

# A Study of Engagement and Collaborative Learning in a Virtual Environment

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**Abstract**—This paper focuses on the pattern of engagement of students collaborating in a virtual environment. Students work different time and place to develop responses to three homework assignments in a collaborative online learning environment. For each assignment, students are asked to cognitively engineer a technology-mediated collaboration in which they must consider issues such as communication, shared workspaces, online communities, and so on. Because of the “distance” between peer collaborators introduced by the virtual environment, the question of engagement becomes more complex. An analysis of the interactions of students in the virtual space is presented. The students exhibit a shift toward putting more effort into the revision stage of the assignment where they have access to the work of their peers. The data shows that students trend toward becoming more engaged from the first assignment to the last. The analysis illuminates changing patterns of engagement which gives insight as to how to improve student engagement in virtual, different time and place collaborations.

## I. INTRODUCTION

When engaged, a student learns more. The degree to which a student is engaged can depend on multiple factors, ranging from the learner’s social position within a community to her prior skill and knowledge. Developing an effective learning activity requires that careful attention be paid to engagement factors.

There is an immediacy to a face-to-face collaborative learning situation that lends itself to more engagement. Because the learners are co-present, it is natural to monitor each other’s behavior, their joint progress, and the degree to which other participants are engaged in the activity. A study of middle-schoolers participating in a close collaboration developed a four-factor model of engagement composed of behavioral, social, cognitive, and conceptual-to-consequential factors [1]. Each one of these factors depended on the immediacy of the learners being co-present.

The conditions of collaboration are different for the study presented in this paper. The students do homework over a several week period on a different time and different place (DTDP) online homework platform. The virtual space changes the circumstances under which the students are collaborating and thus effects their engagement. Under these conditions, communication and participation are more distributed and opaque: it is more difficult to communicate and monitor

progress [2]. Despite these complications, the students settle into a pattern of engagement.

This paper presents a study of engagement in a collaboration on a learning platform where the students work DTDP. The data presented centers on modeling the patterns of engagement exhibited by the community and understanding the engagement pattern that the community of students settle into. Understanding how students are engaging is very complex. Different students have different preferences for patterns of engagement. Some choose to focus on engaging socially while others tend to engage more cognitively. At first, students may not be sure how to best utilize the resources in the virtual environment. As a result, over time, their pattern of engagement may change. Modeling these changing patterns of engagement will help to make sense of the variety of engagement patterns exhibited in the distributed collaboration over time.

This research is a concerted effort to present a larger view of how the pieces of engagement might fit together in a virtual environment. The analysis is framed in terms of an adaptation of the four factors of engagement [1]. This adaption is necessary because of the distributed nature of the collaboration in a virtual environment. The data shows that students shift toward putting more effort into the revision phase of the assignments where they have access to the work of their peers. They trend toward engaging more as a community as the assignments go on, but exhibit a preference toward effort that directly benefits their own work and only secondarily the work of others in the community. They also exhibit a preference for content-based engagement over behavioral and interactive engagement. With this sort of bird’s eye view, it becomes possible to move beyond characterization toward the design and realization of virtual environments that best support student engagement.

## II. BACKGROUND

Success at learning depends on prior knowledge, skill, and effort. Engagement is related to how much effort students put into the activities and tasks at hand as they are learning [3]. There is a range of factors that can influence the engagement of an individual student. Engagement depends on the dialectic relationship between individual and collective, especially with regards to broad social elements like diversity and privilege

[4], [5]. It also depends on the learner's facility with the tools [6]. Confidence in one's ability is another factor: learners who lack confidence are less likely to be engaged [6]. The design of a learning activity is also significant: activities where students are active are more conducive to engagement (and learning) than ones where the learners are passive [7].

To make students more engaged, one can "enhance students' self-belief", "enable students to work autonomously", "create learning that is active, collaborative, and fosters learning relationships", and "create educational experiences for students that are challenging, enriching, and extend their academic abilities" [8].

With collaboration, the alternation of viewpoints, and the sum of the participants' skills, can make the learning activity richer and more fruitful. In collaborative learning environments, "successful collaboration involves a large degree of mutual engagement" [9]. The relational elements of collaboration can increase social cohesion and solidarity and thereby motivate further engagement [10], [11]. Collaborators must feel invested and motivated to put in the effort to complete the task at hand. When students are more motivated, "content understanding and skill capabilities are enhanced" [12].

A recent paper in the CSCL literature modeled the engagement of small groups of middle-schoolers working together on a computer, learning about ecosystems [1]. From an analysis of a videotape of the students' face-to-face technology-mediated close collaborations, these researchers developed a model of student engagement in terms of four major factors: *behavioral*, *social*, *cognitive*, and *conceptual-to-consequential*. Behavioral engagement refers to the degree of on-task participation by members of the group. Social engagement is defined as the "quality of group socio-emotional interaction" and the level of group cohesiveness. Cognitive engagement refers to how the students plan, monitor, and evaluate their progress on the task. Finally, conceptual-to-consequential engagement is defined as "making progress in critically considering the utility and impact of disciplinary content, strategies, or tools relevant to a larger task context".

For the study presented in this paper, the collaboration occurs completely online through a different time, different place learning environment, where the collaboration is more loosely coupled. Students produce individual artifacts for each assignment as opposed to collaborating to produce one artifact. We will use the Sinha et. al. [1] model as a starting point to explore and evaluate the students' engagement. Behavioral, social, cognitive, and conceptual-to-consequential factors are still relevant, but because student participation is distributed in a virtual environment, the look and feel of student engagement will be significantly different. Methodologically, the two studies are also different: a review of a videotape versus an analysis of a written transcript requires fundamentally different methods of interpretation [13].

### III. THE STUDY

#### A. Setup

This study was conducted in a semester-long blended class on computer-supported cooperation taught in the computer science department at Brandeis University; the students did their homework online. The class had 29 students and one student who was auditing the class who has been removed from the data since he was not required to complete the assignments. A collaborative homework platform was custom-built on which the students submitted their work and engaged in a collaboration. For each assignment, students were given two deadlines: the first required them to submit an initial draft of their work and the second required them to submit a final draft. All of the submissions were made public to the other members of the class after the initial draft deadline. Students were assigned to small groups of 3-4 students but were also given access to the posts written by students outside of their group. Then students were given time to collaborate using the online knowledge community [14]. They were required to produce comments giving constructive feedback on the posts of at least two of their group members but were encouraged to also provide commentary on posts outside of their small group. Students could then engage in discussion by replying to comments or producing new comments on each post.

Many studies have explored the concept of peer assessment – where it is most productive, what types of assessments have value, and so on [15], [16]. Regardless of the type of peer assessment, the value of the assessment is a function of the engagement of the assessing peer. In other words, if the assessor is weakly engaged, the assessment is likely to reflect the student's lack of investment in providing constructive feedback and vice versa.

While giving and receiving feedback, students could freely edit their initial draft until the final draft deadline.

The study focuses on the patterns of engagement exhibited by the students over the course of three online homework assignments; each assignment took several weeks to complete. Each assignment required the students design a technology-mediated collaboration: given some scenario, the students' task was to produce a design for collaboration that fit the scenario. For example, one assignment described a situation where members of an organization met virtually to generate a set of slides for a training presentation. The attendees to the meeting were located in different parts of the country. During the virtual meeting, the participants would need to be able to communicate with one another, manage floor control, edit, merge, and develop slides, and have breakout sessions where subgroups could focus on particular parts of the presentation.

#### B. Measuring Each Type of Engagement

Measuring engagement can offer insights into the "quality of the learning experience as a whole" [3]. A summary of the types of engagement and measurements used can be found in Table I.

TABLE I  
MEASURING ENGAGEMENT BY TYPE

	Definition	Measurement
<b>Behavioral</b>	staying on task and completing activities she is supposed to	reads of posts of other students and edits between drafts
<b>Social</b>	participating in a social situation with others in the community	interactivity score of comments produced on a scale of 0-2
<b>Cognitive</b>	depth to which the students discuss each other's work	score of how substantial comments produced were on a scale of 0-2
<b>Conceptual-to- Consequential</b>	connecting the material within the assignment to the "bigger picture"	score of how explicit design problems were in post on scale of 1-3

1) *Behavioral Engagement*: A student is considered to be behaviorally engaged if she is staying on task and completing the activities she is supposed to. Reading the posts of group members is one measurement of behavioral engagement: as a student reads more and attends to activity on the class website more, she exhibits a higher degree of behavioral engagement.

Another measure of behavioral engagement is the edit distance between the first draft submitted by a student and the final draft: students who are behaviorally engaged will put in the effort to iteratively revise an initial design. The edit distance measure was calculated using the Levenshtein distance between the two versions of a student's post and dividing it by the length of the longer of the two drafts in order to normalize the data.

2) *Social Engagement*: A social situation includes two or more participants, mutually monitoring the situation, with shared background knowledge about the actions taking place [17]. The participants have shared or overlapping goals. Within a social situation, encounters can occur between two or more participants. In an encounter, the participants are focused on one another; conversation is an example of an encounter.

For a different time and place virtual collaboration, like the one that exists on the homework platform, the "feel" of a social situation is hampered by the lack of co-presence amongst the participants. In a face-to-face social situation, it is directly evident that the participants are mutually monitoring the situation from the fact that the participants are co-present [18]. In a different time and place situation, mutual monitoring is not directly evident.

In many offline homework situations, students do not have access to the work of their peers. The homework platform used in this study gives students access to another student's work, which is fundamentally a social dynamic, during the revision phase. In the construction of the initial draft, the students work alone; there is no opportunity to access, review, and discuss with their classmates the problem or design solutions. Once the initial deadline has passed, the students can access each other's work and talk about the problem using the platform. By definition, since the initial online phase does not enable

peer collaboration, it is only during the second stage that social engagement can emerge. Thus, the balance of activity between the first and second phase of each assignment is, in itself, a gross indicator of increased social engagement. Finer distinctions can be made about the kinds of social engagement in which students participate.

When a student posts a draft of her work, it is broadcast to the rest of the class. The students work under the general assumption that their posts will be viewed by other students. Some students will only take note of the contribution, other students will read the contribution, and yet a third group of students will read and comment on it.

An increase of activity during the revision stage is an indicator that the students are more likely to be engaging in one of these three activities. All three of these depend on the social element of the homework platform. Nevertheless, commenting on another person's draft is the only avenue by which two students can directly engage with one another: it is in an encounter of this sort, that mutual knowledge can develop [19].

The results section will focus on interactivity of the conversations as the most explicit form of social engagement, which occurs when one student comments on another student's post. In order to measure the interactivity within a conversation, all the comments written on the homework platform were given an interactivity score. The scale for this score was adapted from work on interactivity in online discussion forums [20]. Comments that showed no reference to other comments were given a score of 0, those with references to the comment immediately preceding it were given a score of 1, and comments that referred to other comments further up in the conversation or those that referred to multiple comments were given a score of 2. Each comment was scored independently by two graders. All scores were within 1 point of each other on the scale with 92% agreement between both graders across all assignments. Where there were disagreements, the average of the two scores was used. For each student, a sum of their interactivity scores for all of the comments they produced for a given assignment was calculated.

3) *Cognitive Engagement*: Recall that Sinha et. al. [1] tied cognitive engagement within the collaboration to how the students collectively planned, monitored, and evaluated their progress as they proceeded. For their work, the students were producing a single artifact, which meant engagement in the collaboration and engagement in the task were co-extensive. On the homework platform, each student produces her own artifact and the collaboration is more loosely coupled. Thus, there are two kinds of cognitive engagement on the platform. One kind 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 social, that is the focus of this paper. The cognitive engagement amongst the students with regards to collaboration occurs in the conversations that develop on individual posts. The crucial element in the analysis of the conversations is not whether they are planned or not. Rather, it is

the depth to which the students discuss each other's work. The deeper the discussion, the greater the cognitive engagement of the participants. Previous work related to engagement in discussion forums defines cognitive engagement as "attention to related readings and effort in analyzing and synthesizing readings demonstrated in discussion messages" [13].

To measure how substantial each comment was, a 0-2 scale was used. A mostly vacuous comment that provided no concrete, constructive suggestions for the author of the post was given a 0, comments that provided constructive suggestions for the author but remained abstract in providing potential solutions to the problems were given a 1, and comments with concrete, constructive suggestions as well as concrete potential solutions were given a 2. As with the interactivity scores, each comment was scored independently by two graders. All scores were within 1 point of each other with 72% agreement between graders across all assignments. An average was used where there were disagreements about the score. For each student, a sum of their engagement scores for all of the comments they produced for a given assignment was calculated.

4) *Conceptual-to-Consequential Engagement*: Students who are conceptual-to-consequentially engaged show evidence of connecting the material within the assignment to the "bigger picture". In this study, the students are given abstract design scenarios and they have to relate the abstract scenario to the "hidden" real problems that exist. For example, an abstract scenario where virtual collaborators need to co-reference items on a shared virtual whiteboard hides some hard problems of coordination: pointing at an object on the whiteboard, who is pointing, knowing that other participants are paying attention to what is being pointed to, and so on. Converting an abstract scenario like this to a concrete description of the real problems that are "hidden" is both something to be learned and a measure of the degree to which a student is conceptual-to-consequentially engaged.

The posts of each student were given a score between 1 and 3; half points were awarded as needed. A score of 1 was given to posts where the design problems were not explicitly identified and a score of 3 was awarded to posts where the major design problems were made explicit and the author of the post justified why each problem was, in fact, a problem that needed to be addressed. Both the first draft and the final draft of each post was scored independently by two graders using this scale. Where there were disagreements of more than 1 point, a conversation ensued where the graders negotiated their reasoning behind the score until the scores were within 1 point of each other. The final score of the post was calculated by using the average of the scores of the two graders.

5) *Design Score*: Students in this class were expected to learn how to design collaborations mediated by technology by completing the assignments [21].

The posts of each student were given a design score between 1 and 3; half points were awarded as needed. A score of 1 was given to posts where the design did not adequately solve the problems at hand and a score of 3 was awarded to posts where the design was discussed in depth and the decisions made

were well described and well justified. Both the first draft and the final draft of each post was scored independently by two graders using this scale. Where there were disagreements of more than 1 point, a conversation ensued where the graders negotiated their reasoning behind the score until the scores were within 1 point of each other. The final design score of the post was calculated by using the average of the scores of the two graders.

#### IV. RESULTS

The factors of engagement were measured using the following numbers for each assignment: edit distance between first draft and final draft, number of reads by a student, conceptual-to-consequential score of the student's final draft, sum of interactivity of all of the comments they produced, and the sum of the cognitive engagement scores of all of the comments they produced. The behavioral engagement numbers are discussed first – reading and edit distance; these numbers reveal the balance of effort between the initial draft and revision work. The second analysis compares individual engagement – edit distance, reads, and conceptual-to-consequential score – to collective engagement – sum of cognitive engagement of comments and sum of interactivity of comments. This analysis focuses on the degree to which the students use the online space to support their own work compared to how they use the online space to help and interact with the work of their peers. The third analysis compares behavioral/interactive factors – edit distance, reads, and sum of interactivity of comments – to content-based factors – conceptual-to-consequential score and sum of cognitive engagement of comments. This analysis reveals whether students are using the space to socialize and interact or if they are mostly focused on the content of the assignments.

In each case we will compare student engagement on the first assignment and student engagement on the last assignment. Together these analyses paint a picture of the shifting patterns of engagement as the students learn the most effective way to work on the online platform.

##### A. Behavioral Engagement Trends

Recall that edit distance is measured as a percentage of text from the first draft changed in the production of the final draft. Table II shows that for each of the assignments, the edit distance was incrementally increasing on average for all of the students. The average number of times a student read the posts of other students decreases across assignments.

TABLE II  
BEHAVIORAL ENGAGEMENT AVERAGES BY ASSIGNMENT.

Assignment	1	1→2	1→3
Edit Distance	33%	+6%	+8%
Number of Reads	46.93	-9.83	-14.79

The increase in edit distance is an important shift to note. On the first assignment students revised a third of their submission. On the second assignment, there is a 18% increase

in the amount of revisions of their post ( $6\% \div 33\%$ ). By the third assignment there is a 24% increase from the first assignment ( $8\% \div 33\%$ ). To put it differently, students went from editing about a third of their initial draft to editing about 41% of their initial draft.

Recall, there were two phases of the students developing their designs for each assignment: the initial draft followed by a discussion period where the students collaborate as they continue to develop their design. If the focus of effort is on the first draft, it means that students are perceiving fewer benefits to the collective parts of each assignment. Even on the first assignment, the students were doing a healthy amount of reworking of ideas during the collaboration phase. The gradual increase in effort across the three assignments shows that the students are increasingly finding benefit during that phase of their work.

The decrease in average number of reads is also noteworthy. The reduction in reading effort could have resulted from the students becoming more selective about what they chose to read. Another possibility is that students found it more beneficial to engage in conversation instead of passively reading the post of another student. The fact that students were spending increasingly more effort on their revisions signifies that a third alternative, less general interest in the activities of their peers, is unlikely.

### *B. Collective Online Engagement Components vs Individual Online Engagement Components*

Figure 1 shows two graphs that depict the interaction between collective engagement and individual engagement. When a student participates in the online environment, there are two possible kinds of objective: collective engagement and individual engagement.

Collective engagement translates to a participation directed towards the work of another student or an interaction with another student. It is measured as a function of the sum of the cognitive engagement scores of the comments they wrote and the sum of the interactivity scores of the comments they wrote.

Individual engagement is a preference toward effort that directly benefits their own work. It is measured as a function of the number of times a student read the posts of their classmates, the edit distance between their first draft and final draft for that assignment, and the conceptual-to-consequential score of their post.

In order to combine the measures for each kind of objective, each raw score was normalized to a scale of 0 to 1 and the sum of each of the components was calculated to produce an aggregated score for each student for each assignment.

The graph on the left shows the interaction of these two factors on the first assignment and the graph on the right shows this interaction on the last assignment. The horizontal and vertical lines in the figure represent the average for all of the students on that assignment for each of the factors. The shift in the placement of the crosshairs between the two assignments depicts the changes in patterns of engagement that emerged

as the community settled into a routine: the averages along both axes shift upward from assignment 1 to assignment 3. This means that the community as a whole is trending toward engaging more in relation to both individual and collective components. Although we have not shown the intermediate graph, it supports the notion that students were moving in this direction from the first assignment to the third assignment. The students who received a score of 2 or above (out of 3) on their final design are denoted with dots: these are considered to be the students that did well on their design in the assignment. Those who received below a 2 are denoted as an "x".

The figure shows that students trended towards exhibiting more engagement in both collective and individual components. It is also interesting to note the concentration of the students that produced a good design is highest for both assignments in the top, right quadrant. This means the best students exhibited higher than average engagement in individual as well as collective components. This pattern of engagement becomes even more pronounced on assignment 3. The students with below average engagement along both axes (lower, left quadrant) overwhelming tended to be students who did not produce very good designs.

A two-tailed, paired t-test on this data shows that the means from assignment 1 to assignment 3 are significantly different (absolute value of individual components t exceeds the critical value:  $4.9558 > 2.048$  at  $p < 0.05$ ; absolute value of collective components t exceeds the critical value:  $3.5434 > 2.048$  at  $p < 0.05$ ). While both are significant, the shift along the individual components shows more evidence of being a significant shift. Thus, the community as a whole got significantly more engaged relative to both of these types of engagement.

Even though students are shifting toward more engagement along both individual and collective components, a qualitative analysis of the transcript reveals that students tend to exhibit a preference toward the individual engagement components compared to the collective engagement components.

*1) Preference toward Individual Engagement in a Social Context:* Some students made the extra effort to engage collectively, responding to the comments they received and participating in discussions:

- (1) **User 18:** Ha! I really liked that you used slack for home-school collaboration. I didn't think of it. I also like that you are keeping track of tasks via slack's to-do list. However, what about decisions on various topics/problems? How do you manage them?

**User 10:** Thanks for the comment! Each channel in slack has its own to-do list. You can create as much channel as you want for each problems/topics. The to-do list within that channel represents the tasks that should be done correspondingly.

**User 18:** That actually prefect ! Good job making the connections :)

More often, however, the comments did not lead to a conversation. In some of these instances, the comments were

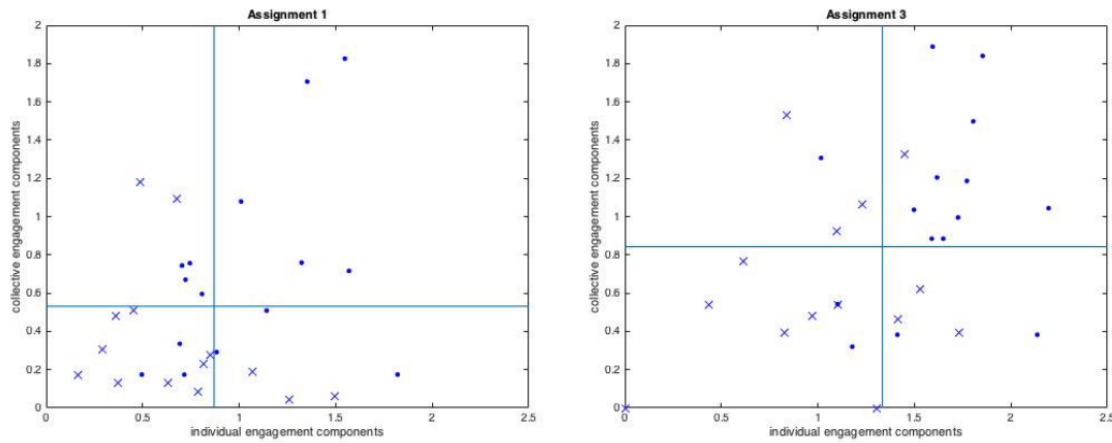


Fig. 1. The relationship between collective and individual engagement components on assignment 1 compared to assignment 3.

superficial and may not have warranted a response. For example User 27 received the following comment but does not respond to it:

- (2) **User 35:** I feel like your post is well written and points out different issues of the COLAB design that I did not even notice or had thought about when I was reading it. For instance I didn't even consider the visual element of the workspace

Other times the comment is substantial but still does not receive a response. For example, User 3 received a comment on his post that calls into question the type of device he intends to use for the collaboration but chooses to never respond:

- (3) **User 11:** I like the voting system for dealing with disagreements about the direction of the essay, simple yet elegant. I may add something similar to my own design, I hadn't really given much thought to disagreements and how to resolve them. I would point out that I feel like taking notes on a phone would be a bit of a pain, I hate taking notes on my phone, the screen is too small. Of course, a tablet might be better for that, but at the same time, it might also be clunkier.

This analysis shows that the students are preferring individual engagement: they put in the effort to edit their post and are using the space to read the posts of other students but they are not as willing to engage in interactive conversations and have discussions of their work or the work of their classmates.

### C. Behavioral and Social Engagement vs Cognitive and Conceptual-to-Consequential Engagement

Figure 2 shows two graphs that depict the interaction between behavioral and interactive engagement and content-based engagement. Behavioral and interactive engagement includes the number of reads of classmates' posts by the student, edit distance between their initial and final drafts, and the sum of the interactivity of all the comments they produced for that assignment. Content-based engagement includes the sum

of the cognitive engagement of the comments they produced and the conceptual-to-consequential score of their final draft. In order to combine these measures, each raw score was normalized to a scale of 0 to 1 and then the sum of each of the components was calculated to produce an aggregated score for each student for each assignment.

The graph on the left shows the interaction of these two factors on the first assignment while the graph on the right shows the interaction on the last assignment. The horizontal and vertical lines in the figure represent that average for all of the students on that assignment for each of the factors. The shift in the placement of the crosshairs between the two assignments depicts the changes in patterns of engagement that emerged as the community settled into a routine: the averages along both axes shift upward from assignment 1 to assignment 3. This means that the community as a whole is trending toward engaging more in relation to both types of components. Although we have not shown the intermediate graph, it supports the notion that students were moving in this direction from the first assignment to the third assignment as well. The students who received a score of 2 or above (out of 3) on their final design are denoted with dots: these are considered to be the students that produced good designs on the assignment. Those who received below a 2 are denoted as an "x".

The figure shows that the community as a whole is trending toward engaging more in relation to both behavioral/interactive components and content-based components. Again the concentration of the students that produced good designs is highest for both assignments in the top, right quadrant. This means they exhibited higher than average engagement in behavioral and interactive components as well as content-based components. This pattern becomes even more pronounced on assignment 3. Again, the students in the lower left quadrant – those with below average engagement along both axes – tend to be overwhelming students who did not produce good designs.

A two-tailed, paired t-test on this data shows that the means from assignment 1 to assignment 3 are significantly different

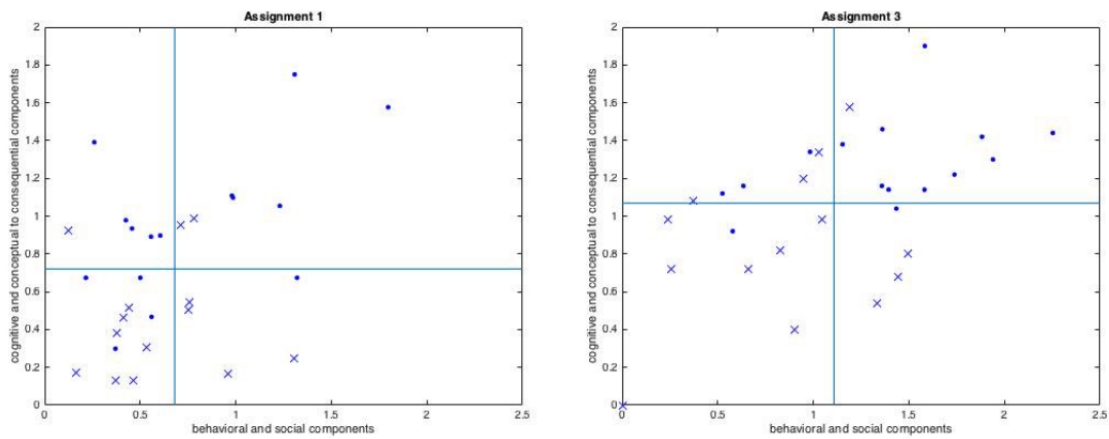


Fig. 2. The relationship between behavioral engagement and interactivity and content-based engagement on assignment 1 compared to assignment 3.

(absolute value of behavioral/interactivity components  $t$  exceeds the critical value:  $4.3602 > 2.048$  at  $p < 0.05$ ; absolute value of content-based components  $t$  exceeds the critical value:  $4.9653 > 2.048$  at  $p < 0.05$ ). While both are significant, the shift along the content-based components shows more evidence of being a significant shift. Thus, the community as a whole got significantly more engaged relative to both of these types of engagement as well.

While the students are shifting toward more engagement along both the  $x$  and  $y$  axes, a qualitative analysis of the transcript reveals that students tend to exhibit a preference toward the content-based engagement components compared to the behavioral and interactive engagement components.

1) *Preference toward Content-based Engagement*: Many students appear to be willing to write substantial comments for their classmates but are not willing to engage in an extended discussion about the comments they gave or the comments they receive on their own post. The average sum of cognitive engagement scores of all of a student's comments for a given assignment was substantially higher than the sum of their interactivity scores for all of their comments – for assignment 3 the average sum of cognitive engagement is 5.55 and the average sum of interactivity is 1.79. This means that students, in general, wrote substantial comments for their peers but did not engage in interactive conversations very often.

Students exhibited an increase in cognitive engagement of the comments they produced. For example, User 10 exhibited a large increase in cognitive engagement of her comments from the first assignment to the third. On the first assignment, she only produced the required minimum of two comments. However, on the third assignment she produced two comments as well as replied to four comments. The quality of her comments on the third assignment also were much improved. For example:

- (4) **Assignment 1**: Project folder based meeting mechanism is really smart! One concern is that how do users conveniently shift from online general meeting

to a breakout meeting and vice-versa? Since in my perspective, a breakout session is a part of the general meeting, shift between those two meeting should be designed gracefully and concisely.

**Assignment 3**: Great job! The Museum collaboration project system diagram is well illustrated and impressive. Comments: A little bit confusion about STATUS bar. In what case should they tag the status as “Done”? The task of the first stage in the museum, I think, is collecting information continuously. It seems to me that there isn't exist an arbitrary “done” status for each question. And also the design of status bar showed in Interface is confusing.. What does the number in the small circle represent?

On the first assignment, she points out a concern she has but remains fairly abstract in her thinking about the problem. She does not provide the author with concrete direction for revising the idea of breakout sessions. However, on the third assignment she concretely points out parts of the design she is confused by, specifically mentioning the status bar and a number in a circle, and asks the author to clarify the scenario in order to better understand the design.

This trend toward content-based engagement is not only seen in the conversational elements, but also in the posts themselves. Many students tended to put more effort into developing their discussion of the design problems in the assignment and why they are, in fact, problems: this is what we define as a measurement of conceptual-to-consequential engagement. For example User 15 exhibited a large improvement in his conceptual-to-consequential engagement from his first assignment submission to his second assignment submission and remained highly engaged in this way for the third assignment as well. In his first post, he did not provide any evidence of understanding the design problems at hand. There was no discussion of why the technology he was designing was important and how it helped to support the collaboration within the scenario described in the assignment. However, in



his post for the second assignment, he was much more explicit about how features of his design would serve to address some of the problems collaborators would face in the given scenario. He included a reflection within his post to address this issue:

- (5) **User 15:** In the previous assignment I felt like I took a generic and safe approach to the problem. This time I want to work outside the box from the onset. A successful design would preferably be revolutionarily functional, but more realistically, I hope that what I create will inspire myself and my group-mates to think in new ways about this task. Outside of the groupware elements of this project, I want my design to shine in two areas: Responsive Mobile Access and Easy Budgeting Tools. I'll go into depth about both of these areas later, but in my mind they are essential for a trip planning application. I am fascinated by the diagram in the text of cooperative work frameworks.

On the other hand, the average sum of interactivity scores of each student's comments remained about the same from the first assignment to the last meaning that the students did not get more interactive with one another as the semester progressed. One possible explanation for this is simply that of timing. Often, students wait until the last minute to write comments on the posts of other students. The longer they wait to produce the comment, the less time there is for discussion. Many students mentioned that they felt they received the comments on their posts too late and, as such, did not have enough time to incorporate the feedback into their final drafts.

This analysis shows that the students are preferring content-based engagement: they are willing to write substantial comments and develop the consequentiality of their posts but the cases where students are engaging in interactive conversations are limited.

## V. DISCUSSION

Suppose that students have a fixed amount of effort they will put into an assignment because of busy schedules and competition for their focus from other classes: if they put in more effort to the first phase of the assignment (individually developing a draft) then they put in less effort to the second phase of the assignment (collectively and iteratively editing and improving their draft) and vice versa. As the semester progresses, the data shows that students are making a shift toward putting more effort into the collaborative phase of each of the assignments. On the first assignment, students edited about a third of their initial post. However, by the third assignment there was roughly a 24% increase in the number of edits they made. Students are finding value in putting more effort into the revision phase of the assignments. The shift toward increased engagement is motivated by the adjustment toward spending more effort in the revision process; if a student is going to spend more effort revising her draft, then engaging more online is going to give her a better return on investment.

At the same time, the crosshairs of the averages presented in figures 1 and 2 show that the students are moving toward more engagement. In both figures, students who produced good designs for the assignment fall in the quartile of above average engagement along both axes. Is there some relationship between how well a student does on their design and their level of general engagement? The concentration of students who produce good designs in the upper, right quadrant implies that those that engage more along both axes in both graphs are likely to also be the students that produce good designs; perhaps the increased engagement helps to debug and improve their designs.

Based on a qualitative analysis of the data, the preferences of the community as a whole seem to favor individual and content-based engagement over collective and behavioral and interactive engagement factors. A possible explanation for these trends is that students perceive the interactive components to require too much effort without enough reward. They may also feel that the interaction is unnatural and difficult.

The pattern of engagement that develops within the community over time as the students explore the space gives insight on how they perceive the factors of engagement that they feel provide the most benefit to them. While each individual student may engage differently, the trend toward higher engagement as an overall community implies that the students feel there is some value in changing their pattern of engagement.

## VI. CONCLUSION

Students tend to settle into a pattern of higher engagement as the semester proceeds, spending more effort on the revision phase of each assignment. This increase in engagement appears to favor individual and content-based engagement. It is possible that this is a result of the distance introduced by the virtual space which can make engaging socially and interactively feel more difficult, unnatural, and "awkward". As designers of educational technology, these trends can inform the types of features that should be included to prompt students to engage more and to engage earlier on in the collaboration.

There is benefit to getting students to engage in a social and interactive manner in addition to engaging individually and on the content at hand. An important consideration for designers of these types of collaborations is how to make the conversational components feel more natural and immediate. One possible solution is to reduce the time between comments and replies. Another possible solution is to organize the space to encourage more frequent, less formal comments. Making the space feel less anonymous might also help decrease feelings of awkwardness, allowing students to put a face with the name they are seeing online and forming a sense of identity on the online platform. Each of these possibilities have tradeoffs but encouraging students toward a balance of engagement that has both individual and collective components as well as content-based and behavioral and interactive components may enhance the collaboration and provide the students with more benefit from the activity.



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