Towards the Facilitation of an Online Community of Learners: Assessing the Quality of Interactions in Yammer

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Abstract: This paper focuses on evaluating a theoretically informed approach to using social media as a means to support the development of a community of learners in an introductory human computer interaction course at a major US research university. Social network and communication analysis were used to examine the form and function of social interactions in Yammer. The data suggests that the theoretically informed approach to using Yammer succeeded in encouraging processes associated with a community of learners. The methods used in this paper may contribute to more effective ways of assessing the quality of discourse in socio-technical environments and the findings provide potential models for using social media as new contexts for developing conceptualization and discourse practices.

Introduction

User-Centered Design is a methodological approach within the field of Human Computer Interaction (HCI) that requires diverse knowledge and expertise. Both user-centered design and science share an inherent complexity, and the need for practitioners to make sense of many facts in order to advance solutions. Specific similarities include the requirement for a deep understanding of practice, higher order reasoning, and the ability to apply theory in concert with the accepted methods of the field. The inherent problem in teaching an introductory course in user-centered-design in higher education is that students expect a traditional lecture-based pedagogy, a form of instruction that is ineffective in helping beginning designers to develop necessary knowledge and abilities. In order to become designers, students need opportunities that require them to start thinking like designers: to critically evaluate artifacts in the real-world, think about user needs, cognition, emotion, resources, markets, and how all of these variables lead to the design of innovative solutions. Progressive instructional methods that emphasize student-centered learning have the potential to allow students to become more active participants in the learning process. The problem is that senior college students come with rigid mental models of what classroom interactions should be like in college settings. These student expectations have been shaped by past experiences and create obstacles for those aiming to introduce more progressive instructional methods, such as the development of a community of learners. If previous experiences create obstacles, then perhaps there would be fewer obstacles to progressive instructional methods in environments where students have had less educational experiences. Therefore, we wanted to examine the utility of using a social media environment, called Yammer to create learning environments outside of the classroom. We applied educational theory to guide the use of Yammer and examined the extent to which it could provide an engaging socio-technical context for learning. Yammer was used as a means to facilitate back channel discourse and communication in an introductory HCI Course at a major US research university. We then examine whether the form and function of discourse activity coincides with expected outcomes derived from learning theory.

Related Literature

Becoming Human-Centered Designers

Human-centered design (HCD) is a complex approach to developing design solutions that requires deep understanding of psychological theories and design practices. A central consideration of HCD is the identification of the needs, goals, and limitations of end-users. In order to become an effective user centered designer, students need to develop a wide range of content-specific and domain-general knowledge and skills. Students have to understand multiple theories related to how people think, learn, and interact with their environment as well as how these theories can be articulated through design (Carroll, 1997; Norman, 2002). Students also require domain general skills. They must learn to collaboratively illustrate their understanding of design problems and potential design paths, create representations to summarize findings, and communicate their ideas and reasoning to diverse audiences (Dym et al., 2005).

Unfortunately, students in HCD courses have been shown to lack domain-general skills: they do not reflect on their practice, negotiate or evaluate ideas with others, and also have problems applying course concepts to real world examples (Borge & Carroll, 2010). Students learn how to replicate methods and practice, but without a full understanding of why they are necessary or when they are useful. Such a findings are likely when students are not provided with opportunities to develop content specific and domain general knowledge in synchrony (Schunk, 2012).

Characteristics of Learning Communities and Implications

Students have been historically treated as peripheral in the learning process (Cuban, 1984). Most classrooms follow a model in which an instructor transmits knowledge to students and the main instructional goal is to motivate students to be receptive to the transmission (Rogoff, 1994). These types of classrooms are typically lecture-based, where the teacher is the primary source of verbal activity (Dunkin & Biddle, 1974).

Many researchers have advocated against traditional instructional practice in support of a more student-centered learning model. A student-centered learning model requires the instructor to shift from the role central knowledge authority to a facilitator of knowledge building activities, while students move from the periphery towards becoming central contributors of ideas for the community (Lave & Wenger, 1991; Papert, 1993). *Fostering a Community of Learners* (FCL) is one such model with certain key features: (1) students engage in individual research in order to (2) complete an important task and (3) share information in order to help each other complete the task. Meanwhile, students are also trying to deeply understand the disciplinary content that is inherent to the task (Brown & Campione, 1996). Another important aspect of FCL is for the instructor to make time to model thinking processes (Brown, Collins, & Deguid, 1989; Collins, Brown, & Houlm, 1991). For this reason metacognitive reflection is also an important element of this learning environment. Brown and Campione (1996) argue that it is not enough to have scripts or rules for how to behave, but that it is necessary to develop a system comprised of the previously mentioned components to provide a meaning and philosophy to support the culture of a community of learners.

The literature presented suggests potential methods that could be used to examine whether a learning community is actually developing in a virtual environment. For example, certain patterns of social interaction would need to be present. The instructor (expert) would likely be a central participator towards the beginning of a course with more posts and more interaction with students. In the beginning, students would likely be legitimate peripheral participators, participation in regular, low-risk behaviors that still aid the learning process (Lave & Wenger, 1991). As the course progresses, we would expect to see the expert slowly move to the periphery, while the students move towards central participation; the students would gradually become primary verbal contributors and participate in more sophisticated and risky social interactions. High quality and riskier interactions for design students in particular would include evidence of students reflecting on their learning practice or course concepts, evaluating course concepts, and applying course concepts to real-world examples in order to explore ideas in different contexts (Borge & Carroll, 2010). We can also infer from Brown & Campione (1996) and Brown et al. (1989) that it is crucial for the majority of a learning community's discussions to center on disciplinary content, where students use the language of the course, and try to develop their understanding by sharing resources, opinions, or interpretations meaning and implications in order to effectively apply course concepts to a task or practice.

Analysis of online participation data opens an opportunity to visually represent the patterns of interaction in an online community and examine the extent to which they coincide with theory. The ontology and methodological approach of group informatics (Goggins, 2013) will help us to systematically connect quantitative, visual indicators of movement from a network core to a network periphery with a qualitative understanding of how participants interact through Yammer. This can help to identify the primary ways that students discuss disciplinary content and to what extent this "talk" shows evidence of collaborative analysis and interpretation of course content.

Study design

Design-Based Research Methods and Research Questions

The overall methodology was design-based research, a method used to evaluate the potential of an educational technology that is grounded in theory or prior work and evaluated in real classroom settings (Brown, 1992). The main research questions were, (1) to what extent do patterns of interaction support or negate the development of a digital community of learners and (2) to what extent would students demonstrate sophisticated levels of thinking in the environment. The first question explores the extent to which the instructional approach succeeded in pushing students to communicate with each other about course content and become the primary providers of information for the community. Whereas, the last question focuses on ensuring that the discourse is productive from a learning perspective, as content related interpretation is more conducive to learning than off-task discourse (Wienberger & Fischer, 2006).

Course Content, Learning Objectives, and Student Assessment

The introductory course to user-centered design is a requirement for students in the design and development track of an information sciences and technology college in a large, US University. The course introduces students to fundamental concepts and practices of interaction design. Interaction design bears a resemblance to HCI, but goes beyond HCI's traditional emphasis on interaction with computers to include designing for a variety of human experiences (Rogers, Preece, & Sharp, 2007). Nonetheless, interaction design and HCI share many core concepts and techniques. The course builds on a foundation of knowledge from cognitive and developmental psychology in order to help students understand "users", the people they design products for. The course presents users as thinking beings with specific cognitive limitations that learn to interact with objects by synthesizing present experiences with past experiences and the knowledge, tools, and values associated with those experiences. These psychological theories serve as the foundations for design heuristics, additional theories, and methodological frameworks that evaluate the products that designers and developers create in their attempts to solve everyday problems.

The introductory 16-week user-centered design course was divided into two parts: Part 1 (knowledge comprehension) and Part 2 (knowledge application). It was taught by one instructor and supported by an undergraduate learning assistant. During each week of Part 1 of the course, students worked on a design challenge connected to course concepts. During Part 2, students picked their own design challenge and were expected to complete a project to demonstrate their ability to apply the core concepts and techniques covered in the course. The class met three times per week for 50-minutes sessions. On the first day of the week the instructor would take 20 minutes to go over difficult concepts, on the last day of the week the instructor would use 15 minutes to review the week and answer questions. During the rest of class time, students worked on design challenges with a team of five-to-six members. During these work sessions the instructor and the learning assistant would walk around the class and check in on teams. In place of additional homework, students were required to post on a professional social media site, called Yammer, outside of class each week and discuss course topics. Students would receive credit for starting new discussion threads by creating an original post. They would also receive credit for engaging in an existing discussion by replying to an original post or by replying to a reply. Students could also "like" posts or replies, but would not get full credit for this kind of activity. This was the primary form of discussion for students with other class members that were not in their immediate team. Course participation accounted for 25% of the students' overall grade and consisted of attendance, posting to and moderating Yammer, and providing one peer review of another team's design challenge.

Participants

The study participants were junior and senior college students enrolled in an introductory human-centered design course at a large, US university. Students were divided into nine teams of five-to-six students in part one of the course and a different team in in part two of the course. There were 38 participants included in the study, four of which were women; this is fairly representative of the gender distribution in the college.

Introducing Social Media as a Learning Tool

When integrating Yammer into classroom, there were design principles derived from the learning theory that the instructor followed. These were used as a means to increase the likelihood that Yammer would serve as an effective learning tool. For example, a modified version of cognitive apprenticeship was used as a means to acculturate students to the online community and present it as a situated learning environment (Brown et al., 1989; Collins et al., 1991). The Instructor would model desired posting behaviors, coach students on their posts, encourage sense-making activity, provide guides to help students learn how to moderate Yammer, slowly shift moderating responsibility to student teams, and then slowly fade from the environment. The goal was for the students to eventually take ownership of the environment.

Students were introduced to Yammer in the first week of class and the instructor modeled a variety of different original posts: reflecting, sense making, resource sharing, coaching, and polling students. Students were told that posts should relate to weekly course content. Throughout the next four weeks, the instructor used Yammer to model how to use and evaluate a range of outside resources, (i.e., academic articles, professional UX design blogs, magazine articles, and Wikipedia) and thinking (how sources could be used as a means to further develop understanding). The instructor maintained full responsibility for moderating Yammer for four weeks and then assigned each team to moderate thereafter. When moderating, students were responsible for encouraging each other to connect course content, respond to posts, and keep track of participation. The moderation of Yammer was a large part of their participation grade.

Data Collection

The data from the Yammer environment was extracted and exported to excel spreadsheets. There are three types of posts in Yammer: original posts, replies, and replies to replies. Each *original post* was the start of a new conversation and was time stamped. The data also provided the name of each poster, a unique ID, and created a Thread ID matching the unique ID of the poster. When students *replied* to original posts, the replier would be identified by a new unique ID and associated with a Thread ID that matched the original poster's ID. This allowed us to see who replied to whom and identify different threads of conversation. The data also allowed us to see *replies to replies*. These posts contained the users unique ID, as well as a Replied to ID that matched the unique ID of the person they replied to; the thread ID still match the unique ID if the original poster. The term "post" refers to original posts, replies, and replies to replies. Whereas, the top-level post that starts a new conversation thread refers to an original post. The data also included the entire content of what was being shared and links to any additional articles or materials that students attached to the post. This allowed us to analyze the quality of content.

Examining Social Interaction Patterns

Group informatics methods were used to examine patterns of interaction that emerged over time (Goggins, Mascaro, & Valetto, 2013). The data was cleaned and exported to a social networking analysis tool, called Gephi. In total, 503 posts were analyzed in Gephi. This tool facilitated the creation of visualizations to capture activity: people are represented as nodes and lines between nodes represent connections. Connections indicate events where students respond or are responded to in the Yammer. Two separate students exported the data into Gephi and produced independent visualizations and ran analysis in order to ensure that the system and subsequent analysis was reliable. Besides aesthetic differences, the results of the analysis were the same.

Classification and Assessment of Posts

The objective of this analysis was to assess the quality of discourse that students engage in while using the environment, for this reason the 98 instructor posts were excluded from the analysis. The remaining 405 student posts were classified according to the topic of the contribution and whether it was connected to course content. Posting behavior was categorized according to the type of cognitive activity represented in each post. In order to develop a valid and reliable coding construct, coding activity was initially based on differing levels of cognitive activity that coincided with previous work (Borge et al., 2012). When possible behaviors were exhausted, a construct map was developed with levels of cognitive behaviors, definitions, and concrete examples. The different types of activity were then compared to research from communication analysis and sense-making literature (Convertino et al., 2009; Dyke, Howley, Adamson, Rosé, 2012; Pirolli & Card, 2005). It is important to note that the levels of did not assess writing quality, but rather the level of cognitive activity that students displayed in the post. Utilizing methods similar to interaction analysis (Jordan & Henderson, 1995), meetings were held with student researchers to pick out behaviors and distinguish between codes in order to refine the coding construct. Level of cognitive activity was used as a means to assess the quality posts in the social media environment: informal, practice oriented conversations. Once the coding construct was finalized, the first author and a research assistant analyzed 20% of the data. The inter-rater reliability was substantial (Landis & Koch, 1977): $r = .89$, $p < .001$; Kappa = .78, $p < .001$. Disagreements were discussed and resolved. The research assistant then coded the full data set.

Results

Social Interaction Patterns

Social network analysis revealed three major patterns in the data. These patterns support the claim that there was a high-level of student participation and connections between students during discourse, and that students eventually took responsibility over the learning environment. Our findings use the language of social network analysis and group informatics. Conceptually, lower centrality measures correspond with what Lave & Wenger (1991) describe as "peripheral" participation. High "degree centrality" corresponds with membership in the core. The first pattern is related to the density of participation and level of connectedness of students. Findings indicate that there was a high degree of participation from the class as a whole and students were very connected to classmates through posting behavior. This is characterized by the visualizations in Figure 1, which shows a high degree of participation and ties between students at each four-week time interval. Nodes indicate students who contributed posts and the size and color of the nodes indicate frequency of posting behavior. Lines between nodes indicate connections between people, meaning they received a post from or sent a post to another contributor. Of the 38 students enrolled in the class, only 2 did not participate in the environment at all. Of those that participated, four did not establish any connections to other students. On average, students made a total of 10.28 posts to the environment over the 12-week period, $SD = 7.18$, $Min = 0$, $Max = 29$. Total posts include original posts and replies. The total number of student posts was 405, compared to 98 for the instructor.

The second pattern identified is related to ownership and cognitive presence in the environment (Garrsion, 2003). The instructor moves from a central to peripheral participator over time, while students become more central contributors. Figure 1 shows this pattern over three time intervals. Degree centrality, or the impact a member has in the discussion, is shown by the relative position in the network: the more impactful a person is relates to how centrally they are located in the network. At P1 the instructor (with the alias of II) is in the central left with a relatively high degree of posts and connections. At P2, "II" shows movement towards the periphery of the graph, with fewer connections and posts than at P1. At this time, several students start to become more central than the instructor. By P3, "II" has moved to the periphery with very few posts and far fewer connections, whereas students' posting behavior becomes more equitable and central to the network. We also find a shift in type of participation from P1 to P3, adding analysis of the direction of degree centrality and weight of connection, shown in figure 2. "In degree" centrality (x-axis) is expressed as replies to a person; "out degree" centrality (y-axis) as replies from a person. Figure 2 illustrates increasing diversity of participation across the time periods, with more people favoring "in degree" or "out degree" centrality. To calculate weight of a connection, we assign less weight to communications engaging a larger group and greater weight to direct replies to another student, following benchmarks established by Goggins, Laffey, & Gallegher (2011), and a systematic methodological approach for analysis of trace data, called Group Informatics (Goggins et al., 2013).

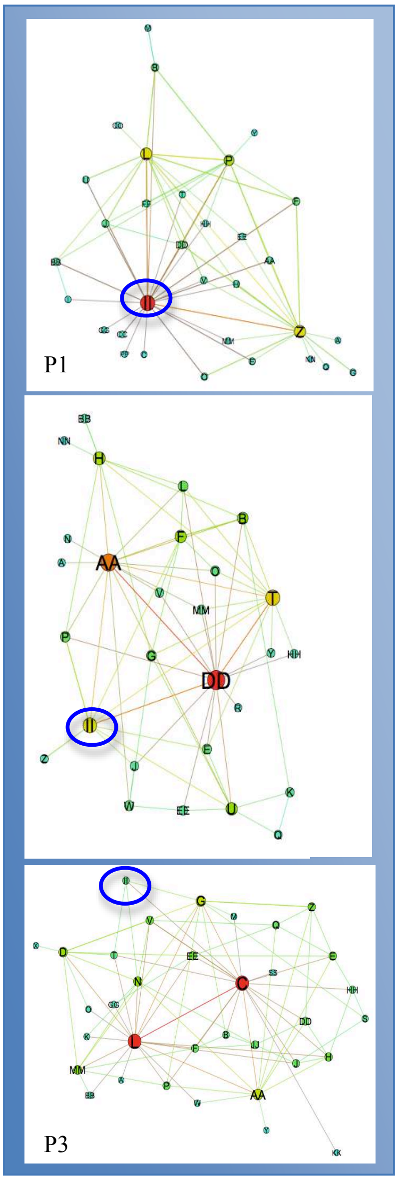

Figure 1. Social network diagrams of Yammer activity at three time periods: P1, P2, and P3. The instructor is labeled "II" and is circled for easier identification. Nodes are color-coded based on centrality from least to most central.

Types of Posts

Posts were initially classified as containing course content talk or "other" talk. Course content talk is defined as posts or replies related to core concepts and techniques of the class, as well as project related discussions. "Other" talk included course management and metacognitive behaviors related to awareness and reflection of students' own learning needs, practices, or experiences. Of the 98 Instructor posts, 58 (59.2%) were related to course management, a type of "other" talk. In contrast, only 55 of the 405 student posts (13.6 %) were "other" talk and 86.15 were directly tied to course content. Some of this "other" talk was included posts where students shared resources that challenged traditional learning models and would discuss their own learning experiences. Only 0.25% of total talk was considered off-task, not dealing with content or learning.

Content-related posts were examined for level of cognitive behavior. There were five levels of exhibited cognitive behaviors for content related talk: sharing, extending, checking/ rephrasing, synthesizing and interpreting (see table 1 for a list of exhibited behaviors, definitions, and frequency counts). Though extending posts were not ranked as highly as interpretation posts, these were used a great deal by students. Students would regularly go back to search for content materials or resources other students shared and would refer to them in class or use them for their projects. In fact, the most common student complaint of Yammer was that it was hard to find previous posts.

Findings indicate that the quality of posts were relatively high. Sixty-six percent of the posts were classified as synthesis or interpretation of course content. However, there was a range of quality within each level. For example, a post would be classified as interpretation if students made a content related claim and (1) supported this claim with evidence or rationale or (2) considered alternative viewpoints and weighed options. There were better and worse examples of rationale, evidence, and weighing of concepts in

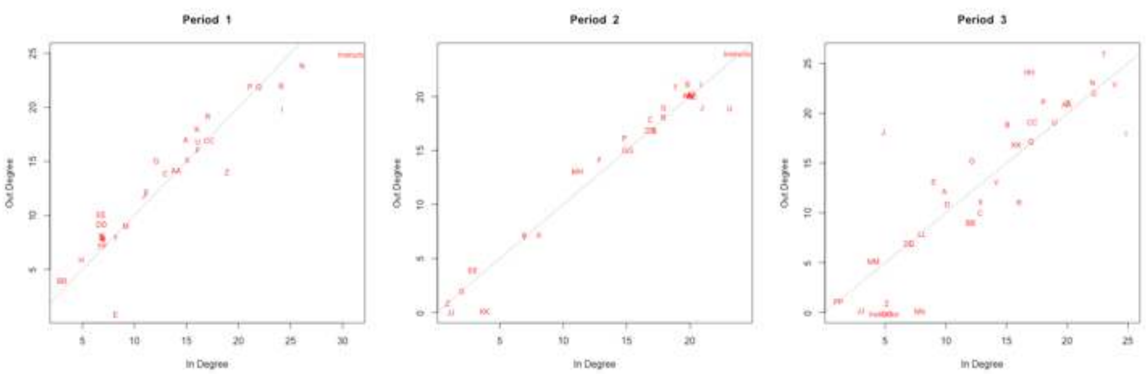

Figure 2. Increasing diversity of participation role across three time periods

Table 1: Types and levels of talk exhibited by students in the Yammer environment.

	Level/Type	Definitions	% of Posts
Content-related Talk	1- Sharing (SHR)	Discussing content or facts without making claims that are supported by rational or evidence. Cannot include concrete examples related to real-world use, links or attachments to additional material, reference to previous reply, or reflections on learning or thinking processes.	9.1%
	2- Extending (EXT)	Extending available readings or content material by providing links or attachments to additional content (video, article, concrete example, etc.) to help think about or understand course content. May include level 1 behaviors, but cannot Include rational, concrete examples related to real-world use, reference to previous reply, or reflections on learning or thinking processes.	17.3%
	3. Checking/ Repeating (C/R)	Checking understanding, clarifying what someone previously said, or repeating/rephrasing previous post without adding new ideas. May include level 1 or 2 behaviors, but cannot include new fact, claim, rational, evidence, connections to the real world, or reflections on learning or thinking processes.	1.7%
	4- Synthesizing (SYN)	Connecting info to other info - making connections to the real world, bringing multiple ideas together. Evidence that post is referring to previous post and adding to the idea, or that poster is connecting a previous idea to a real-world example that no one else has mentioned. May include level 1-3 behaviors, but cannot include evidence or rational for claims, or reflections on learning or thinking processes.	31.6%
	5- Interpreting (INT)	Connecting course content info to other info and making a judgment about it or evaluating a claim or work. Claims or opinions MUST be supported with rational or evidence, or they must show that they are weighing ideas against each other. May include level 1-4 behaviors, but cannot show evidence of reflecting on learning or thinking processes.	26.4%
Non-content Related Talk	MC- metacognitive Reflection/Awareness	Thinking about or sharing awareness of learning experiences as an object of thought. Reflecting on learning process, or demonstrating awareness of learning process by articulating learning patterns, or needs as learners. May include level 1-5 behaviors.	4.7%
	CM- Class Management	Posts related to organizing, coordinating, documenting, or deciding on classroom activity.	8.9%

posts. For example, a project team was gathering requirements for a design idea aimed at college students, posted a survey, and asked the class to help by providing data. A fellow classmate responded to the post by saying, “Hey I really liked the way your survey was designed, in terms of asking questions that all relate to each other in a series, and having repeating variables. Good luck with everything!” In this example, the student shares his opinion and supports that opinion with a rationale. For that reason it was coded as a level five, but it was one of the least sophisticated examples found. The following example shows a higher range of sophistication of thinking. The chapter students read, the week of the post, focused on different user interfaces and their affects on user experience. In Yammer, a student started a new thread, asking students to think about different user interfaces, trade-offs and design ideas related specifically to air-based gestures. The student presented Kinect for Xbox360 as an example from the book and asked, “Do you think adding a hand-held motion sensor control option would help to improve the Kinect's interface? Yes, it would make gameplay easier, No, the Kinect is fine how it is, Indifferent, I dislike the Kinect and prefer controller-based games?” Many students responded to this post and what follows is a response rated as a higher range level five post:

> “I agree with Stanley [tagged], Don [tagged], and Jack [tagged]. I prefer controllers over motion sensor gaming, and I think adding a "sensor controller" would make it way too similar to the Wii. I think the Kinect is a good concept, and is perfect for casual gamers or families who have younger kids, since I find that a lot of Kinect games are geared towards that age group. I think it helps to balance the Xbox360 as a whole to be more marketable to a wider ranged audience. It allows hardcore gamers to continue using controllers while allowing their younger siblings (or possibly children) participate in game time. In response to Julie [tagged], I was able to find statistics that say in 2011, 59 million Xbox 360's were sold and 18 million Kinect's were sold. Not the exact statistics we're looking for, but I think that it shows not all gamers who have 360's are strictly one type of gamer, although I think it does show that more users tend to use the 360 for hardcore over casual gaming.”

The student begins by choosing which students he agreed with, indicating that he read their posts and begins to synthesize their input with his own. He repeats one of the claims made in a previous post, “adding a "sensor controller" would make it way too similar to the Wii" and "Kinect is a good concept, and is perfect for casual gamers", but then adds his claim about appealing to younger kids. The student supports this claim, stating that Kinect games are mainly marketed to younger audiences. He further supports the claim that adding the Kinect appeals to different audiences, citing facts about the number of Xbox consoles and Kinects sold. He interprets the difference in sales as meaning that only small portions of Xbox users add the Kinect option and concludes that this is indicative of different markets. Here there is evidence of sharing, synthesizing, and interpreting. Interpreting is the highest level of cognitive activity; this post is categorized as a Level 5, interpretation post.

Discussion

Our approach examined the form and function of the social interactions that took place over time in the Yammer environment. Group informatics methods provided visual tools that allowed us to see changes in the structure of social interactions and changes in member activity. Communication analysis informed us as to the type of discourse activity that occurred and whether it matched to the designer's intent. Combining these research methods provided us with a clear understanding of how the instructional approach for using Yammer functioned in practice. Our findings shed light on the use of social technologies as a means to provide a place for students to share, explore, and think about course concepts with others. The learning goals for such a discourse environment are comprehension and application, not pure problem solving. This fills an important gap in research, as previous studies examining collaborative discourse, are directed at assessing the quality of joint problem-solving (Roschelle & Teasley, 1995), creation of common ground (Convertino et al., 2009), or conceptual change (Gunawarda, Lowe, & Anderson, 1997). These are important contributions, but they are not focused on more casual forms of knowledge application and the quality of discourse in a learning community.

Our data suggests that the combination of theoretically informed pedagogical design paired with the use of lightweight social media technology can provide students with opportunities to engage in learning processes associated with a community of learners approach to instruction without requiring unsustainable management practices from instructors. This is an important finding because it paves the way for exploring whether such approaches might scale to larger online learning environments. As online learning environments become more prevalent, a critical consideration should be what kinds of learning experiences do the environments model and support and how will these experiences shape students' understanding of important learning processes and expectations for student-instructor interaction. Our approach enabled students to learn how to become members of a design community, by connecting course content to real-world examples, seeking out ways to better understand course content, and engage in discussions with other students about core concepts and techniques related to human-centered design. Also of importance, it planted a seed in students about what it means to learn that challenged traditional instructional models. Students were also extremely connected within the environment, discussed disciplinary content in fairly sophisticated and meaningful ways, and eventually replaced the instructor as the central information giver and evaluator. Such processes may be even more critical for purely online courses as it may help students to feel more connected to each other and to the course content.

Another important contribution of this work is that presents social media environments as learning environments in their own right, spaces for learning through discourse rather than supplements for transmitting or checking information. These learning environments will likely never be the same as face-to-face interactions and this fact has both costs and benefits. Rather than emphasizing the ways in which these environments fail to emulate real-world learning activity, we must start figuring out how to use the inherent differences of these environments to extend learning opportunities. We can leverage the lack of students' experiences with these environments to create a "space" for students to engage in processes they might avoid in face-to-face interactions. Previous findings related to students' lack of ability in college courses, may be the product of a context that prioritizes task completion over quality of discourse. When groups face time pressures they tend to prioritize task completion over the processes they use to complete tasks (Kerr & Tindale, 2004). This implies that the pressure of time constraints and required activities imposed by college course structures, combined with students' previous experiences, may interfere with students' ability to exercise and improve processes of conceptualization and discourse. Providing students with a less stressful context, new structures, and theoretically informed interaction designs may help to mitigate this problem.

Future studies will examine student perceptions of the Yammer as a learning tool and include a more fine grain analysis of the strengths and weaknesses of the pedagogical design. We also plan to compare differences between resident and online student populations. Through this work we aim to develop a better understanding of the variables associated with rich discourse environments so as to better meet the needs of students and incorporate the application of learning theory into the design of new digital learning environments.

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