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Cohesion in online environments

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Abstract
This paper presents a study of group cohesion as it arises in online small group different time and place collaboration. Cohesion is modeled in terms of the extent to which a group makes progress together through contentful and meaningful collaborative interactions. This paper makes the case that cohesion in a small group working collaboratively online emerges as a result of the overall level of engagement settled into by the group. As students participate in a collaborative task, they make choices in the extent and way in which they engage in a particular aspect of that task. The choices made by students in how to engage determine the scope and quality of the cohesion that emerges. Data were collected from a one-semester course where students worked on design problems in an online, different time and place, community in small groups. The collective pattern of engagement gives insights into characteristics of the cohesion that emerges within the community and within each small group.

Keywords Cohesion · Online collaboration · Engagement Q2

Introduction Q3

Early prognosticators of the Internet claimed that the Internet amplified people's social skills (Shirky 2008). From this perspective, learning online portends to be "as much social as cognitive" with the Internet as a medium for sharing information and creating "socially constructed and shared" understandings (Brown 2000, p. 14). Despite the promises of technology-mediated learning collaborations, students frequently find online spaces to be awkward places in which to interact. Thus, the promise of virtual collaboration as a basis for learning is not always achieved (Barron 2003). Online, students find it difficult to feel connected to others (Delahunty et al. 2014) and, consequently, it is harder to communicate,

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coordinate, and collaborate (McInnerney and Roberts 2004). The limits on communication in a virtual space and difficulties in achieving copresence result in a more reflective form of collaboration (Alterman and Harsch 2017). The awkwardness of virtual collaboration interferes with the sense of connectedness that is a prerequisite to effective collaboration and interferes with the group's ability to function as a group. The ideal of small group learning is that the members of the group work and learn together – they work *cohesively*.

Collaborative learning emerges as a result of the meaningful interactions among the participants (Roschelle and Teasley 1995; Stahl 2015; Koschmann et al. 2005). Without cohesion, the members of the group work as separate individuals acting in parallel instead of as a unit working together and building on and negotiating between viewpoints on a collective task. Cohesion within a group is a necessary, but not sufficient, basis for meaning-making: for example, a group can work cohesively to coordinate their collaboration without being focused on meaning-making. When the collaboration is mediated by technology, designing the learning activity and the technology in such a way that allows the group to come together and work cohesively also lays some of the groundwork for meaning-making to potentially occur.

Cohesion is an attribute of both communities (Kawachi et al. 2000; Forrest and Kearns 2001; Easterly et al. 2006) and small collaborative groups (Miyake and Kirschner 2014; Slavin et al. 2003). When small collaborative learning groups are cohesive, the participants are affiliated with the group in the sense that they want to stay a part of the group (Banki 2010) and their identification with the group is a motivation for engaging in the task (Slavin et al. 2003). The interpersonal relationships that develop, whether positive or negative, are characteristic of groups that work cohesively (Hogg and Turner 1985). Group cohesion can be divided into social and task-related components (e.g. Miyake and Kirschner 2014). Task cohesion has been shown to be positively related to group outcomes (Van den Bossche et al. 2006). The relationship between social cohesion and outcomes is less clear: some studies claim that social cohesion is not related to group outcomes (Carless and De Paola 2000), while others show that social cohesion may lay the foundations of commitment to the task and boost task cohesion, making the group more effective (Zaccaro and Lowe 1988). However, in activities where interaction is required to successfully complete the group's goal, such as a collaborative task, both social and task cohesion are required (Zaccaro and McCoy 1988; Casey-Campbell and Martens 2009).

These prior studies have largely focused on cohesion in face-to-face groups. This paper develops a model of online cohesion in the context of small group collaborative learning (small group cognition: Stahl 2006). The features of group cohesion and the issues involved in supporting the emergence of cohesion transform when the group interacts exclusively online. Cohesion, in this paper, is characterized as the extent to which the group makes progress together on a learning activity through contentful and meaningful collaborative interactions. Cohesion is explored in terms of social and task-related factors. A cohesive group is characterized by engagement by group members in a manner that helps the group as a whole make progress: individuals in the group will share and develop ideas that help one another through the collaborative task. In working groups, the group as a whole may work in a manner that is more individually-oriented or more collectively-oriented. A group with a more collective orientation exhibits a stronger commitment to the collaborative process and displays more cohesion.

The data presented in this paper were collected from a one-semester case study of students working on design problems in an online, different time and place, collaborative learning

platform. In small groups, individual learners share their own first draft of a response to an assignment, then give and receive feedback within their group before submitting a final draft of their individual response at the deadline. The balance between individual and collaborative elements of their task are directly relevant to the cohesiveness that emerges within each group.

The analysis relates the overall cohesiveness of the group to the engagement of its members. The degree of cohesion within the collaborative group is directly related to the individual decisions of the extent and manner in which to engage. If one participant perceives others in the group as lacking engagement in the collaboration, the potential for collaboration perceived by the first participant is diminished, so she also becomes less engaged. At some point, each group reaches a level of participation that reflects the collective estimates of the potential for productive collaboration. This settling point is a marker of overall identification as a group and is co-extensive with the cohesion exhibited by the group. The pattern of participation settled into by the groups in the study indicates that, while students are willing to produce substantial content that can help their group members make progress, the effort associated with dialoging within the group limits within-group cohesion that develops in the online space.

This study is a stepping stone toward understanding how to design online collaborative learning platforms that support the development of cohesion within the group, which will have an impact on the productivity of the learning collaboration and the ability of the group to engage in intersubjective meaning-making.

Background

Collaborative learning has multiple features: the participants are of equal status, they have equal opportunity to contribute, and they work together to negotiate their different points of view as they make progress on a joint task (Dillenbourg 1999). Collaborative learning depends on the cognitive effort students put forth to build their shared understandings (Schwartz 1995): it is the development of shared understanding within the context of their joint endeavor that gives rise to learning (Roschelle and Teasley 1995; Stahl 2015; Koschmann et al. 2005).

Learners engage in meaning-making when they jointly try to make sense of a knowledge construct, skill, or task. Intersubjectivity is the idea that, through meaning-making interactions, individuals make progress toward a common understanding. The frequency of "rich interactions" can serve as a marker for the cognitive effort that students are putting forth (Dillenbourg et al. 2016), and thus, the collaborative learning that is occurring. Intersubjectivity is achieved in groups that are able to interact productively in order to make progress on their collective goals (Stahl 2010) and is shaped continuously throughout the collaborative task (Arnseth et al. 2004). An important case of collaborative learning is small group learning (Stahl 2006).

Collaborative learning within a small group is more than the sum of individual learning (Stahl et al. 2014). Instead of theorizing about the mental models of individual learners as they engage in a learning activity, the focus of small group learning is on things that emerge from interaction during the collaboration. The interaction and conversation of small groups leads to the production of group cognition (Stahl 2006). Group cognition is a form of intersubjectivity (Stahl 2016): the meaning-making that a group engages in is the process through which the group learns. It is not that the sum of each individual's understanding equals the amount of knowledge "contained" in the group, but that the group, as an entity itself, learns through the interactions of the individuals. The knowledge acquired by the group, in turn, can be learned

by each individual in the group. Thus, a small group is an important unit of analysis (Stahl 2007); analysis of conversation and activity within the group provides significant evidence for the learning that occurs in collaborative learning environments (Roschelle and Teasley 1995).

Group cognition – and, more generally, collaboration – depends on social context. Because the interactions within a group are part of a social system, the quality of the discourse that enables the development of group cognition is, at least in part, a function of the strength and quality of the social bonds (Vygotsky 1964). Cohesion – roughly the extent to which a group sticks together in their joint endeavor – in a small collaborative group shapes the social structure of that group. A group can stick together to accomplish a task but the task is not necessarily meaning-making; for example, a group that does divide-and-conquer to accomplish some goal can be working cohesively but is not specifically engaged in meaning-making. On the other hand, intersubjective meaning-making only occurs if there is some level of cohesion within the group. If a group is not cohesive, there is not enough of a basis of togetherness for intersubjective meaning-making to occur.

Technology and meaning-making are the central components in Koschmann (2002, p. 20)'s definition of the field of computer-supported collaborative learning (CSCL): "a field of study centrally concerned with meaning and the practices of meaning-making in the context of joint activity and the ways in which these practices are mediated through designed artifacts". When technology mediates the learning collaboration, the design and affordances of the learning technology impacts the ways in which the group inter- acts, and thus, the intersubjectivity that is achieved in the working group (Suthers 2005). The focus of CSCL should be the "design and study of fundamentally social systems that are informed by the affordances and limitations of technology" (Suthers 2005, Ibid., p. 666). The design of the technology impacts many facets of a collaborative activity: for example, the extent to which collaborators achieve common ground (Dillenbourg and Traum 1999), the intensity of the discussion and the number of indicators of mutual understanding within the discussion (Bause et al. 2018), and the ability of collaborators to connect and socialize (Kreijns et al. 2013). If a design supports within-group cohesion, a necessary condition for meaning-making is achieved.

Traditionally, meaning-making has been tied to the production of a shared artifact. In the study presented in this paper, the participants are not producing a shared artifact. Nevertheless, they are engaging in meaning-making through shared discussions about individually constructed artifacts. These shared group discussions are where the students negotiate their viewpoints. The content of the individual artifacts provides a starting point for the meaning-making. This paper aims to measure cohesion in online collaborative learning groups that work different time and place. Engagement in productive interaction serves as a marker of cohesion as it is an indicator of the group's commitment toward making progress toward collective goals. By measuring cohesion in this manner, the cohesion that emerges in the working group is also an indicator of the level at which intersubjective meaning-making is occurring and the productivity of the collaboration that is achieved. This paper will also show that the design of the technology also influences the ways in which the group is able to work cohesively.

Cohesion and engagement

Two general methods of measuring cohesion are self-reports (e.g. Carron et al. 1985; Miyake and Kirschner 2014) and behavioral markers (e.g. Mizruchi 1993). Online, behavioral markers are tied to actions taken and content created by the user; for example, communication within a working group has been used as a behavioral marker to measure online group cohesion

(Garrison et al. 1999). The study reported in this paper uses behavioral indicators of engagement to measure cohesion. It examines closely the interaction between how the students engage and the cohesiveness of the group. The basic idea is to connect the behavior of the participants, as measured by their engagement, to the degree and manner of cohesion that manifests among the working groups. Both the type of engagement and the degree of engagement factor into the type and extent of group cohesion that emerges. The crux of the matter is that, because collaborative engagement is more difficult to achieve in an online environment, engagement becomes a determining and limiting factor for group cohesion.

Engagement online In an online collaboration, engagement, overall, is more difficult to achieve and maintain (Sun and Rueda 2012). For example, the cost of production, cost of interaction, and the cost of grounding are all higher online compared to face-to-face (Clark et al. 1991). The increased cost of engagement can introduce constraints on cohesion.

In an online environment, it is not readily obvious when students are attending to the collaborative task (Beuchot and Bullen 2005; Alterman and Larusson 2013); for example, participants might be logged in but not near their computer or might be attending to information on a different part of the page or a different page entirely. It is not always clear if a contribution has been noticed and understood by other participants. This can make it more difficult to communicate and impacts the ability of participants to socialize (Wainfan and Davis 2004), which diminishes the potential for interpersonal relationships to develop (Aragon 2003). The hampering of social presence impacts the ability of relationships to develop as quickly or as strongly as it may in a face- to-face interaction (Aragon 2003). If the online medium makes it too difficult to convey substantial thoughts, it may also reduce a student's willingness to participate thoughtfully.

These obstacles to online engagement also introduce potential obstacles to cohesion within the group. Without engagement, there is not going to be any cohesion in the group because members will not be involved enough for the group to function effectively on the task as a group.

Types of engagement Four types of engagement were identified by Sinha et al. (2015) for face-to-face collaborations:

Behavioral engagement Behavioral engagement is the degree of on-task participation by members of the group.

Social engagement Social engagement is the quality of the relationships between group members.

Conceptual-to-consequential engagement Conceptual-to-consequential is defined as the degree to which the learners make progress toward applying the learning content to a larger task context. This type of engagement is more centered on the content of the learning task and the commitment of learners to work toward connecting the concepts from the learning activity to a larger context or purpose.

Cognitive engagement The Sinha et al. (2015) definition of cognitive engagement focused on the cognitive engagement to collaborate, i.e., the extent to which the participants planned, monitored, and evaluated their collective actions. Cognitive engagement can also refer to how

much effort the students are willing to put into their learning and how much and to what depth they are thinking about the material at hand (e.g. Blumenfeld et al. 2006); for example, the work on online discussion forums defines cognitive engagement as "... attention to related readings and effort in analyzing and synthesizing readings demonstrated in discussion messages" (Zhu 2006, p. 454). The analysis in this paper will focus on cognitive engagement in making contributions that communicate, which more closely aligns with the second version of cognitive engagement.

To convert these types of engagement to an online collaboration will require they be translated from face-to-face activity to the interface actions and content created by the users. Online, the ways in which participants engage with each other and with the task can be quantified by analyzing patterns of participation and assessing the online artifacts that are created within the group (e.g. Perkins and Murphy 2006).

The study

This study is part of a research project to develop different time and place platforms that support within-group cohesion during collaborative learning. The overarching method is design-based research (DBR) (Barab and Squire 2004; Collins et al. 2004). The goal of DBR is to bridge the gap between education research and practice. The DBR framework allows researchers to advance theory through several iterations of design: each iteration of a learning platform represents a different configuration of practice, theory, and artifact as it impacts learning. In this context, researchers can study social interaction in a naturalistic environment, allowing for more transfer between educational theory and implementation in the real-world classroom (Anderson and Shattuck 2012; Hoadley 2002).

This paper presents evidence from a case study of a particular collaborative learning environment. Case studies are in-depth explorations and examinations of a confined example that can be generalized to have broader implications (Flyvbjerg 2006). Conclusions drawn from the interaction patterns within the confines of the environment used in this study "can also represent generally applicable results, in that the methods that people use to interact are widely shared" (Stahl et al. 2006, p. 416).

This study was conducted in a semester-long interdisciplinary class on computer- supported cooperation cross-listed in the Computer Science and Psychology departments at Brandeis University. The class was taught as a blended class with lectures in-class and homework completed online. The class had 29 students.

For this study, a homework platform was custom-built to support student collaboration for the homework assignments. Any collaborative activity strikes a balance between individual elements and collaborative ones, each of which have their respective tradeoffs (Alterman and Harsch 2015). For example, individual elements allow students to own their own thoughts and work, while collaborative elements allow students to be exposed to multiple viewpoints. The balance between the individual elements and collaborative elements in the task will inform the degree of cohesion that is necessary for success in the situation: collaborative elements will require more cohesion (Dietrich et al. 2010). The analysis will focus on the more collaborative elements of the learning activity as these are the elements that require more cohesion for productive work.

For each assignment in the course, students were tasked with designing a technology-mediated collaboration. For example, one assignment tasked students with designing a collaboration for employees who were located in different parts of the country but needed to meet virtually in real-time to organize a set of training slides for new employees. Students were asked to consider things such as turn-taking, floor control, and co-referencing in their design.

The students first submitted an initial draft of a design for each assignment and those posts were then made public to the rest of the class after a given deadline (Alterman and Larusson 2013). The initial individual drafts allowed students to develop their own thoughts before sharing with others. Students used pseudonyms on the platform and were asked to keep their pseudonyms private from other members of the class. After the initial draft deadline, students worked collaboratively to improve each of their individual drafts. The collaborative phase allowed students to gain exposure to different points of view with relation to the assignment. After completing the assignments, the ten posts that received the most activity in the form of reads and merit badges entered a "tournament" in which the rest of the class then ranked those ten posts producing a final ranked list of the top ten posts for an assignment as decided by the students in the class. The tournament data are not considered in this study.

Students were each randomly assigned to a group of 3–5 students and were required to produce comments on the posts of at least two of their group members. They were also encouraged to leave comments on the posts of students not in their group and to participate in dialog, both within and across groups, by replying to comments and carrying out conversations as a way to develop their ideas and leverage the knowledge of their classmates. As another form of feedback, students could also give merit badges to the posts they read with the following four categories: good design, good examples, well-written, and good reflection statement. During the commenting phase, students could freely edit their initial draft up until the given final draft deadline. Students completed three assignments throughout the semester using this progression and each assignment took several weeks to complete. For a summary of this process, see Fig. 1.

The platform

Figure 2 shows a snapshot of one student's post for the training slide assignment on the homework platform that was used. Each student developed a draft of the design for technology that would mediate the training slide problem. Some key elements of the interaction on the homework platform are marked 1–4 in the figure. Roughly, the left-hand side of the screen has the current draft of the student's post and the right-hand side of the screen is where the discussion with group members occurs. Students can contribute to a discussion by adding a new comment or replying to a comment that has already been left. Each member of the team has a separate post and discussion associated with their post.

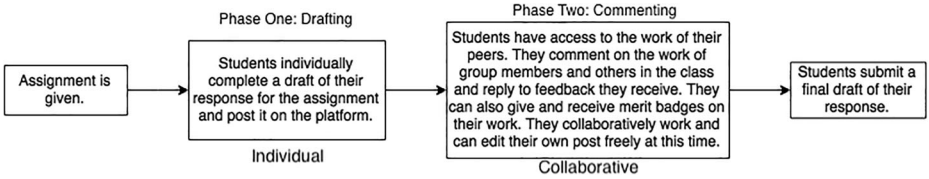

Fig. 1 The two drafts of a homework assignment

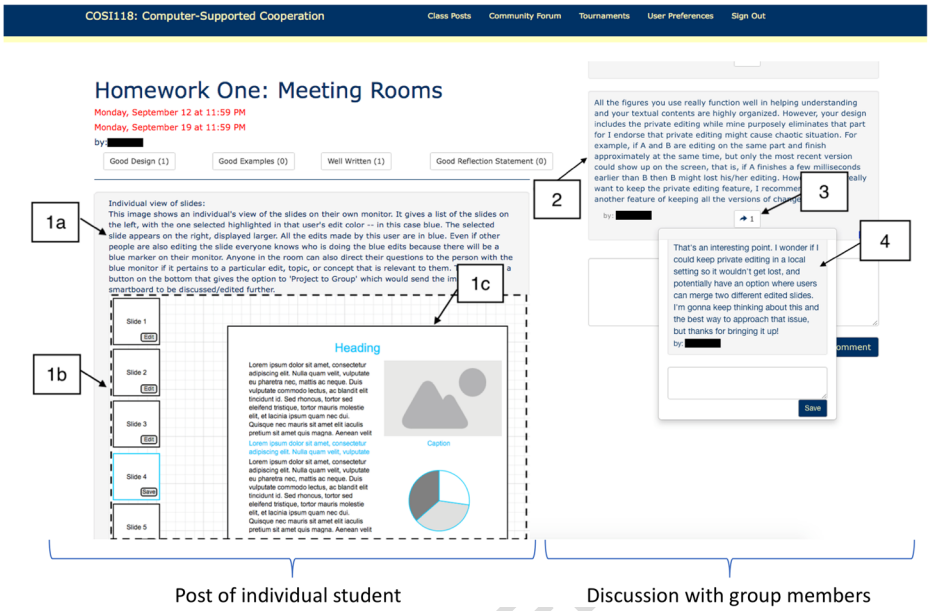

Fig. 2 A screenshot of the homework platform. (1a) The post of this student includes some text explaining how each individual user of their proposed design for the training slide problem would view the slides. (1b) The post of the student includes an image of the proposed design in which you see a selection of all the training slides on the left-hand side. In the student's example, the user has selected slide 4 (outlined in blue). On the right-hand side of the image, you see the details of one of the slides. In this case, since slide 4 is selected, the right-hand side of the interface will display the details of slide 4. (2) Students can leave comments to the author of the post giving them feedback about the current state of their post. (3) Each comment can be replied to where the replies will be nested under the comment they are linked to. Clicking the button associated with each comment will open a popup that displays all the direct replies to that comment. (4) In the example shown, the author of the post has replied to a comment received by one of their group members, which is nested under the comment to which the author is replying

Data

The online learning environment was built using Ruby on Rails with a MySQL database. The system collected data about which posts students read, when they edited their homework post, and when they visited various pages on the platform using the Ahoy gem. The database also contained the full text of the first and final draft submitted by a student for each homework assignment and all of the comments and replies they wrote across all three homework assignments.

Measuring cohesion in terms of engagement

Cohesion is comprised of social and task elements. Multiple components impact and influence each element (see Fig. 3). There are multiple factors that impact social cohesion; for example, the interpersonal space, inclusivity, and interactivity. Similarly for task cohesion, there are multiple factors of impact; for example, coordination of effort, joint focus, and cognitive engagement.

The focus on this paper is the relationship between engagement and cohesion. Engagement factors provide measurable indicators of the cohesion that is emerging within an online group.

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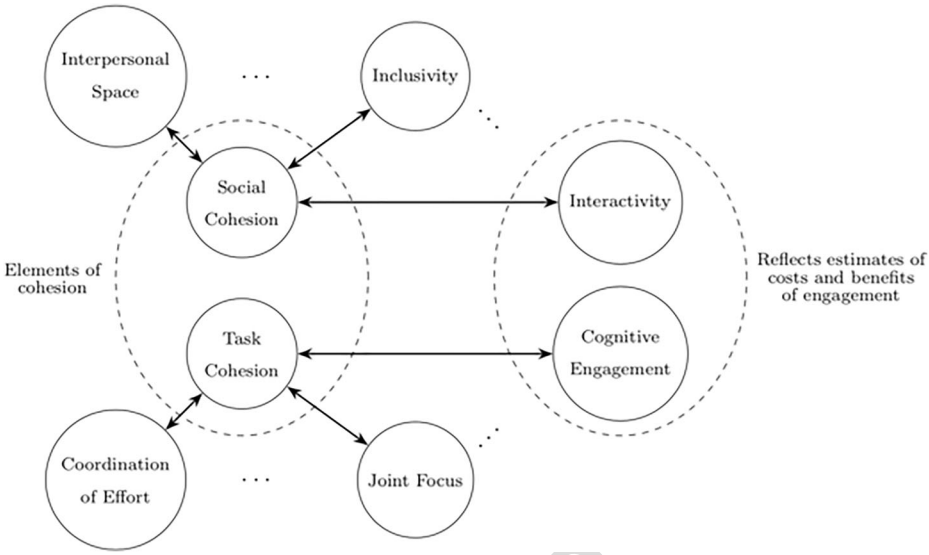

Fig. 3 The interaction between elements of cohesion and the choices individual students make toward how to engage in the collaboration. Social cohesion also interacts with other factors like the interpersonal space and inclusivity. Task cohesion also interacts with factors like coordination of effort and joint focus

When the work of the group is done online, the technology has an impact on the degree of engagement of the participants. If it is too hard to engage, the amount of cohesion will remain limited. The manner in which the learners engage with one another is an indication of the type of cohesion that is emerging. For example, if the learners engage interactively with one another, then there is evidence of both social engagement and social cohesion emerging; if they engage thoughtfully, then there is evidence of both cognitive engagement and task cohesion emerging. However, if these types of engagement remain limited, then the cohesion within the group will also be limited.

Behavioral engagement and cohesion

Behavioral engagement in the context of this learning activity includes factors like how much an individual student read, the degree to which they edited the draft they produced during phase one of the assignment, and how many comments they generated during phase two of the assignment. Factors like these are behavioral because they are simple measures of work. If the student reads a lot, they are spending time reading. If there are a lot of edits, it means, during the second phase, the student put effort into editing their initial draft. If they do not generate many comments, they are not putting much effort into participating directly in the collaboration. And so on. All of these factors impact the cohesion that emerges within each group.

Interactivity and social cohesion

In this paper, social cohesion, is measured by interactivity among group members, which is a form of social engagement. This serves as a marker of the extent to which the group is working together as opposed to working in parallel, which is a key element of social cohesion.

When the collaboration proceeds completely online, it becomes more difficult to know who is attending to the information on the platform (Beuchot and Bullen 2005). A passive interaction occurs between students when one student reads the post of another student; another form of interaction, which is more active, is when one student comments on the post of another student (Alterman and Larusson 2013). Online, there is no immediate way for the student who wrote the comment to know if their comment was read by anyone.

The only avenue by which two students can directly engage with one another is when one student directly replies to the comment of another student. This interaction is observable by both participants in the interaction: the writer of the reply to the comment has read and considered the content of the comment and, by receiving a response, the writer of the comment that was replied to has evidence that their comment was read and considered by another participant. In this paper, interactivity is based on the amount of dialog of this sort between students.

Cognitive engagement and task cohesion

Task cohesion is measured in terms of cognitive engagement within the group's work. This serves as a marker of how thoughtful and committed the participants are toward their joint purpose and collective goals.

There are two types of cognitive engagement on the platform. One type is the degree to which a student cognitively engages in her individual design work. A second kind is where the students cognitively engage in the collaboration. It is the second kind, which is more related to the quality of the collaboration, that is the focus of this paper.

Methods

In order to develop a model of cohesion as it relates to patterns of engagement in a collaboration, three engagement factors are quantified in this study (see Table 1 for summary): behavioral engagement, interactivity (a form of social engagement), and cognitive engagement. While the quantifications made are specific to the learning activity in this study, they can be generalized to other learning activities.

Behavioral engagement was measured in terms of reading, editing, and commenting. Each time a student navigated to a post on the site, the system logged it as an instance of that student reading that post. Each student could have read a specific post once, multiple times, or not at all. Editing was measured in terms of edit distance between the first draft and the final draft of the student's post. This was done using a Python script that calculated the Levenshtein distance

t1.1 **Table 1** Quantitative measures

t1.2	Behavioral Engagement	Count of reads Edit distance between drafts Number of comments
t1.3	Interactivity of Comments	Tag 0: no references to any previous comment Tag 1: at least one reference to a previous comment
t1.4	Cognitive Engagement of Comments	Tag 0: no evidence of critically thinking about course material Tag 1: at least some evidence of critically thinking about course material

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between the first and final draft and dividing it by the longer of the two drafts to normalize the data. Commenting behavior was quantified using counts of comments and replies to comments written by students. These comments or replies could have been on their own post, the posts of other members of their group, or the posts of other students in the class who were outside of their group.

For the interactive and cognitive engagement scores, a tagging scheme was used.

Each comment and reply to a comment was tagged independently by two raters for the presence or absence of interactivity and cognitive engagement: each comment received a 0 or a 1 for each of these concepts.

The scale for the interactivity score was adapted from work on interactivity in online discussion forums (Beuchot and Bullen 2005). In this case, a comment that received a 0 made no explicit reference to another comment within the conversation and a comment that received a 1 made some explicit reference to at least one other comment in the conversation. Example 1 shows a snippet of one of the conversations that occurred on one post.

(1) a. **User 24:**. .. I am curious about how the descriptions of locales will work though. You mention that if you click on a location on the map, a detailed description will appear. I feel like there can be a lot to say about cities, so what relevant details will be included?. . .

b. **Author of Post:**. .. For the locale part, once you click on the map, a pop-out window will occur, and corresponding information will be there. ...

The comment written by user 24 in 1a does not refer to another message in the thread. Consequently, this comment is considered to be a non-interactive comment and receives a tag of 0 on the interactivity scale. The author's reply in 1b, however, does directly respond to the preceding comment (1a by user 24) and thus receives a 1 on the interactivity scale. In 1a the student discusses locales, and in 1b the author of the post responds to that part of the previous comment. This kind of interaction warrants the tag of 1 for comment 1b.

Example 1 shows that the author of the post is being interactive in the comment they write but it does not measure whether the students are focused on content (i.e. cognitively engaged). In order to quantify whether student contributions were focused on the content of the course material, comments were tagged as a 0 or 1 with regard to the absence or presence of cognitive engagement. A comment that is not cognitively engaged remains mostly superficial, without any evidence of the student critically thinking about the material at hand and would receive a tag of 0. A cognitively engaged comment shows evidence that the commenter is critically thinking about the subject matter at hand and would receive a tag of 1 on the cognitive engagement scale.

Example 2 shows a snippet of a longer comment that is not cognitively engaged. In this example, user 21's comment simply compliments the post. The rest of the comment continues in a similar vein, one compliment after another without saying anything substantial. The compliments do not show evidence of critically thinking about the content of the post as the commenter does not explain why the aspects he or she is complimenting are, in fact, good and does not go further and explain how they could be better. As such, this comment receives a 0 for cognitive engagement.

(2) **User 21:** Great job on the HW! I liked how you thoroughly explained the COBLAB readings and listed the problems that the monitoring had by combining what we learned in class. Also, I liked how you added a new critique of grounding as I didn't know too much about that subject.. . .

In contrast, example 3 shows a snippet of a longer comment that is cognitively engaged. User 3 poses questions to the author of the post. He quotes a portion of the draft and points out some potential issues that would arise with the idea the author is proposing. This comment shows that the commenter is critically thinking about the content of the post on which he is commenting. As such, this comment receives a 1 for cognitive engagement.

(3) **User 3:**. .. What methods do you propose to repair divergences in group member ideas? "things can be pinned but only once all users have pinned it together in agreement." – this sentences implies unanimous decision-making is required – this is easier in small groups than large ones. Would you impose a restriction on group size?. . .

In order to measure inter-rater reliability for the codes, Gwet's AC1 was used (Gwet et al. 2002). Because the study seeks to observe and measure a skew in the relative proportion of interactive and non-interactive comments as well as cognitively engaged and non-cognitively engaged comments, a reliability measure was chosen that was insensitive to this sort of proportional skew. Inter-rater reliability was found to be substantial across both scales (cognitive engagement: 0.904; interactivity: 0.930). Because inter-rater reliability was substantial across both scales, the tagging of one tagger was randomly selected and used for data analysis purposes.

Results

Students could participate in the collaboration in different ways. For example, students could choose to put all of their effort into the initial draft and then do minor revisions or they could do a quick first draft and put greater effort into the revised draft. During the revision phase, students could choose to ignore the draft work of others or use the draft work to support their revision work. In terms of commenting, students could choose to engage in purposeful and interactive dialog with their group or they could largely ignore one another. Each of these choices the students make on how to engage in the collaboration informs the features of the cohesion that emerges within the working group and serves as a marker for that cohesion.

Writing and Reading

In writing the assignment, a student's effort is distributed between writing the first draft, reading the work of others, and revising to produce their final draft. A student can choose to put most of her effort into the first draft and not do much revision work, or she can choose to put more effort into the revision. Whether or not, and to what degree, the students avail themselves of the draft work of other students as they revise also impacts cohesion. The choice to make the investment in closely reading the work of other students is a sign that the student is finding some value in the collaborative elements of the platform: the students are collaborating to share with one another their draft work as a resource for their revision work.

The analysis of the data shows that the students found benefit in using each other's draft work as a basis for their individual revision work. The students' investment in the revising phase and their selective use of the draft work of other students increased over the course of the semester. Their decision to engage in this manner is evidence that the community is functioning with some level of cohesion: through their actions, they reveal a consensus to commit to a

certain level of cooperation and collaboration, which is a marker for a minimal level of cohesion emerging.

Cohesion in revision work (both social and task cohesion)

Revision behavior is measured by edit distance. Edit distance is calculated as the percentage of text from the first draft changed in the production of the final draft. Table 2 shows that after assignment 1, students increased the amount of editing and maintained that increase for both assignments 2 and 3.

On the first assignment students revised 32.2% of their submission. On the second assignment, they revised an additional 9.54% of their posts. This increased editing behavior persists for the third assignment as well. This shift towards more editing denotes a shift in engagement toward the second phase of the assignments.

Another indication of this shift in engagement is that, by the third assignment, the length of the first draft, as measured by word count, is roughly 9% shorter than it was for the first assignment, while the final draft on the last assignment is roughly 14% longer. These edit distance and word count numbers imply that students are increasing their engagement toward the collaborative phase.

By the third assignment, the students are doing more editing, but, while they are editing, to what degree is their editing informed by the work of other students within their group or in other groups?

Students will extensively read the work of their cohort only if what they are reading is useful and informative. Thus, the effort they spend in reading the work of their peers is one measure of the extent to which participation in the group has value. If the drafts are poorly constructed, there is no incentive to spend much time reading. If the drafts are written thoughtfully, the benefit of participation increases. For these reasons, there is a connection between reading behavior and cohesion.

During the revision phase, both the number of times students read posts and the number of different posts they read are substantial. Table 3 shows the distribution of reading effort for posts within their group versus posts outside of their group.

Within their groups, nearly all of the students read all of the posts written by their group members over the course of the three assignments. Reading the posts of group members is an indirect requirement of the assignment because commenting on the post of at least two group members is required. In order to write a substantial comment on a post, one must first thoughtfully read and consider the content of that post. There is no requirement to comment on the posts written by students in other groups, yet students are still reading multiple posts written by other members of the community: students read, on average, 5.46 unique posts per assignment outside of those written by their group members.

Students read a variety of posts, but they also sometimes read individual posts more than once. The students read individual posts of their group members substantially more frequently

t2.1 **Table 2** Editing behavior

t2.2		Assignment 1	1 → 2	1 → 3
t2.3	Edit Distance	32.20%	+9.54%	+9.17%
t2.4	Word Count of First Draft	1258.43	−27.13	−116.98
t2.5	Word Count of Final Draft	1702.77	+157.55	+234.71

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t3.1 **Table 3** Reading Behavior

t3.2		Avg. # of Unique Posts Read Per Assignment	Avg. # of Times Specific Post Read
t3.3	Within Group	2.87	9.18
t3.4	Outside of Group	5.46	1.43

than posts they read that were produced by students in other groups. Across the three assignments, on average, students read an individual post of a group member 9.18 times, and, individual posts written by students outside of their group 1.43 times.

Taken together, this pattern indicates that students tended to read posts within their small groups with a focus on depth, while they read posts outside of their group with a focus on breadth. In other words, students would carefully read the posts within their group and would explore the greater community, reading more posts but fewer times, to gain a wider viewpoint on how others in the community were thinking about the problem. This pattern is an indication that the students felt more committed to helping those in their small groups make progress, while the community at large was used as more of a resource. As such, there was more cohesion within their small groups than among the community as a whole.

A more detailed analysis of the reading gives insight into how participants are choosing the posts they read outside of their groups. On each assignment, roughly a third of the posts attract 50–60% of the across-group reads. There was variance in the characteristics of the posts that attracted many of the across-group reads, indicating that individual students had different strategies when it came to identifying posts to read outside of their groups.

After an assignment was completed, the teaching staff identified certain posts as "gold star" work, ones that were exceptional for one reason or another. During the assignment, the student did not know what posts would be identified as gold star work. Nevertheless, posts that were identified as gold stars had a higher concentration of across-group reads than posts that were not later marked as gold star work. Posts that were later marked as gold stars were read by individuals outside of the group in which they were posted, on average, 9.78 times compared to 7.36 times for posts that were not gold stars. This is an indication that the students, as a community, are discovering quality work on their own and focusing their reading on those posts, which means that many students are cognitively engaged enough to recognize good work.

The posts of students who were more active in the community also attracted a higher concentration of reads. Eleven students wrote comments for posts outside of their group during the course of the semester. The data show that there is some relationship between having written an out-of-group comment for an assignment and attracting more reads for one's own post for that assignment. There was a positive correlation between the number of across-group reads a particular post attracted and whether the author of that post wrote comments for others outside of their group for that assignment, $r = 0.23$, $p < 0.05$.

The community, as a whole, identifies quality work and focuses reading effort on those posts. Reading is also focused on the work put forth by those who are more active in the community. The pattern of participation reveals that the students feel it is worthwhile to put effort into revision work and selectively read the work of other students as input to revision work. To sum up, in terms of cohesion, the fact that students have enough of a commitment to the collaboration to both produce work that has quality and to discover and read the quality work is an indication that, on the online platform, the students are functioning, to a certain degree, cohesively.

Commenting and discussion

In the commenting phase, the balance of effort is determined by the student's choices with regard to engaging in discussion with their peers. For each assignment, each student was required to write two comments on the posts of their group members; they were also encouraged, but not required, to write comments for group members who had not yet received comments on their post. There was no requirement to write comments on the work of students in other groups.

Within the context of the collaborative elements of the task, students could choose to simply write a comment, write a thoughtful comment, respond to comments, and write a thoughtful response to comments. Each of these decisions impacts both the quality of the collaboration and the cohesion that develops. The choice to respond to comments thoughtfully is required for students to begin to negotiate about ideas, which lays the groundwork for the most productive form of collaboration and indicates the most cohesion.

Writing comments (social cohesion)

Students were required to write comments on the posts of other students but they could also write comments on their own post in response to comments they received.

Students wrote more comments than was required of them. Students, on average wrote roughly 4 comments per assignment. Of those 4 comments, 2.55 were on the posts of other students, which is an increase of 27.5% over the requirement. The remainder were attached to their own post, largely in response to feedback they received.

Thoughtful comments (task cohesion)

The cognitive engagement scale measures how thoughtful a comment was. The data show that students were largely cognitively engaged in the comments they wrote. The average cognitive engagement score of the comments and replies produced across all of the assignments was 0.907 out of 1; of all the comments and replies written, 90.7% were cognitively engaged.

There were two kinds of comments: comments written on another student's post and comments written on their own post. Students were more likely to be cognitively engaged when writing comments on the post of their peers than they were when writing comments on their own post. The average cognitive engagement of comments written on the post of others was 0.95 out of 1 (SD = 0.23). The average cognitive engagement of comments written on their own posts was 0.84 out of 1 (SD = 0.37). An independent samples t-test was conducted to determine the significance between cognitive engagement of comments on the posts of others versus their own posts. The difference is statistically significant; $t(364) = 3.44$; p value <0.01.

The sum of comments on a given post was also measured. If more than 50% of the comments attached to a given post are cognitively engaged, then, on average, the discussion of that post was thoughtful. In the data, across all three assignments, in 95.7% of the cases, the discussion attached to an individual post exhibited a high ratio of cognitively engaged comments out of total comments.

These data show that the class, as a whole, saw benefit in writing thoughtful comments.

Responding to comments (social cohesion)

Some students engaged in an interaction with other students. However, the amount of interactivity was limited on the platform. Of the comments and replies produced, 43.7% of

them were interactive, where interactive means that the comment or reply interacted with or referred to another comment or reply in the conversation. Cognitively engaged comments were more likely to get a reply. Of the cognitively engaged comments, 53.7% of them received at least one reply. The reply was not necessarily cognitively engaged. In contrast, none of the non-cognitively engaged comments received a reply.

Students were significantly more likely to write comments that interacted with other comments in the conversation on their own post rather than the posts of others. The average interactivity of comments and replies written on the posts of others was 0.14 out of 1 (SD = 0.34) while the average interactivity of comments and replies written on their own posts was 0.99 out of 1 (SD = 0.09). An independent samples t-test was conducted to determine the significance between interactivity of comments on the posts of others versus their own posts. The difference is statistically significant; $t(364) = -27.9$; p value <0.01.

The analysis above focused on individual comments. It is also possible to examine the interactivity of the sum of comments on a given post. The sum of comments had high interactivity if more than 50% of the individual contributions were interactive. In the data, 20.4% of the discussions associated with an individual post exhibited high interactivity.

These data show that the class as a whole has some commitment to engaging in discussion. By and large, they choose to write thoughtful comments. However, the effort toward engaging in interactive discussion is limited.

Thoughtful interactions (cohesion = social + task cohesion)

A thoughtful interaction between two individuals would occur if the reply to a cognitively engaged comment was also cognitively engaged. Many of the interactions were not thoughtful because the replies were a simple "thank you" or another similar reply. Across the three assignments, there were 111 total thoughtful interactions across the three assignments, which is roughly 37 per assignment and 4.6 per group per assignment. Some students participated in no thoughtful interactions. Some students only participated in a thoughtful interaction in that they wrote a comment that received a thoughtful reply but did not reply thoughtfully to any thoughtful comments.

This manner of engagement remained limited in the community relative to other ways of engaging. It is possible that students did not leave thoughtful responses as often because they felt their replies would not be read as a result of people being online at different times. Another possible explanation is that students read the comment received on their posts near the deadline for the final draft and put their effort into incorporating the feedback into their post instead of directly responding. In any case, some aspect of the structure of the activity or the design of the platform limited the willingness of students to engage in thoughtful interactions.

Summary of results

Table 4 summarizes the key findings presented in the results section.

On the whole, students found value in participating in the collaboration as evidenced by their patterns of engagement and participation. In writing their assignments, students found value in the collaborative elements of the learning task as evidenced by a shift in their editing behavior. They also got more selective in their reading behavior. In the commenting phase, students found value in participating in the commenting. Comments throughout all three

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t4.1 **Table 4** Cohesion in the community informed by patterns of engagement

t4.2	Reading and Writing	
t4.3	Reading	Students read widely and in depth.
t4.4	Effort in first draft	The length of first drafts decreased over the course of the semester.
t4.5	Increasing effort in revisions	There was a 29.63% increase in revising.
t4.6	Commenting and Discussion	
t4.7	Writing any comment	Students wrote 27.5% more comments than were required of them.
t4.8	Writing a thoughtful comment	Of the comments written, 90.7% were cognitively engaged.
t4.9	Responding to comment	Of the comments written, 43.7% were interactive.
t4.10	Thoughtful interactions	There were 111 instances of thoughtful interactions (37 per assignment and 4.6 per group per assignment).

assignments were largely cognitively engaged. Students provided thoughtful feedback on the posts of their classmates. They were more likely to respond to comments they received than they were to interact with comments in the thread associated with the post of another student. Sometimes those replies were thoughtful and substantial but not always. When the reply to a thoughtful comment was also thoughtful, this constituted a thoughtful interaction.

The results show that the students are selective in the different ways that they choose to participate. They use the draft work of other students to support their own revision work. They also put in the effort to write thoughtful comments. However, when it comes to interactively engaging, particularly engaging in thoughtful interactions, the students' commitment is more limited. This limitation impacts the degree and type of cohesion that manifests on the platform. The community is, and groups within the community are, functioning in terms of producing content that allows others in the space to make progress given the constraints of the affordances of the platform. They are collaborating – they do talk about each other's work – but there is less evidence that they actually talk to each other. This pattern of engagement is indicative of the degree to which the community is cohesive.

Discussion

Figure 4 shows how the different patterns of participation relate to a student's commitment to and engagement in the collaboration. The left-hand side of the diagram shows how student work is viewed from an individual perspective, and the right-hand side from a more social perspective.

On the left-hand side, the major individual task for the student is to produce the written assignment. From this perspective, the student's participation in the collabo- ration is focused on reading and revising. A student writes a first draft of their post, reads the posts of other students, and edits their post based on their improved understanding and ideas generated from their reading behavior; this is depicted as an interaction between reading and revising. With this type of participation, the learner can work fairly independently, although the reading requires cooperation in that it depends on other learners producing useful content. There is potential for meaning- making to occur through this activity; it depends on the participants using the varied points of view in each of the posts as a basis for reflectively negotiating and progressing in their own understanding. The evidence showed that most students made the commitment to produce first drafts that their peers found value in reading and also put forth

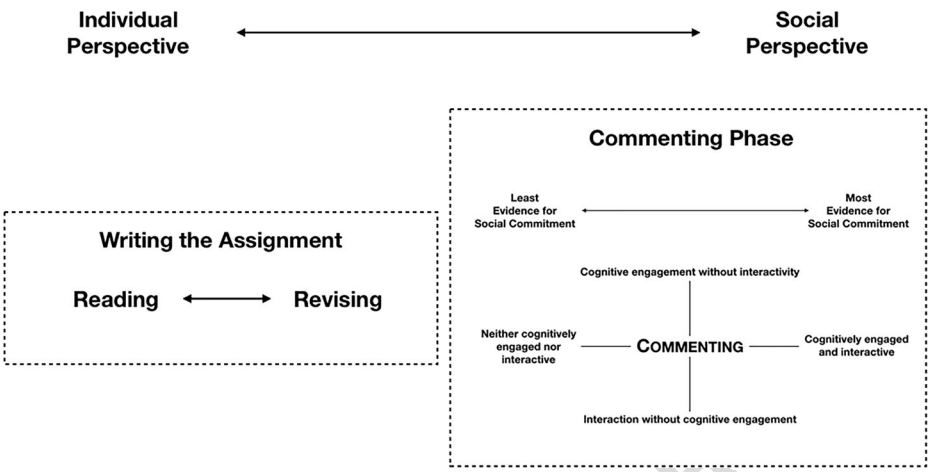

Fig. 4 Learners vary in their commitment to the collaboration

effort toward reading the work of others to support their revision work. In other words, because the data show an extensive pattern of reading and revising throughout the assignments, even though the learners are not always explicitly negotiating points of view, they are integrating alternate approaches to the work into the revisions of their own work – which is a reflective form of meaning-making.

On the right-hand side, the major social task is to engage in commenting behavior. The figure depicts some of the choices the learners make with regard to how they engage and participate in the commenting phase of the activity. Exhibiting a more active engagement in these collaborative elements indicates a stronger commitment to the collaboration. The amount of cohesion that develops within the community is directly related to this element of online engagement and vice versa.

Commenting varies along two axes: whether or not the comment is cognitively engaged and whether or not the comment refers to another comment (i.e. is interactive). Comments that are both cognitively engaged and interactive are markers of a community that has a greater degree of cohesion than communities where either cognitive engagement or interactivity is lacking; they are also markers of potential meaning-making exchanges.

When viewed on the community level, the set of choices that individual students make sheds light on the overarching pattern of student participation. This pattern is an indication of the type of cohesion emerging within the community. On the platform, there are four levels of cohesion that are possible, each characterized by a different pattern of participation (see Table 5).

Each level up, requires more effort and engagement from members of the collaborative group: writing a thoughtful comment (level 2) is strictly more work than writing a superficial comment (level 1) and engaging in a conversation (level 3) is strictly more work than writing a thoughtful comment alone (level 2). In other words, the collaborative cognitive load (Kirschner et al. 2018) of each level is strictly more than that of the previous level. Each level up also has increased potential learning benefits and increased potential for productive collaboration: reading the work of others exposes one to varied viewpoints compared to simply ignoring others in the community and engaging in commenting behavior allows the opportunity for negotiation and meaning-making to occur between varied viewpoints. In

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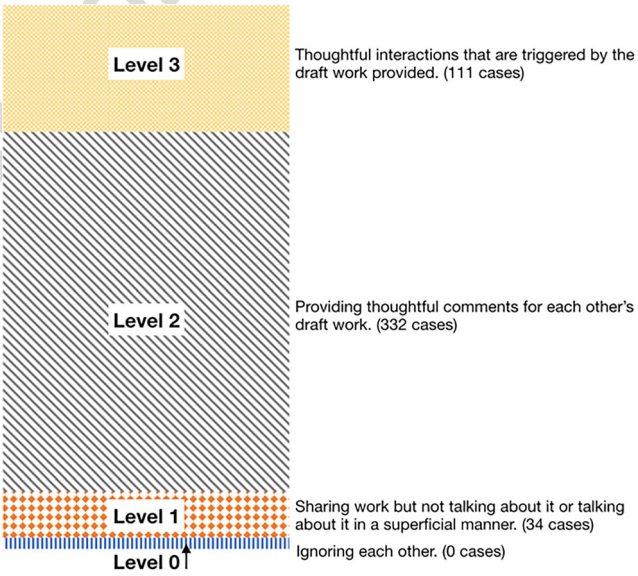
t5.1 **Table 5** Four levels of cohesion

t5.2	3	Thoughtful interactions that are triggered by the draft work provided
t5.3	2	Providing thoughtful comments for each other's draft work
t5.4	1	Sharing work but not talking about it or talking about it in a superficial manner
t5.5	0	Ignoring each other

deciding how to participate, each individual in the collaboration assesses whether or not the effort required of engaging in a certain way is worth the potential benefit of that level of engagement. The pattern of engagement exhibited by the community as a whole gives insight into the balance between effort and value into which the community, on average, settled.

Figure 5 depicts the relative degree to which each level of cohesion emerged on the homework platform used in this study. None of the students ignored the rest of the community (level 0); all of the students did at least some reading of the work of others. A small percentage of students shared their work and used their reading to support revisions but did not engage in the commenting phase (level 1). Most of the students shared their work and provided thoughtful comments but did not engage in thoughtful interactions (level 2). Some of those thoughtful comments were then replied to thoughtfully, constituting a thoughtful interaction (level 3). The level of cohesion achieved in the community supported collaborative meaning-making. When a thoughtful interaction occurred, the meaning-making was explicit in the commenting threads in which students participated. Most of the community remained at level 2 (thoughtful comments without interaction); for this case, any potential meaning- making that was achieved depended on whether or not the individual participants reflected on the thoughtful comments of others. The figure visually represents the manifestation of the pattern of engagement into which the community, overall, settled.



Q5 **Fig. 5** Relative proportions of different levels of cohesion that resulted from the choices of students regarding how to engage

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Other characteristics of the cohesion that emerged

While there was some interactivity, for many students, their engagement remained limited to producing thoughtful content that other members of the community could reflect on.

Some other interesting features of the cohesion that emerged:

Interactivity on their own work There was a tendency for students to be more interactive on their own posts than they were on the posts of other students. This shows that the students perceive a limit on the benefits of protracted interaction on other student's work. The most exchanges observed in a set of comments was one instance of 5 exchanges and three instances of 3 exchanges. Perhaps because the interaction is asynchronous with slow response time, there is a dampening effect on collaborating on the work of other students. They are more willing to interact on their own work. Perhaps this is because they want to encourage more feedback, or perhaps because it is an opportunity to advance their own individual project. It is also possible that they feel a social obligation to acknowledge the feedback given to them by their peers.

Pairing behavior There is evidence that some students paired up. Pairing occurs when two students engage in more than one thoughtful interaction over the course of the semester. Reciprocal pairing occurs when two students engage in more than one thoughtful interaction, with at least one of those interactions being on the post of each partner in the pair. These cases are markers of increased cohesion between the partners within the pair. There were 27 pairs over the three assignments and 23 of those pairs were reciprocal. Cohesion is stronger within a pair that engages in thoughtful interactions with one another more than once and is stronger, yet, within a pair that does so reciprocally. Thus, cohesion has both local and global elements: there is a general quality to the cohesion within the community at large but there is variance in terms of the cohesion that emerges for sub-groups within the community.

Cohesion within the small working group In the ideal case, for a single group, all members of the group are engaged in multiple thoughtful interactions with all possible pairings within the group. This represents the best possible case of cohesion within a part of the community. If all groups within the community are like this, the community at large is functioning very well in terms of cohesion at the group level. Beyond that, it would be possible that there are multiple pairs both within and across groups. For large communities, this seems fairly unlikely as the cost of maintaining this level of commitment to the community would be great. On the platform, the average number of pairings within a group (with average group size of 3.875) was 3.00 (standard deviation: 1.22). In a group of 3, there are 3 possible pairings; in a group of 4, there are 6 possible pairings. Each group had at least one pair form. In one group out of the 8 groups, all possible partners paired up over the course of the semester.

Cohesion at the community level The community as a whole identifies participants who tend to produce more useful content. In some ways, deciding who writes the useful posts in the community is a process of identification; students whose work becomes more prominent online are more socially present than students whose work is largely invisible (Alterman and Larusson 2013). These students' posts are read more frequently than others, and are read more often by members of groups other than their own. This settling shows

that the community is cohesive enough to begin to recognize quality content both within and across groups.

Conclusion

The focus of the paper has been on cohesion as it relates to engagement in an online, different time and place, collaboration. All three parts – cohesion, engagement, and time and place distribution – are significant to the study.

Cohesion, in this paper, is measured by the extent to which a group engages in meaningful interactions as they work on their collaborative task. Cohesion is necessary for meaning-making, but cohesion, in itself, is not sufficient. Without cohesion, the participants lack the mutual focus that is a necessary component of intersubjective meaning-making; it is possible to be cohesive and not engage in meaning-making.

The results show that as the students progress through an online, different time and place collaboration, they make choices regarding how to engage in the collaborative task. The choices they make have direct bearing on how cohesively the group functions. The community found that the effort of writing thoughtful comments was worth the perceived benefits gained, but the effort to engage in thoughtful interactions, by and large, remained more limited. Correspondingly, the level of cohesion they achieved supported collaborative meaning-making; some of it occurred through direct online interaction and other parts depended on whether or not the individual participants reflected on the thoughtful comments of others.

The advantage of working different time and place is that the coordination requirements are relaxed and, consequently, the group members can collaborate at their convenience (Alterman and Larusson 2013). Under these conditions, the collaboration is more reflective: there is a natural inclination for the participants to take a step back as opposed to leaning forward into the collaboration (Alterman and Harsch 2017). This step back leads to more secondary participation, more distance between the collaborative group members, and greater difficulty in achieving cohesion. Nevertheless, as the paper has shown, the participants can and do become cohesive. The manner and degree by which it is achieved directly depends on the design of the online environment. In the case of this study, the design made it easy for students to share their draft work, supported thoughtful commentary, and enabled, but did not encourage, thoughtful interactions. Future work will explore the impact of alternate designs of communication structure on patterns of student engagement in a collaborative task and, thus, the degree and type of cohesion that emerges.

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