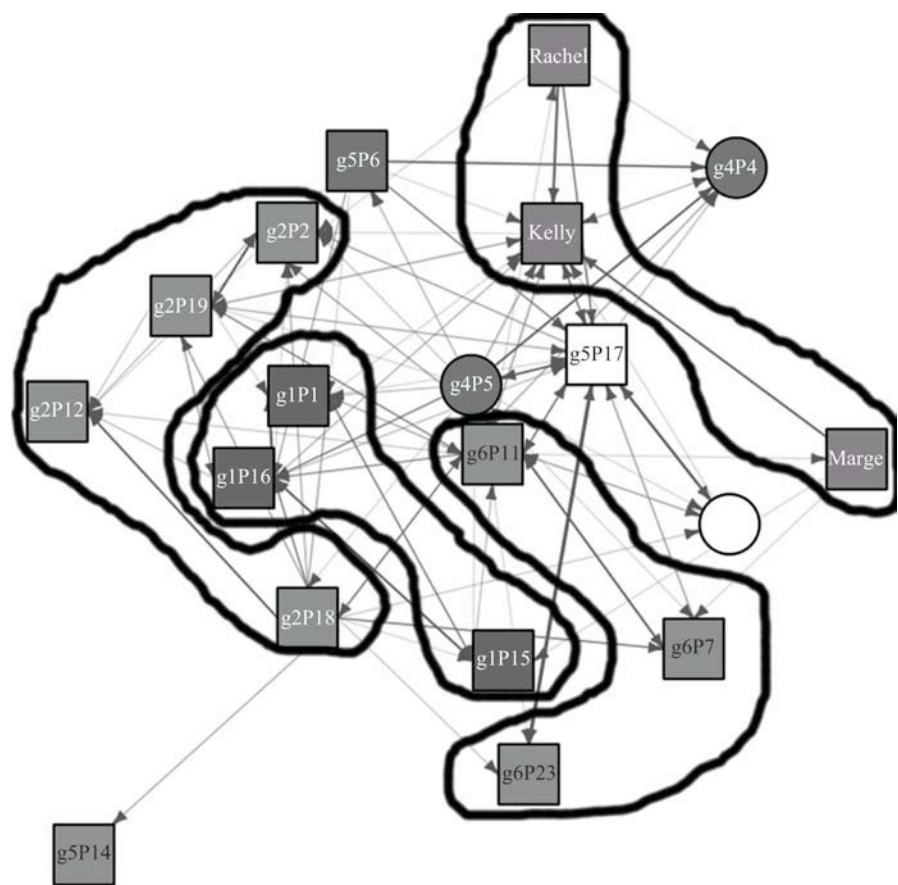


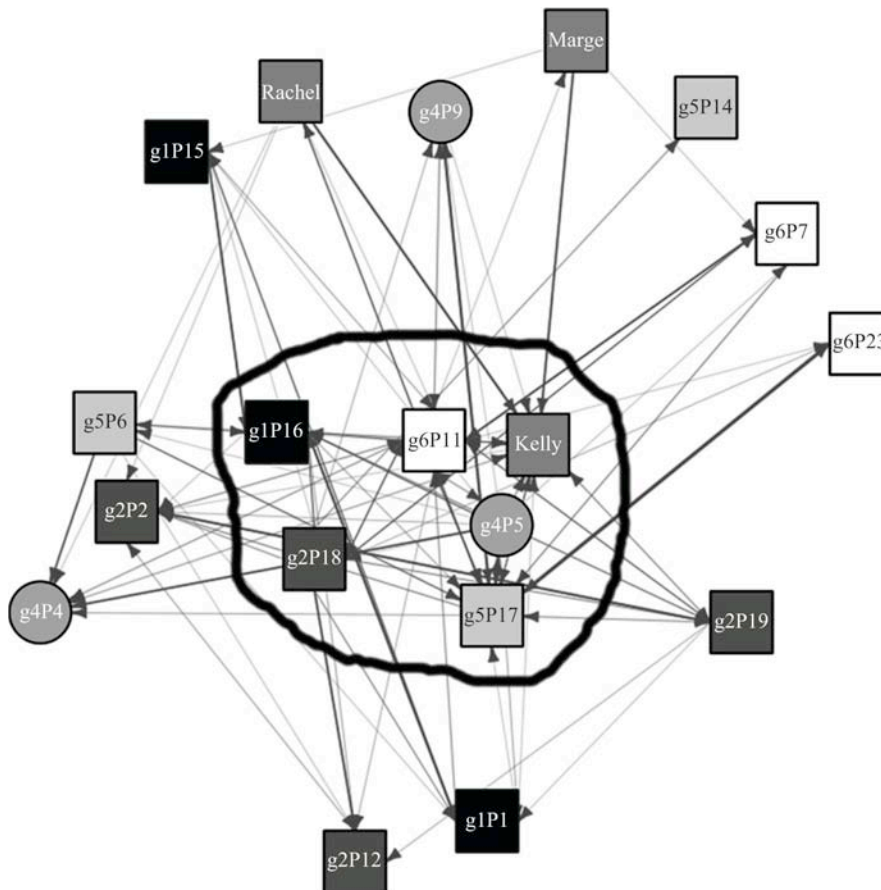
Figure 2.
Module Five group
clusters

Note: In this figure, groups members are assigned a color based on similarity of their relations in the network

role did not appear in the sociogram for module three. In the second engagement, we see that members of each group allow one member to coordinate with the larger course, and with the instructor as needed. The groups are not only identifiable from their external structure, but also from their internal structure. For this sociogram we take advantage of the spring repulsion visualization algorithm described by Brandes *et al.* (2003); Brandes *et al.* (2006), and implemented in iGraph for R. The algorithm performs well for visually identifying central members in fully connected, dense graphs like ours. The same members were visualized in the core using UCI*NET.

5.4 Groups after the end of group activity

After group activities have completed, analysis of log files demonstrates a unique feature for our case study group. During module six, which occurs after their last team activity, no groups appear in the same subgroup in either our UCI*NET analysis or analysis using methods defined by Barabasi or Brandes. Yet, in our qualitative



Note: In this figure, members are assigned a color based on a priori group assignment

Figure 3.
Module Five clusters,
showing a single
coordinating member for
each of six teams,
clustered around the
course instructor

analysis of member reflections and reading of member interactions in the discussion board, connections clearly remain; group members do interact with each other. What is going on here, and what are the implications for network analysis of trace data? First, it suggests that, possibly, analysis of trace data becomes less reliable toward the end of group interactions. Perhaps what we can discern from posts and reflections does not emerge as strong, read and post connections in member interactions because their work together is done. In sense, this confirms earlier findings of Axelrod (1984), who found an increased likelihood of member defection when future interactions are less likely. This phenomenon warrants investigation in future studies.

6. Discussion

6.1 Summary

In this study we present an in depth case study of one group in a completely online course. We then examine the structure and practices of the larger community of six small groups. This is an analysis at two levels of social interaction in a socio-technical

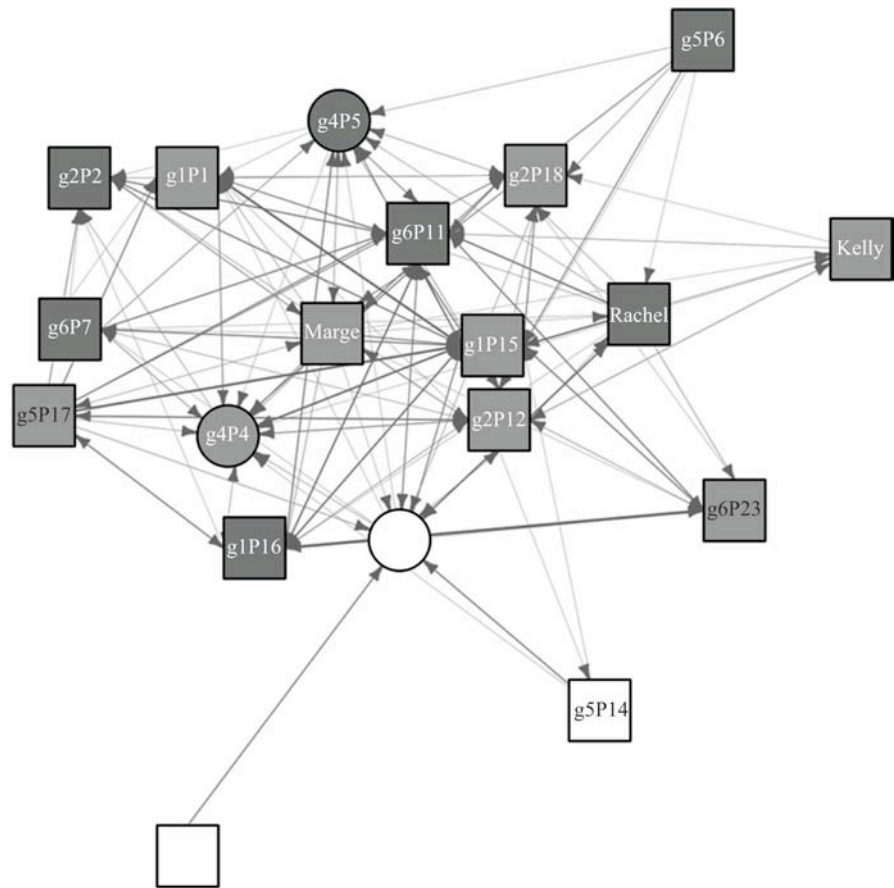


Figure 4.
Sociogram of course
activity during module
six, none of the groups
have all of their members
in similar network
structures

Note: In this figure, member color is determined by network structural similarity

community, which lacks any history or continuity across time, space, organization or culture for the members. We develop a picture of how groupness and community are constructed when members must make sense of the tools, each other and their work all at once. Completely online small groups are not bounded by time, space or even membership. They gravitate toward assigned teams, and negotiate time and place within those teams and across the larger community. They do this when they are ready, and not the first time they are asked to. And they become groups, and become a small, completely online community by taking up and using a diverse array of ICTs for whatever task each tool is best suited. Past studies demonstrate the munificent variation of ICT uptake and use; this study demonstrates that munificent ICTs are taken up and used when available.

The three patterns that emerge in Alpha Group's practice provide insight into the influence that familiarity with a virtual environment or toolset has on group formation and community development in an online environment. The limited bandwidth and context poor nature of online communication is a salient concern, but one that Alpha

Group overcomes. The group demonstrates a willingness to experiment with the tools, and sustains ongoing adaptation of those tools until they successfully complete their joint enterprise. Previous literature identifies high level meta patterns of group development, such as storming, forming and norming (Tuckman, 1965) and punctuated equilibrium (Gersick, 1988; Gersick, 1989). At a high level we could argue that dimensions of Alpha Group's development can be classified this way; but the patterns identified here suggest that the analytical details of completely online groups are different at the mid-level, compared to physically situated groups. For example, the construction of a socio-technical space incorporates experiences of identifying with a community and identifying with a group simultaneously. This is possible through technology because it is not always clear which level of social organization one is interacting with – the small group or the wider course community. This is as unclear to the participant as the researcher. Consequently, both theory and unit of analysis are less certainly pre-determined in the study of completely online groups.

For example, in the description of the first pattern, each member of Alpha Group behaves with an observable awareness of the repertoire to be used in the course tools selected, and discusses the critical importance of abiding by established protocols (such as doing your share) in an online collaboration. In this way, the Alpha Group demonstrates some manner of membership in a broader community of online learners at this Midwestern University, while, at the same time, forming membership in a specific, new collaborative group.

Wenger's model of communities of practice includes consideration of joint enterprise, shared repertoire and mutual engagement. Distributed, technology mediated groups like this emerge into communities differently than physically co-present groups. The boundaries of community and task group are, in this case, possibly bounded by the use of tools. Alpha Group successfully completes their joint enterprise by somewhat organically developing the necessary and efficient communication protocols required for task-focused work. That the quality of those work products improves when they use the wiki instead of the exchange of a file has implications for how cooperative tools play a role in the construction of all dimensions of Wenger's notion of a community of practice in the context of a small, online cooperative group. Similarly, we see the structure and practices of other groups take a common shape during the second group activity.

In online communities, tools themselves act as the objects around which cooperation occurs and community forms. This study explicates the tool-centered aspects of group cooperation and community formation by seeking and analyzing experiences of members of a newly formed small, completely online workgroup. Tools that enable cooperation among small groups and support the formation of community in a completely online setting are viewed from a different angle when observed in detail, from the perspective of participants. Marge's use of the wiki and preference for social interaction inspires the notion of wiki-chat. Kelly's active role in the second module sparks innovation. Multi-tasking with individuals in the physical world while participating in an online form of social organization is the new normal.

Kling and Courtright (2003) make a compelling argument for the overuse and misuse of community as a construct for online research. Community has a specific meaning. Brint's (2001) six dimensions of community are:

- (1) dense and demanding social ties;
- (2) social attachments to and involvements with institutions;
- (3) ritual occasions;
- (4) small group size;
- (5) perceptions of similarity with the physical characteristics, expressive style, way of life or historical experience of others; and
- (6) common beliefs in an idea, a moral order, an institution, or a group are never all met. But many are met here.

The identification of small group size as a dimension of community reinforces, at least implicitly, that the division between research on each in an online setting is not ever clear (Porter, 2004). The patterns described here point to a need for greater development of socio-technical theory related to small group development when those groups exist completely online.

6.2 Completely online small groups as socio-technical systems

We think the present findings point to a need to reconsider theories of community and group development when the context is completely online; that present social theories of learning, communities of practice and group development are insufficient for this new context. Returning to our theoretical framing, networks of practice are more amorphous than groups in completely online settings; yet these same groups pulled together in a larger “group of groups” arrangement are not long running enough to constitute a community. Theories of small groups focused on task performance are also insufficient for explaining the role of technology in the development of group practices and structure. Online groups engaged in creative or unstructured activities, as those in this study were, are not sufficiently explained through analysis of task performance.

Constructs from the physical world like community, network and group lack a virtual corollary. The use of these well-worn constructs in the study of technologically mediated interaction is possibly misleading. Kling and Courtright (2003) suggest that the construct of community, when applied to online settings is aspirational. Present findings suggest that “network” and “group” conjure images from the physical world that are not descriptive of the experience people have in completely technologically mediated environments.

How completely online group members experience cooperation, participate in activities and become visible through analysis of context enhanced electronic trace data show that the small group unit of analysis has descriptive power. For example, how groups accomplish work is not discernable from individual member behavior, but by examining multiple groups in the same context we are able to make comparisons between groups. The relative structure and interaction patterns across groups in the same socio-technical context provide a necessary contrast for exploring group behavior and understanding how different levels of interaction emerge and evolve.

Theory building for community, network and group development through technology should, therefore, center on the small group unit of analysis. This is not happening today. Online community and network research is mostly focused on massive online systems like Facebook and Wikipedia. Online community research is, we argue, analytically deterministic in the sense that tools for data mining and network

analysis that were originally developed in different contexts and for different purposes are now applied to the analysis of trace data from massive systems. Howison, Wiggins and Crowston (under review, *Journal of the Association of Information Systems*) provide a comprehensive critique of this practice.

For its part, online learning research is largely focused on the provision of new technologies and makes only limited contribution to the development of social theories of learning. Laffey *et al.*'s (2006) theory of social ability comes the closest to a contribution to social theories of learning in technologically mediated environments by providing a parsimonious construct that considers tools, tasks and individuals. Our study contributes an explication of how learning occurs socially through small groups.

We propose three constructs, derived from existing notions of community, network and group that help to explain the formation and development of completely online groups. First, each of these units is studied as a social construction in the physical world but here we see how technology matters. Members come to new social arrangements with experience in a tool, and with experience interacting in completely online groups before. These experiences are emotionally powerful. The experience of prior social failure drives attentiveness to an online group. Prior experiences with the same technology enable members of completely online small groups to quickly develop practices for coordination that function well – unlike face to face groups.

6.3 Design implications: more deliberate and precise activity logging

CANS provides a more complete record of online activity than ordinary weblogs; We see all activity, and we see it contextualized in the course structure, artifact and course member relations. Our structural analysis of this rich data demonstrates consistent leadership patterns across all groups, and unique structural forms within each group.

Using a range of tools and configurations, the algorithms from network science, implemented in existing open source and proprietary tools, do not reveal the structures identified by qualitative analysis the edges of collaboration – the beginning and the end. They do function well in the middle. This gap speaks to the need for mathematically oriented network analysis to be more closely connected to the ground truth of lived, socio-technical experience.

6.4 Limitations

This in depth case study identified a number of interesting elements in the formation of an online group that is situated in a larger, tool bounded, virtual learning community. The primary limitation of this research is sample size. The detailed analysis consisted of three members of a 16 student online course, and should be continued with larger numbers of students in more diverse online collaborations in the future.

6.5 Future development

This online group's ability to build a useful repertoire in the space of a week, and then apply that repertoire to rapid application of different tools in an online environment suggests that community formation, which is described by Wenger as a longitudinal process that evolves over long periods of time, may be enormously compressible in the virtual world. The more familiar the metaphors and tools are to participants, and the more intuitively adaptable the tools are, the more quickly community is able to form. The implications for 3D virtual environments and other emerging collaborative

technologies is that creative small groups will adapt those tools to their purposes. Construction of tools that consider the critical aspects of community formation should drive the development of small communities in online contexts.

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