

Social Network Analysis for Signaling Pedagogical Shifts in Challenge-Based and Traditional Online STEM Courses

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Abstract: Challenge-based learning (CBL) supports students' learning and transfer of key disciplinary principles, but students may need support when transitioning to the expectations of CBL. One way to provide support is for instructors to monitor students' understanding of course challenges and content in discussion boards. Using SNA, we explored how two instructors participated in students' discussions in CBL and traditional online courses to see how instructors adapted support with CBL courses. Instead of differences across pedagogies, we found differences across instructors: one instructor contributed on the periphery of students' discussions, while another instructor directly contributed to students' discussions. Based on sociograms and instructors' feedback, we found that the instructors took different approaches to providing formative feedback (e.g., private communication versus public discussion) intended to scaffold students' knowledge construction.

Introduction

Challenge-based learning (CBL) is an inquiry-learning approach that contextualizes learning within authentic challenges (Martin, Rivale, & Diller, 2007). Students develop real-world solutions that help them learn key disciplinary concepts and skills that are connected to future work. CBL's benefits include improved attitudes about learning, conceptual outcomes, and knowledge sharing (Martin et al., 2007; O'Mahony et al., 2012).

Implementing CBL, however, can be challenging, as instructors must develop challenges that highlight key disciplinary principles that transfer to new situations (Martin et al., 2007). When adopting CBL within online courses, instructors often monitor discussion boards to assess students' understanding of challenges and underlying principles, and to provide support as formative feedback (Wise & Paulus, 2016). Students' participation in online discussions opens opportunities to co-construct knowledge with others. Interactions with instructors and classmates on online discussion boards can improve course satisfaction and perceived learning (Swan, 2001), but students may need guidance for engaging in online knowledge and community building (Covelli, 2017). One way to assess students' discussions is through social network analysis, or SNA (Wasserman & Faust, 1994). SNA provides a lens for understanding the interactions between and roles of students and instructors. SNA also helps assess students' sense of community (Stepanyan, Mather, & Dalrymple, 2014) as facilitated by the instructor to support online knowledge construction (Covelli, 2017).

To understand participation in online discussions, we created weekly SNA sociograms of discussion boards for two courses, each with a CBL and a traditional section. We examined sociograms for changes over time, especially students' and instructors' roles and connectedness within the course. We hypothesized that the shift from instructor-centered traditional course formats to a learner-centered pedagogy embodied by CBL would be signaled by differences in the positioning of the instructor within online discussion boards. Our research question was: *How did the instructors situate themselves within students' online discussions for CBL and traditional courses?* This question has implications for how we understand patterns of interaction between students and instructors in different instructional approaches, and can help us determine the suitability of SNA as a tool for characterizing pedagogical shifts in online courses at scale.

Methods

Participants were two instructors and 40 undergraduate students participating in online courses in fall of 2017, offered by a university on the U.S. East Coast that hosts programs for post-traditional adult learners pursuing professional degrees. Instructor AJV taught two sections of a human-computer interaction course (Course 1), with 7 students enrolled in the CBL section and 8 students in the traditional section. Instructor BC taught two sections of a web development course (Course 2), with 18 students in the CBL section and 7 students in the traditional section. Students were assigned to CBL or traditional instruction using stratified random assignment and were informed of the new CBL approach in the course syllabus. Instructors received training on CBL, which focused on authentic assessments ("deliverables") situated within challenges, and support from instructional designers. For CBL sections, the instructors shifted to a mentor and/or client role and expected students to take on greater agency in their learning. For traditional sections, instructors continued their business-as-usual approach of weekly lectures, quizzes, and assignments.

We collected student and instructor posts from discussion boards for each week from September 1 to October 29, the semester midpoint. Discussion participation was a grade requirement. We then performed an initial qualitative analysis of online discussions and instructor feedback about transitioning to CBL. For SNA, we created adjacency pairs of participants' posts for each week, which we used to make directed network graphs with *Gephi* and to calculate mean degree centrality for each participant with the *NetworkX* library in Python.

Findings

Our initial qualitative analysis of online discussions and instructor feedback indicated that the instructors had different approaches to scaffolding students' knowledge construction in their courses. Therefore, we examined the weekly sociograms for the CBL and traditional sections nested within the instructors.

Table 1 shows sociograms of interactions between students and Instructor AJV over time. With the CBL section (top), we see a strong connection between Instructor 1 and student RM in Week 1, and between students AB and MK in Week 2. However, the following weeks showed similar, decreased levels of interaction among participants, especially for weeks 4, 5, and 8. Also, students posted messages that did not receive replies (node NULL) in Weeks 1-7. With traditional instruction (bottom), we found strong connections between students JB and PF in Week 4 and JB and TS in Week 8. Overall, though, we found similar levels of interaction among participants. Students posted responses with no replies (node NULL) in weeks 4-8. In summary, both sections of Course 1 showed fairly balanced participation, but the traditional section showed more balanced participation over time compared to the CBL section.

Table 1: SNA sociograms of Course 1 online discussion posts during the first eight weeks

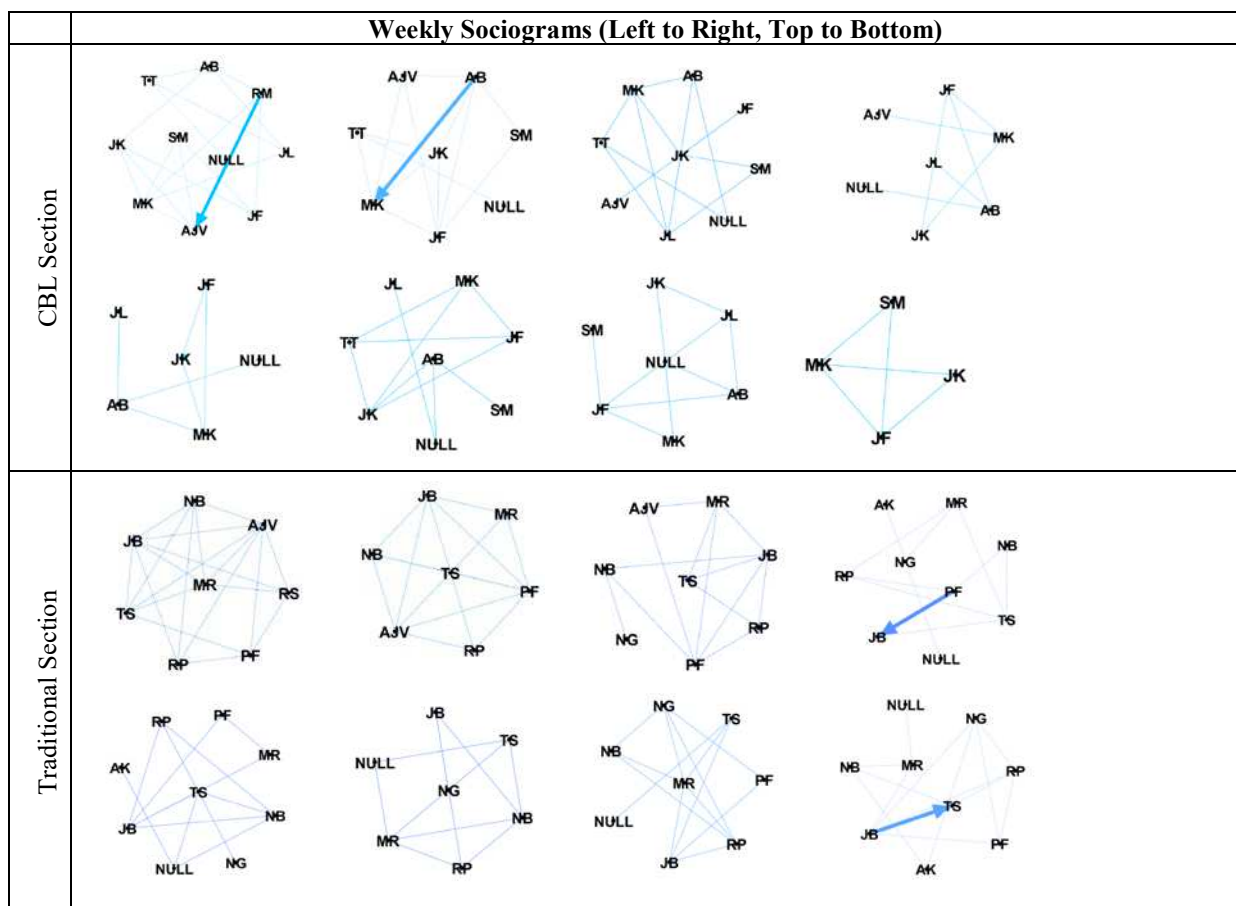


Table 2 shows sociograms of interactions between students and Instructor BC over time. With the CBL section (top), we see that students' discussion was often directed toward Instructor BC, resulting in connections with several students (NT, WR, SH, WCL, and WW) over time. Participation decreased slightly over time, but all students received replies to their posts. With traditional instruction (bottom), fewer students directed their

posts toward the instructor. The instructor still connected with several students (NG, RM, and MK) over time. Students NG, RM, and MK also connected with each other at different times. As with CBL, participation decreased slightly over time, but only week 8 included a posting without reply. Overall, we see greater interaction among participants in Course 2 (with Instructor BC) than Course 1 (with Instructor AJV).

Table 2: SNA sociograms of Course 2 online discussion posts during the first eight weeks

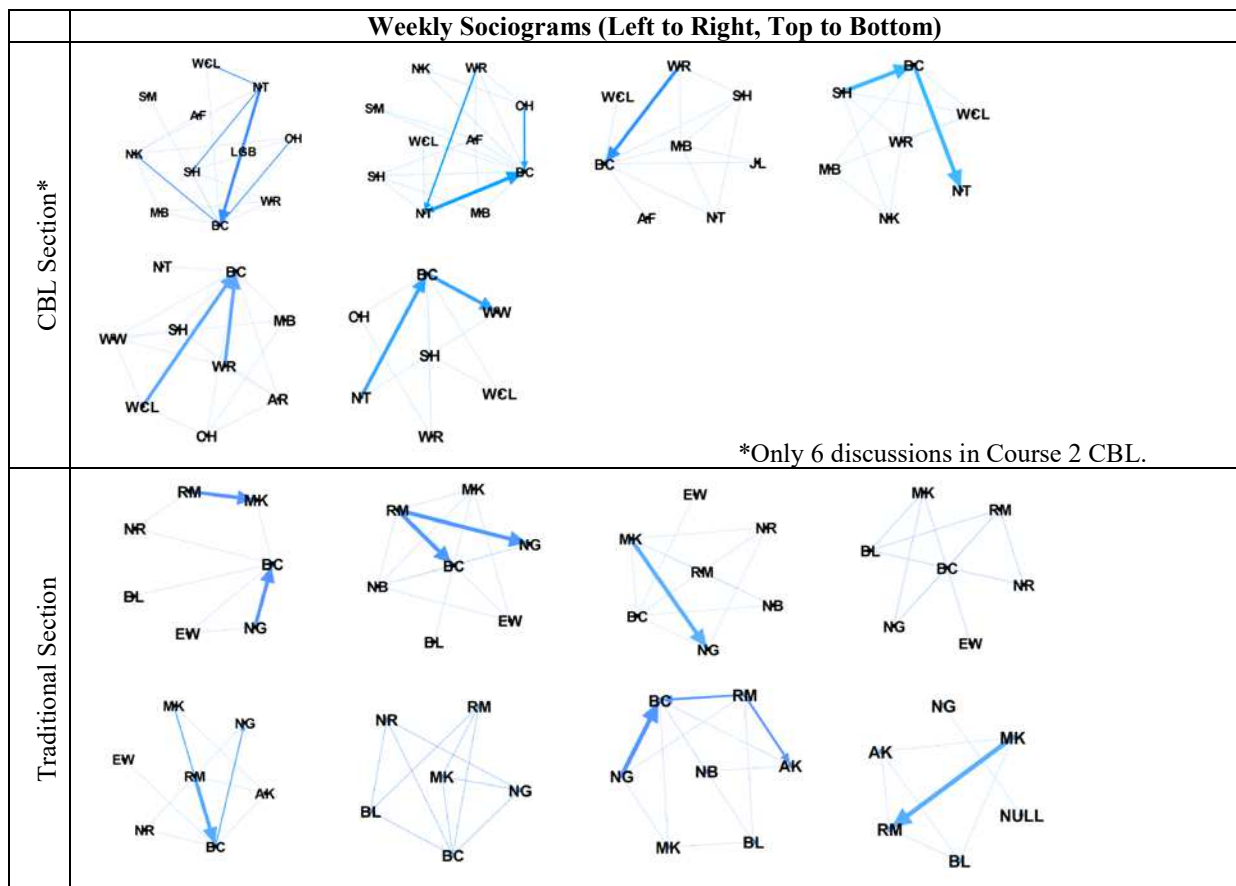


Table 3: Mean degree and centrality values for students in each section

Course	Section	Mean Degree Centrality
1	CBL	Instructor AJV = 1.2; Student AB = 1.7 , TT = 0.8, JL = 1.2, MK = 2.0 , S = 1.3 , JK = 1.4 , RM = 0.7, JF = 1.6 , NULL = 0.6
	Traditional	Instructor AJV = 1.3; Student RP = 1.7 , RS = 0.5, AK = 0.4, TS = 1.5 , NG = 1.2, PF = 1.6 , MR = 1.6 , NB = 1.4 , JB = 1.4 , NULL = 0.6
2	CBL	Instructor BC = 1.5; Student JL = 0.2, CH = 0.6, SH = 1.1, LGB = 0.2, DR = 0.1, MB = 0.7, AF = 0.7, KM = 0.4, WW = 0.4, NK = 0.5, OL = 0.1, WR = 0.8, SM = 0.2, DW = 0.1, NT = 0.8, WCL = 0.6, AR = 0.3, NULL = 1.0
	Traditional	Instructor BC = 1.8; Student BL = 1.0, AK = 0.9, NB = 1.0, TS = 0.1, MK = 1.3, NG = 1.5, RM = 1.5, NR = 0.8, EW = 0.4, NULL = 0.3

We also quantified connectedness as mean degree centrality, which indicated how closely connected each participant was to other participants over the eight weeks (see Table 3). In both sections of Course 1, Instructor AJV was less connected than her students, as indicated by values in bold font. In contrast, Instructor BC was the most connected participant in both sections of Course 2. This finding is echoed by our initial qualitative analysis, which found that Instructor AJV typically replied to students at the end of discussions, decentralizing her role in the discussion, and preferred private email communication for feedback. In contrast, Instructor BC replied to students' posts throughout discussions, which more firmly centralized his role.

Discussion

This study leveraged SNA as an initial assessment of participation in online discussions as instructors began to adopt CBL for online courses targeted at post-traditional adult learners. CBL contextualizes learning by foregrounding authentic challenges and assessments, which help students to grasp key disciplinary concepts and skills (Martin et al., 2007). Online discussion boards encourage students to share and negotiate ideas about course content, and offer opportunities for formative feedback (Swan, 2001). To understand students' and instructors' roles and connectedness in online discussion boards, we created week-by-week SNA sociograms of online discussion participation for both CBL and traditional (i.e., business-as-usual) sections.

Regardless of the type of instruction, students demonstrated relatively balanced participation over time. The CBL section of Course 1 showed a decrease in participation over time, possibly explained by the instructor's preference for email communication over discussion boards. This foregrounds our unexpected finding that differences among instructors were more salient. We found differences in the two instructors' roles and connections with students in discussion participation, regardless of the type of instruction. This difference points to a need for future research about instructors' approaches to scaffolding online courses, especially about formative feedback as public versus private communication.

Identifying patterns of participation, especially early in the adoption of a new instructional approach, may help instructors to support students by showing high or low levels of connectedness in discussion boards (Covelli, 2017). Analyzing sociograms may help instructors to adopt and/or reinforce effective knowledge and community building practices, such as revising discussion prompts or rotating responsibilities for leading discussions. Pedagogical feedback may also help reassure instructors adopting instructional approaches that are new to them. Implementing CBL is often difficult for instructors (Martin et al., 2007), and more objective feedback mechanisms like SNA may help instructors to identify areas for improvement as they arise. While this exploratory study is limited by its small sample size and focus on participation in discussion boards, we see this as a promising first step to support the identification of pedagogical shifts and practices as we integrate CBL into online courses at a larger scale.

Conclusion

Challenge-based learning (CBL) supports students' conceptual outcomes, but students may need support as they transition to CBL instruction. For online courses, instructors may monitor students' understanding and provide support via discussion boards. We used SNA as an early signal of the adoption of CBL in online courses to identify differences across instructional approaches. Instead, we found differences across instructors regarding their roles and level of connectedness to students over time. While we did not find notable differences across CBL and traditional instruction, we discovered a need to understand differences in instructors' scaffolding approaches for online courses, especially when providing formative feedback.

References

- Covelli, B. J. (2017). Online discussion boards; The practice of building community for adult learners. *The Journal of Continuing Higher Education*, 65(2), 139-145.
- Martin, T., Rivale, S. D., & Diller, K. R. (2007). Comparison of student learning in challenge-based and traditional instruction in biomedical engineering. *Annals of Biomedical Engineering*, 35(8), 1312-1323.
- O'Mahony, T. K., Vye, N. J., Bransford, J. D., Sanders, E. A., Stevens, R., Stephens, R. D., ... & Soleiman, M. K. (2012). A comparison of lecture-based and challenge-based learning in a workplace setting: Course designs, patterns of interactivity, and learning outcomes. *J. Learning Sciences*, 21(1), 182-206.
- Stepanyan, K., Mather, R., & Dalrymple, R. (2014). Culture, role and group work: A social network analysis perspective on an online collaborative course. *BJET*, 45(4), 676-693.
- Swan, K. (2001). Virtual interaction: Design factors affecting student satisfaction and perceived learning in asynchronous online courses. *Distance Education*, 22(2), 306-331.
- Wasserman, S. & Faust, K. (1994). *Social network analysis: methods and applications*. New York: Cambridge University Press.
- Wise, A. F., & Paulus, T. M. (2016). Analyzing learning in online discussions. In *The SAGE Handbook of e-Learning Research*, 2nd ed. (pp. 270-290). Thousand Oaks, CA: Sage.

Acknowledgments

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