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Social Network Analysis for Cybernetic Interaction Design in Technology-Supported College Curricula -17

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In the Information Age, social media tools produce cybernetic feedback loops that respond to human agency on the fly, making it important to equip individuals with skills to navigate these feedback loops and traverse through a society where polarised online debates about controversial issues like climate change and vaccines are common. Educational environments become safe, norm-driven environments to equip individuals with these digital skills. In this mixed methods study, we suggest using a cybernetic interaction design approach to mimic the ongoing effects of the cybernetic feedback loops of social media and equip students with the agency to use such tools to create cohesive learning communities. A participant observer rewired in-class live chats on the Reddit social media platform in a graduate psychology class of 17 students on the fly based on weekly social network analysis of live chats and qualitative field notes taken to construct a brief ethnography of lectures that followed live chats. Discussions about collected data led to restructuring the format of the live chat with regard to the involvement of the instructor, the number of concurrent groups, and group selection processes. Results from our weekly mixed methods analyses suggest that rewiring the live discussions solidified the likelihood for closed ties between n>2 agents to emerge and for each agent to be connected with other users who were popular in the network. Our inquiry suggests that cybernetic interaction design may be used to create a cohesive learning

community that could co-construct ideas in technology-assisted college classrooms through critical discourse, an important skill required to navigate an information-saturated society.

KEYWORDS: network science, interaction design, cybernetics, curriculum design

RSD TOPIC(S): Cases & Practice, Learning & Education, Sociotechnical Systems

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Introduction

With the public availability of the Internet, social media platforms have become ubiquitous tools that are used around 2.62 million individuals across the world as of 2018 (Hidalgo et al., 2019). The algorithms that make up social media produce a cybernetic feedback loop that responds to human agency to try and reverse engineer it (McGlade, 2021), guiding consumer behaviour towards certain products and services. Cybernetics is a transdisciplinary language that enables an understanding of how complex systems (brains, individuals, societies, and even machines)_react to their environments (Tilak et al., 2022). There are hopeful, constructive outcomes that may arise from the use of social media tools and the cybernetic feedback loops they produce, such as the Gamestop stock surges discussed on the GME subreddit (Glassman & Kuznetcova, 2022) and the grassroots organisation of #BlackLivesMatter protests in the US through the use of Twitter (Thelwall & Thelwall, 2021). However, concerning outcomes such as QAnon conspiracy theories emerging through platforms like Telegram (Walther & McCoy, 2021) have led news outlets and scholars (Carr, 2021; Bayles, 2022) to reach the consensus that the algorithms that build social media need control.

In this paper, we suggest that educational spaces become safe, norm-driven environments to equip students with the skills to navigate an information-saturated society (Tilak & Glassman, 2020) where debates about topics such as vaccinations, abortions, and climate change become highly polarised (Barzilai & Chinn, 2020). This study outlines a way to navigate the cybernetic feedback loops of social media through their use in educational settings by mimicking their ongoing effects on human agency

through a cybernetic interaction design approach that rewires social media-driven activities in a graduate psychology classroom based on the nature of networked student interaction. We not only try to enhance student-centred collaboration mediated by social media through iterative course design but also use network analysis as the modelling tool to inform ongoing design insights.

Cybernetics and design

Often, educational environments supported by technology are designed using a probabilistic approach (Kirschner et al., 2004), wherein affordances or design features are forecasted to effect change in learning in a certain direction. Scott (2014), who applies cybernetics to education, suggests probabilistic design lies within a first-order cybernetic framework observing a classroom in a detached way to see whether learning fits a theory of change rather than meeting the emergent needs of students. In this mixed methods paper, we co-design a graduate technology-assisted classroom to meet the emergent needs of learners in a situated, transformative manner (Hummels & Levy, 2021); using a socially conscious cybernetic interaction design (Pangaro, 2008) approach, wherein the curriculum designer/researcher becomes a participant observer who retools classroom activities on the fly based on insights from network analysis. The idea of the participant observer can be traced back to the seminal Macy Conferences on cybernetics (Pias, 2016), where anthropologist Margaret Mead raised important arguments about the idea of social scientists being embedded within a cultural context that they observe as active agents, by recounting her research on the Balinese language.

The idea of participant observation gradually unearthed a reflexive trend in cybernetics in the 1970s, with Heinz von Foerster coining the term "second-order cybernetics", which could be applied to moving social systems (Kline, 2020). Second-order cybernetics gauges how systems change their own reference frames in moving, networked social fields; through ongoing modifications made by the observer to stabilise systems (Tilak et al., 2022), also treating living systems under observation as evolutionary systems (Pask, 1961). Von Foerster used the ideas of second-order cybernetics to co-design a heuristics course with 159 undergraduate students from the departments of English and Electrical Engineering, and several visiting scholars. The project-based class culminated in the

co-authored publication of four texts, namely, *the Whole University Catalogue, Ecological Sourcebook, Metagames,* and *Cybernetics of Cybernetics* (Dubberly & Pangaro, 2015), which contained academic papers, art, and free-verse poetry. The course was based on educational psychologist and cybernetician Gordon Pask's first theorem, which stated that "If a system is legitimately said to teach, then it must be able to learn from its student who may reverse the roles to play at teacher" (Pask, 1972, p. 243). We use this idea to understand if the usage of a social media tool as an output facility to inform the dataset used for network analysis on an ongoing basis can help create a cohesive student-centred classroom marked by productive collaboration in online discussions (Tilak & Glassman, 2022), and an application of ideas accrued from technology-assisted interaction to lecture-based discussions (Glassman & Burbidge, 2014). The "machine" in question in our study is the combination of the social media tool, the network analysis software (RStudio), and field notes that help augment live chatting and the application of ideas to following lectures.

The present study as an experiment in network science

In our mixed methods study, graduate students enrolled in the classroom provide information about learning experiences they have in engaging with an in-class activity on the Reddit social media platform to the participant observer through the structure of the output obtained from their online interactions. The class, which occurred online for the first three weeks, and then in-person, comprised a livestream chat component conducted on the Reddit social media platform that was either shared to the Zoom call screen or projected in class, depending on whether the class was held online or in person. We use social network analysis on a weekly basis to inform the reformulation of online discussions, to meet emergent needs of the learning community, treating students as dynamic observers (Tilak & Glassman, 2022) who inform how the curriculum is (re)designed on a weekly basis. In addition, the observer took field notes from face-to-face lectures that followed to construct an ethnography (Angrosino & Rosenberg, 2011), presented in brief in Appendix A, that investigated links between in-class live chatting and lectures.

Pask (1968) asserted humans are living systems that learn by seeking novelty in their lives. Seminal studies in network science have also shown that a strategic rewiring of

interactions on a regular basis may stabilise or strengthen collaboration (Rand et al., 2011). In understanding whether collaboration is strengthened in a network, degree (number of incoming and outgoing interactions), eigenvector centrality (or the likelihood for a node or individual to be connected to influential others with a greater number of interactions) and transitivity (the likelihood for closed interactions between more than two agents) can help map such activity over time (Kolaczyk & Csárdi, 2014). Following these ideas, we rewired the structure of live chats conducted at the beginning of each class based on network analyses and brief field notes to produce cohesive online collaboration that permeated into an ideological exchange in subsequent face-to-face lectures.

Research Questions

The present study investigates whether dynamically redesigning live chats that precede a lecture using network analysis metrics (specifically degree, eigenvector centrality, and transitivity) as a weekly feedback mechanism may create a cohesive online learning community in a graduate-level classroom and uses ethnography to explain how online discussions were linked to concept development in-class lectures and student presentations (a place-space dialectic; Glassman & Burbidge, 2014). Our hypotheses suggest interaction design:

H1: Helps stabilise the transitivity of discussions with time or tendency to form closed ties between more than two individuals.

H2: Increases egalitarian network participation.

H3: Increases connectedness of community members to influential others.

H4: Produces a space-place dialectic in the classroom.

Methods

Data

Data came from two sources. The first was in-class live chats on Reddit set up for graduate students in a 14-week seminar part of the education department at a large,

Midwestern research university, conducted during the first 15 minutes of each session. Network analysis was conducted on the chats. The second source was fieldnotes the participant observer took of conversations occurring during lectures and student presentations following online live chats (presented in Appendix A) to employ ethnography in explaining the link between online interaction and face-to-face discourse and supplement weekly design decisions for online chats.

Participants

17 graduate students consented to participate in the study. 16 provided demographic details (one was absent during surveys). 62.5% of students were female. 62.5% were White, 12.5% were Black/African American, 6.25% were Asian, and 12.5% were Multiracial. Ten belonged to the School Psychology major, which focuses on counselling practices in schools. One belonged to social work, one to music, one to science education, one to educational philosophy, one to public policy, and one to educational psychology. The course was Social Basis of Behaviour, focusing on theories portending mental models are constructed by complex social environments. In a way, this design experiment is a meta-narrative that employs the theories discussed in the classroom to reconstruct its live chat component over 14 weeks to create cohesive classroom collaboration.

Curriculum

Each lecture began with 15-minute in-class live chats (for both online and in-person classes) on Reddit, wherein students discussed weekly prompts on a livestream-style chatroom. Reddit was chosen due to its capacity to create a private community to discuss topics and its live chat functionality, allowing threads to be dynamically visible. We wanted anonymity, considering several participants were School Psychologists, who often feel their educational opinions should be expressed in safe spaces. Students sat at laptops as prompt(s) appeared on a shared screen (for online sessions), or on the classroom projector (for in-person sessions).

After discussing prompts on Reddit, the class moved into a lecture involving open-ended idea-=sharing between the professor and students. The first three classes were conducted online owing to surges in COVID-19 numbers. For the first seven weeks,

lectures were longer, lasting two hours. Students watched and responded to videos and media about weekly topics and discussed weekly readings. Starting Week 8, the last 40-45 minutes involved student presentations (in groups of 2-3), expanding weekly topics, thus shortening the lectures. live chat participation was voluntary but encouraged in order to allow opportunities to apply of ideas from the online chat to lectures and to writing assignments/preparing presentations. Grading was conducted based on these presentations and reaction papers reflecting on any two session topics. live chats were ungraded but linked to classroom content, reaction papers, and presentations; participation could assist in deeper understanding. Weekly topics and the in-person/online format of each class are provided below (Table 1). Week 14 was a feedback session; students reported perceived strengths and weaknesses of Reddit. Feedback was used to design a further course iteration conducted in Autumn 2022, but lies outside the scope of this paper.

Table 1. Curriculum.

Week	Topic	Class format
1	Reddit demo	Online (COVID-19)
2	Grades vs Mastery	Online (COVID-19)
3	Social contexts and schooling.	Online (COVID-19)
4	Socioemotional learning.	In-Person
5	Constructivism and direct instruction.	In-Person
6	Socio-developmental factors in learning.	In-Person
7	Modes of instruction.	In-Person
8	Cognitive, constructive mechanisms in learning.	In-Person
9	Teacher training in collaborative curricula.	In-Person
10	Cultural/social capital.	In-Person
11	Radical education.	In-Person
12	Motivation.	In-Person
13	Diversity.	In-Person
14	Feedback session.	In-Person

Analysis

The participant observer would help the instructor set up the live chat at the beginning of each class, posting the prompt for the students to respond to as they sat in class. After the 15-minute in-class live chat was carried out, the participant observer would take field notes of the following lecture and student presentations to gauge whether these parts of the class involved constructive and reflective discourse. The observer would then conduct network analysis on the live chat interactions and compute individual and average degree (or connections each individual had with others), in and out-degree (incoming and outgoing interactions), transitivity (likelihood for closed ties between more than two individuals), and eigenvector centrality (likelihood for individuals to connect to influential others or those with higher degree/interaction weight). These were computed (Kolaczyk & Csárdi, 2014) to understand online interactions, develop weekly design decisions and map changes in network cohesion, as they help understand whether agents in the network were able to connect to other agents that were popular in the network, and also whether there were closed ties between a distributed group of n>2. A high transitivity (0.3-0.6) became the marker to maintain the characteristics of the live chat activity, while a lower transitivity constituted design decisions to alter it.

The field notes taken by watching lectures and student presentations (Appendix A) were discussed with the instructor to help understand whether the live chat format used in the classroom produced heightened student participation in lectures, and deeper discussions of presentations, further supplementing design decisions. They also helped the observer to construct an ethnography (Angrosino & Rosenberg, 2011) to tell a story that narrated the progression of the 14 weeks of class.

The frame of reference in Figure 1 shows how the participant observer (the first author of this paper) actively gauged classroom interactions, using social network analysis to analyse Reddit live chats and field notes to gather insights about the lectures and student presentations. The interaction design process involved insights from a mixed methodology of qualitative reflections from lectures and quantitative network metrics from an analysis of live chats. These forms of data produced through participant observations helped create a recursive feedback loop from the observer to the

classroom, to provide design feedback to reconstruct the live chat activity on the fly, to try and augment online interactions and create an idea bank that could be further discussed during the lecture and student presentations.
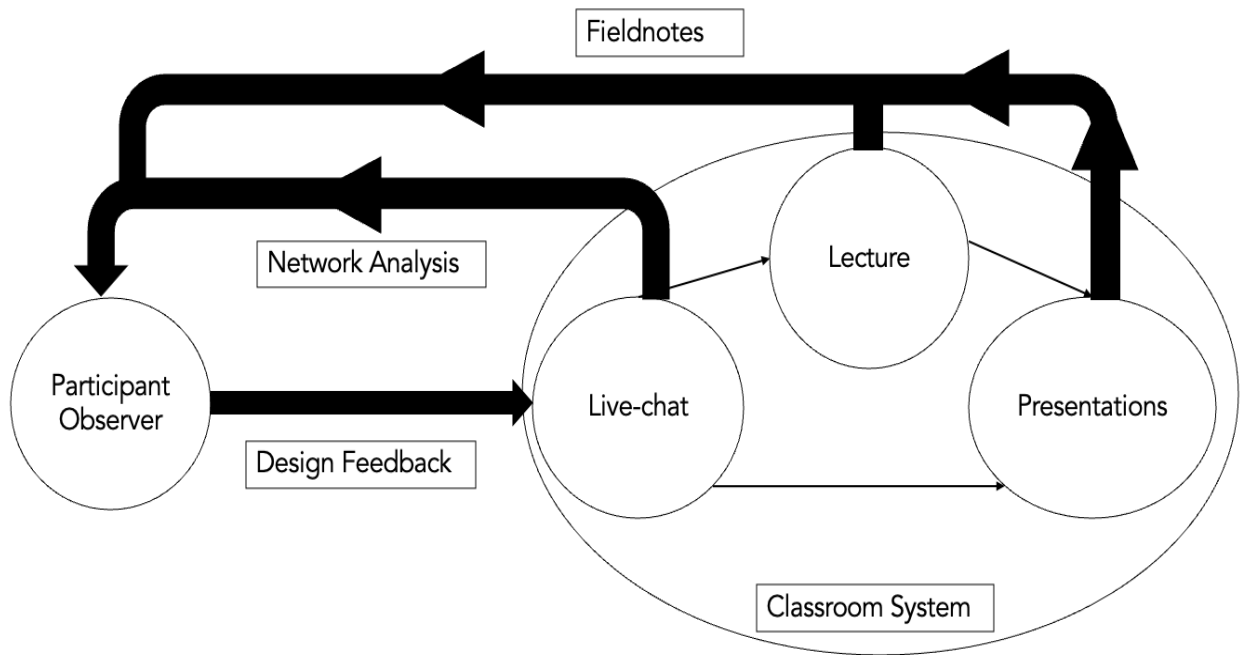

Figure 1. Frame of reference.

Design Phases

Six interaction design phases emerged that guided the (re)design of the live chat activity to augment lecture-based discussion and online interaction, with the first being a demo of Reddit (Table 2).

Table 2. Design phases to explain how the live chat activity was redesigned every week.

Phase	Chat format & Timeline
1	Week 1: Reddit demonstration. We show students how to use the online chat tool and how to log into the community created for the class.
2	Week 2: Live chat, one group, instructor and designer participate. Week 3: Asynchronous blog for testing, one group, instructor and designer participate.
3	Week 4: Week 3 insights suggest the use of live chat, one group, instructor and designer participate. Week 5: Live chat, one group, instructor, and designer refrain from participation. Week 6: live chat, one group, instructor and designer refrain from participating, critical mass seen with a smaller group of students.
4	Week 7: Based on Week 6, we used the live chat, two randomly assigned groups, instructor refrains from participating. Week 8: Live chat, two randomly assigned groups; instructor refrains from participating. Week 9: Live chat, two randomly assigned groups; instructor refrains from participating.
Spring-Break	
5	Weeks 10 &11: Since students wanted assistance, a live chat, with two randomly assigned groups, were conducted, and the instructor provided commentary.
6	Weeks 12 & 13: Since we gave the instructor some control, a live chat, with two self-selected groups, wherein instructor provided commentary was conducted.

Results

Our network diagrams (constructed starting Phase 2) indicate node size/colour by degree/in-degree, respectively, and edge thickness by interaction weight (key in Figure 2). Pink nodes have greater than average in degree or incoming interactions, while blue nodes have less than average in degree. Larger-sized nodes show a greater total degree (sum of incoming and outgoing interactions), and thicker arrows indicate a higher frequency of ties. Sociograms are accompanied by the ethnography of face-to-face lectures based on researcher field notes to indicate whether richer online interactions produced deeper ideation in lectures and during student presentations (beginning Week 8). Field notes from each class are provided in Appendix A.
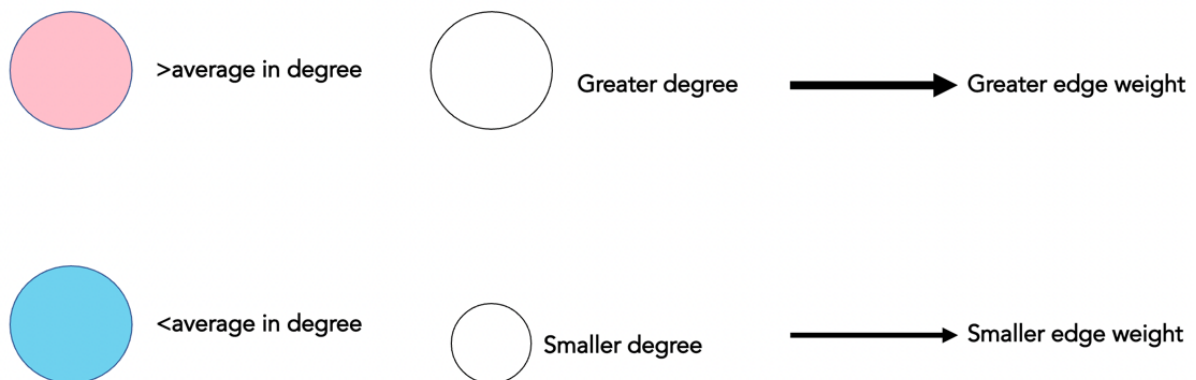

Figure 2. Key for network diagrams.

Phase 2

In Week 2's online class, Reddit live chats occurred in the first 15 minutes. The topic was the viability of grades. It was the first-time students used Reddit for live chatting, and they were curious about its functionalities. 11 of 16 students participated. The discussion produced insights about the necessity of grades accountability and the simultaneous need for project-based education. The instructor and two designers

participated, challenging students to familiarise themselves with live discussions. Extensive interactions were seen, with 123 comments produced. Transitivity was 0.55, indicating a high incidence of closed ties. However, only the instructor and one other user showed in-degree above average (Figure 4), with total degree imbalanced across users. After the live chat, some students reported the live chat speed led them to feel distracted, perhaps leading the five missing participants to avoid posting. This led us to test the viability of asynchronous blogs for Week 3. The following lecture involved considerable back and forth between instructors and students.

Week 3's chat discussed the role of police in schools. Responding to students' concerns about chat speed and prioritising them over network results showing, we hosted an asynchronous blogging activity instead of the chat so students would not be overwhelmed. Most discussants took one-sided stances, indicating the presence of legislative authorities could worsen the school climate, with some suggesting crises could merit the involvement of the police. There was little back and forth. Average degree, in-degree, transitivity (0.18), and eigenvector centrality (0.38) dropped owing to the static blog. 13 of 16 students participated, but students displayed the tendency to post a comment and response to the discussion board before disengaging (Tilak & Glassman, 2020).

Students and instructor agreed live chatting was the ideal format, despite concerns with speed. The following lecture was largely instructor-led, perhaps owing to limited chat engagement. Network diagrams and measures for Phase 2 are provided in Figure 3 and Table 3. It can be seen that the nodes for the diagrams in Week 3 are smaller, indicating a smaller degree. Thinner edges between nodes in Week 3 indicate lower interaction weight. Fewer interactions between n>2 agents explain how transitivity was lowered owing to the use of an asynchronous blog.
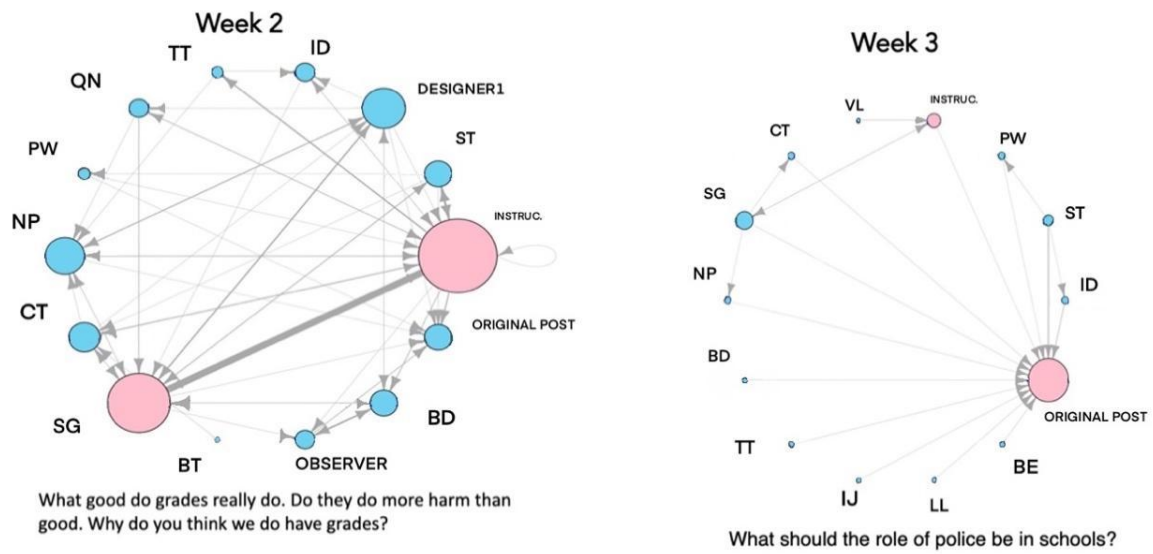
Figure 3. Sociograms, Phase 2.

Table 3. Centrality measures, Phase 2.

	Degree	In	Out	Transitivity	Eigen-Centrality
Week 2	7.71	3.86	3.86	0.55	0.45
Week 3	2.71	1.35	1.35	0.18	0.38

Having understood live chats were the ideal modality, the class and observer decided to implement a live discussion in one large group.

Phase 3

In Weeks 4, 5 and 6, we tried to understand whether sustained interactions using the live chat would increase cooperation. In Week 4, the class began in person, and the live chat discussed curricula designed to enhance self-management and emotional well-being. 14 of 17 participated. The live chat featured arguments about the monetisation of socioemotional toolkits and whether using prescribed approaches or

organic collaborative processes for students in need would help improve the school climate.

A high transitivity of 0.42 was seen, with average degree and in-degree showing increase, perhaps owing to the use of live chats in accordance with students' suggestions. Mean eigenvector centrality remained constant (0.38), indicating users were not more likely to be connected to influential others. The instructor and three other users showed an in-degree greater than average. The following lecture involved considerable back-and-forth reflection between the instructor and students about socioemotional learning (see Appendix A for brief field notes).

Beginning Week 5, the instructor avoided live chat participation to see whether four weeks of chatting allowed students to get more comfortable with using Reddit. The instructor exiting the chat initially caused shock, lowering transitivity (0.34). The prompt was based on developmental factors, asking about the merits and demerits of changing mandatory schooling ages. Despite the shock, all 17 students participated, used concrete examples to support their ideas, and took forward their constructive ideation into the lecture (see Appendix A for field notes).

In Week 6, only eight students attended, with several having gone to an academic conference. Students used newfound autonomy from Week 5 (wherein the instructor exited the chat) to interact in smaller groups, with each present student participating. The prompt asked about the implementation of collaborative and direct instruction. Most students said both methods were viable through concrete arguments. Richer chat interactions occurred in the smaller group, further affirming that they allow less vocal students to express themselves more easily (Delaney et al., 2010), with degree staying stable despite a drop in group size and transitivity (0.49) and eigenvector centrality rising (0.54). Network diagrams and centrality measures for Phase 3 are presented in Figure 4 and Table 4.

Based on the critical mass and upon seeing further discussion of top-down and bottom-up approaches to education in the lecture (see Appendix A for field notes), it was collectively decided to divide chats into two groups to heighten egalitarian participation. It can be seen that in Weeks 4 and 5, while the number of nodes with greater than average degree is high and edges are quite closed, there were proportionately more closed interactions in Week 6 owing to the smaller group size.
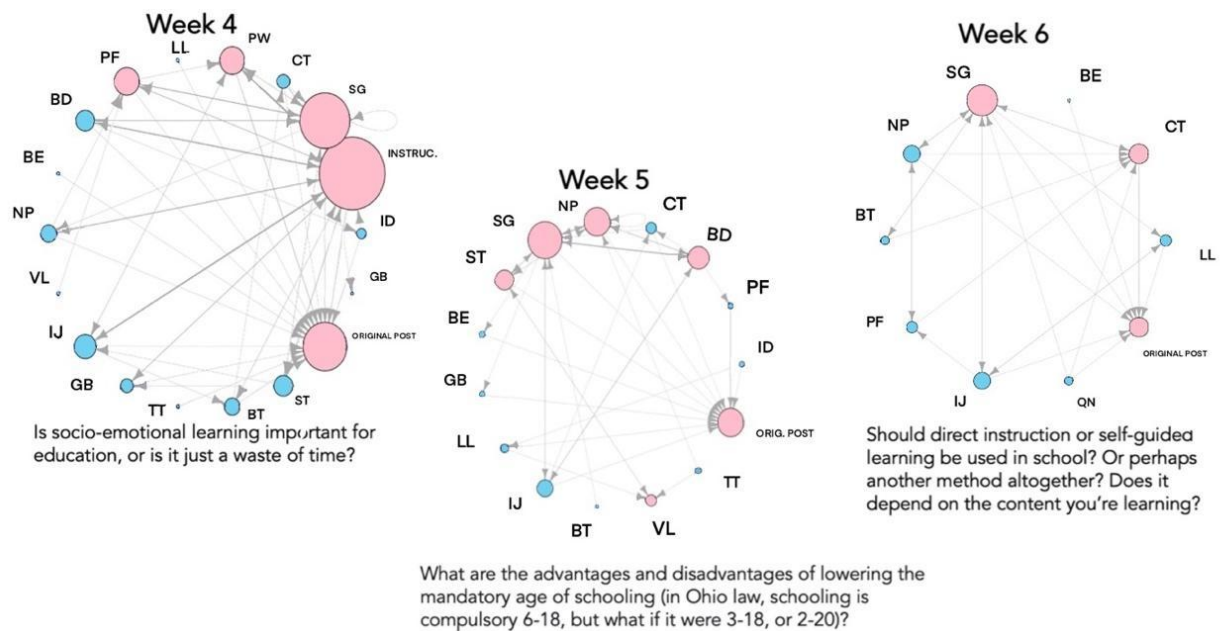
Figure 4. Sociograms, Phase 3.

Table 4. Centrality measures, Phase 3.

	Degree	In	Out	Transitivity	Eigen-centrality
Week 4	6.22	3.11	3.11	0.42	0.38
Week 5	5.06	2.53	2.53	0.34	0.42
Week 6	5.2	2.6	2.6	0.49	0.54

Phase 4

Starting Week 7, discussions were subdivided into two randomised groups (chosen by distributing numbered chits). Randomisation maintained anonymity (appreciated by students as it allowed discussing sensitive issues) and adhered to Rand et al.'s (2010) findings which explain why iterative reformulation of networks amplifies collaboration. In Week 7, the prompts focused on splitting the difference between top-down and collaborative instruction (Group 1) and topic-specific teaching (Group 2); the prompts were thus only loosely related to one another. 16 of 17 students participated. Group 1's discussion was rich, owing to the inks students made to Week 6's topic (individual and collaborative learning). Transitivity (0.51) and eigenvector centrality (0.55) rose. Students filled in gaps from previous discussions with concrete examples from experience.

Group 2 weighed the advantages/disadvantages of subject-specific teaching and generalised approaches. High transitivity (0.47) and eigenvector centrality (0.61) were seen, but the distribution of popular users was more hierarchical than in Group 1. Students were divided in opinion, with some suggesting casting a wide net in content would require effort to keep conversations focused, with counterpoints made suggesting that teachers could help model conversations to maintain on-task behaviour. These discussions spilt over into the lecture, with students discussing strategies that teachers could apply with the instructor (see Appendix A for detailed field notes)

Week 8's discussions focused on processes of learning (how and why of dynamic concepts and cognitive mechanisms like multi-tasking), were less uniform in collaboration across the groups. All 17 students participated. Group 1, which discussed the how/why of concepts in teaching and learning, produced lower transitivity (0.15) but showed stable eigenvector centrality (0.52). Students felt the prompt was vague and responded suggesting "how" and "why" was less important, with the question being "if" students learnt anything. Firm opinions lowered cooperation. Group 2 showed a different trajectory in discussing multi-tasking, a topic covered in introductory graduate courses in education at the university. This group produced higher transitivity (0.40) and comparable eigenvector centrality (0.56). Students engaged in a nuanced discussion, saying complex educational tasks may require targeted attention while menial tasks may use different motor functions concurrently. Despite differences in transitivity, there

were productive interactions seen in the lecture. Student presentations also prompted deep discussion (see Appendix A for field notes).

Seeing variety in discussion owing to different preferences/familiarities with loosely related topics, we maintained the format from Week 7 and 8 in Week 9 to test if fragmentation persisted. All 17 students contributed. Group 1 discussed how teachers could react to disinterested students in collaborative learning, while Group 2 focused on teacher Professional Development (PD), and whether it should be implemented as information provision or embedded into teachers' lives. This session occurred before Spring break, and students expressed exhaustion, saying the discussion was compulsory and laborious, despite it being voluntary. Those discussing PD (Group 2) had more one-dimensional answers, suggesting designing PD to be goal-oriented could provide instructors with a concrete roadmap.

High agreement with the idea of modelling PD around a goal led to lower reciprocal exchange, showing 0 transitivity but stable eigenvector centrality (0.55). While users were connected, they showed less likelihood of forming closed ties. Richer interactions occurred in Group 1, wherein members discussed ways to alleviate issues with collaborative instruction, finding greater opportunities to link ideas to previous prompts about splitting the difference between direct instruction and constructivism. Some students outlined concrete solutions to model collaboration in case of off-task behaviour through open-ended questioning and prioritising students' interests. These interactions showed higher transitivity than Group 2 (0.33) and slightly higher eigenvector centrality (0.59). Perhaps owing to the polarised transitivity in both groups, the lecture-based interactions were largely instructor-driven. However, student presentations were also discussed with a critical eye (see Appendix A for field notes). The network diagrams (Figure 5) display how degree and closed interaction reduced (indicated by smaller node size and fewer ties between n>2 agents) as Spring Break approached.
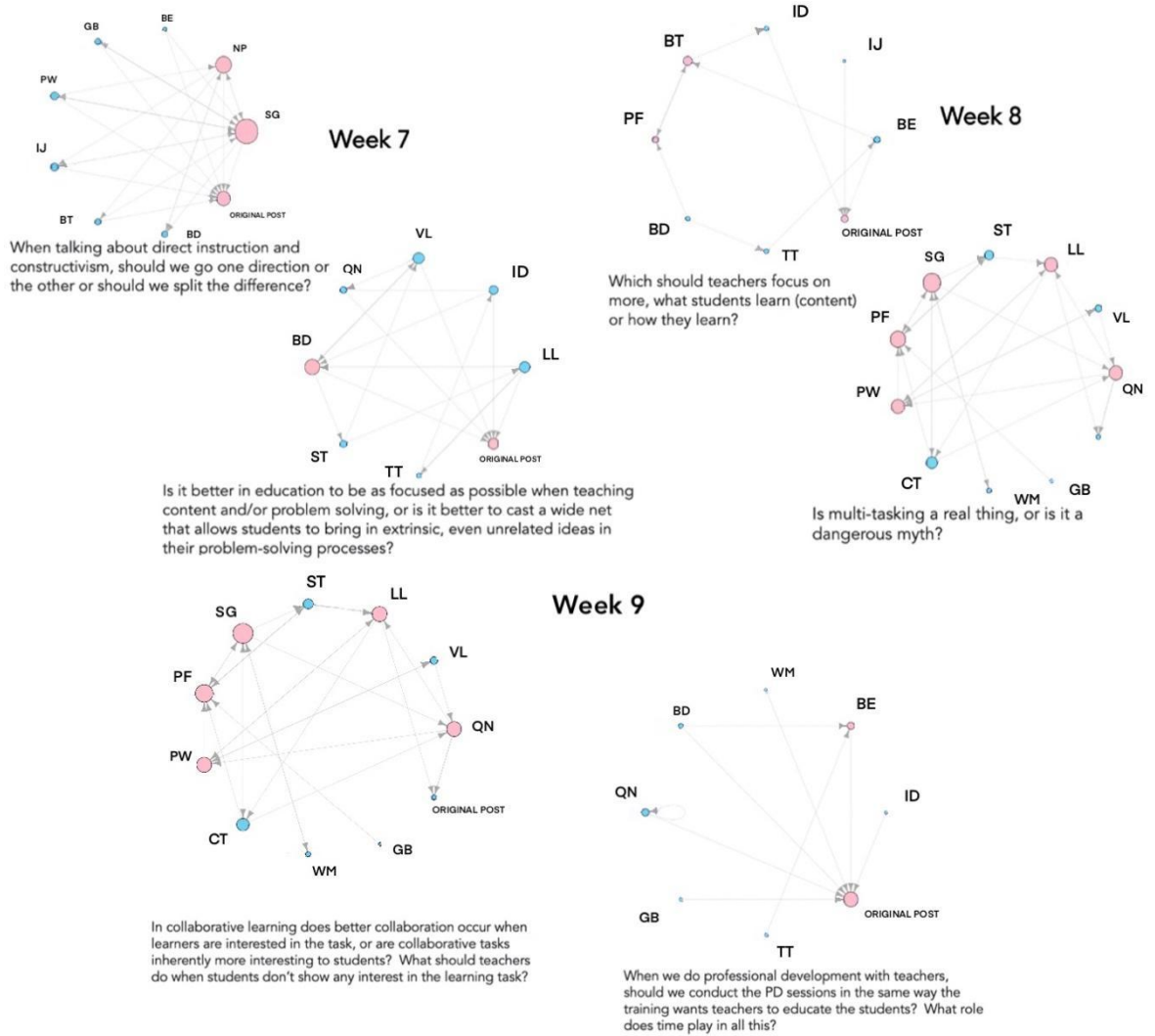
Figure 5. Sociograms, Phase 4.

Table 5. Centrality measures, Phase 4.

	Degree	In	Out	Transitivity	Eigen-centrality
Week 7	4.68	2.34	2.34	0.49	0.58
Week 8	3.86	1.92	1.92	0.28	0.55
Week 9	3.77	1.76	1.76	0.17	0.57

Hearing students' desire for more support with questions in the online chat, the instructor and designer began to brainstorm ways to support concept development and cooperation within online discussions.

Phase 5

Over Spring break, the research team modelled the discussion through in-person commentary from the instructor to support live chat interaction and a deeper understanding of the prompt. In Week 10, we tested this idea by presenting a challenging question about sociological theory. The discussion focused on whether cultural capital (existing information about one's cultural reality) or social capital (ability to collaborate and understand others' experiences to critique information) were more important in learning. 13 of 16 participated. Students initially struggled with the question.

This prompted the instructor to begin modelling the discussion through in-person commentary, explaining how cultural systems are driven by hidden agendas infused within teaching (e.g., teaching about the partition in the Indian subcontinent) that fabricate cultural capital. Room for critique/collaboration could open new learning pathways. Such modelling led to increased collaboration. Some students suggested providing content or cultural capital to bridge inequity was important but allowing critique was equally imperative. In Group 2, which discussed the contrast between content and critique, valid questions about the mutual exclusivity of cultural and social capital were raised, with students asking if cultural and social capital were in opposition

to one another or could co-create one another. This prompted responses suggesting cultural capital was not necessarily bounded within spaces of privilege, but the ability to critique it, while important, may be limited in communities without resources. Group 1 showed transitivity of 0.41, while Group 2 showed a lower tendency for closed ties (0.29). Eigenvector centrality was higher in Group 1 (0.61) compared to Group 2 (0.51). The lecture involved a deeper discussion of ideas in the chat about the hidden curriculum and cultural capital and also involved a deep critique of student presentations (see Appendix A for field notes).

In Week 11, the same format was maintained. The weekly prompt, focusing on applications and risks of radical education calling for a restructuring of schools to be based on informal project-based approaches, produced considerable knowledge-sharing. 16 of 17 participated. In Group 1, students linked critique through radical education to critical race theory (CRT) approaches that have become controversial in the U.S., saying giving students an opportunity to critique a neutral canvas of ideas is often incorrectly tied to liberal agendas. Others responded, saying implementing such processes in individual classrooms could be risky, inviting criticism from fellow colleagues and even parents.

In Group 2, members discussed the potential limitations of radical education. Comments suggested being conditioned to using a top-down, direct instruction approach may cause instructors to panic when students do not show interest in critique and taking agency over their own learning. Students also mentioned the role of the home in transforming education. While pivoting radical pedagogy may transform students' thinking when successful, such change may not be universally amenable to parents.

While discussions were constructive and invited shared inquiry, Group 1 showed lower transitivity (0.22) than Group 2 (0.48), and slightly lower eigenvector centrality as well (0.43 compared to 0.54). Participation in both chats became more egalitarian, indicated by a higher number of nodes with an in-degree higher than average. The students expanded the live chat discussion in the lecture, trying to grapple with ways to apply radical education (see Appendix A for field notes). Network diagrams and average centrality metrics are presented in Figure 6 and Table 6 and display how agents with

in-degree greater than average (pink nodes) slowly increased towards Week 11 as the instructor began to provide support to live chats through ongoing commentary during class.
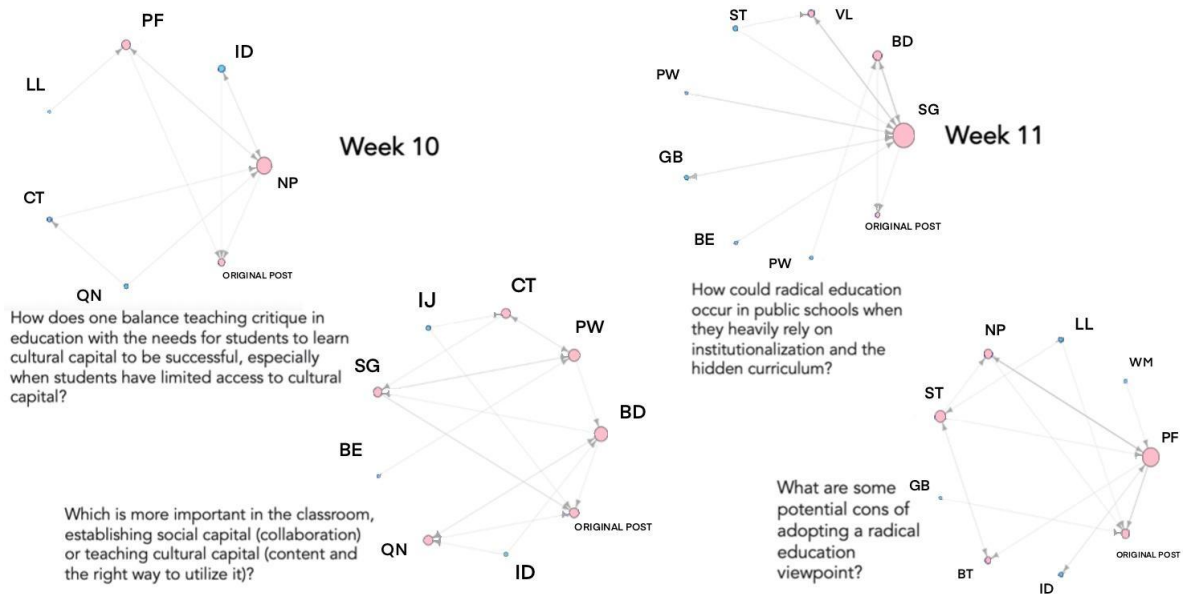

Figure 6. Network diagrams, Phase 5.

Table 6. Centrality measures, Phase 5.

	Degree	In	Out	Transitivity	Eigen-centrality
Week 10	3.45	1.73	1.73	0.35	0.56
Week 11	3.01	1.51	1.51	0.35	0.49

Seeing how transitivity and participation stabilised when autonomy for free interaction was balanced by modelling, we maintained bipartite discussions and provided slightly higher autonomy to students in Phase 6.

Phase 6

Seeing how students came to appreciate the instructor's commentary of prompts, we provided options to students to self-select groups in the final weeks to complement instructor guidance with autonomy. We thought this would enable agency in live chat. In Week 12, rather than choosing groups by informing each other, students counted off in ones and twos, maintaining anonymity. 14 of 17 participated. Group 1 discussed the unmotivated student, trying to decode whether disinterest in a particular topic equalled being "unmotivated". Students grappled with motivation theories and argued motivation could exist when students could not see the utility of context-specific tasks. Others argued that larger contexts also affected perceptions of success. Group 2 discussed how teachers can make sure they factor in students' interests as opposed to content knowledge and whether this is their responsibility. Students agreed teachers needed to know who their learners are as people to understand what engages them and make spontaneous links to topics or examples they find accessible.

The related group chats complemented the lecture, which involved much reflective discussion between the instructor and students about the differences between socio-cognitive and constructivist psychology and a deep evaluation and critique of student presentations (see Appendix A for field notes). Both Group 1 and Group 2 showed high transitivity (0.34 and 0.58). Average degree was higher compared to Weeks 10 and 11 (4 in both groups). Participation became egalitarian, with a greater proportion of users showing in-degree greater than average. Eigenvector centrality increased to 0.68 in Group 1 and 0.69 in Group 2.

In Week 13, students self-selected groups by choosing a preferred prompt in private and posted to that group, determined to stay anonymous. The topic was the role of diversity in education. 16 of 17 students participated. The prompt in Group 1 focused on the role of parents in schools, and discussions focused on the case of children with disability and the infrastructure of school board meetings. In Group 2, participants discussed whether parents should have a say in which practitioners are hired to teach children. Some users suggested parents' limited knowledge of the driving forces behind teacher training would not equip them for such decisions and that political partisanship could increase the risk of polarisation from involvement. The lecture flowed well from

the live chat, trying to understand how to incorporate the role of cultural histories and backgrounds into education through back-and-forth discussion (see Appendix A for field notes). Both groups showed high transitivity (0.41 and 0.45) and comparable average degrees (3.6 and 3, respectively) and in-degree (1.8 and 1.5). Eigenvector centrality in Week 13 was comparable to Week 12 and balanced across groups (0.54, 0.58). Sociograms are provided in Figure 7, and average metrics in Table 7 show how closed interactions between more than two agents, and agents with a greater than average degree (pink nodes) became more stable and balanced, respectively, towards the end of our study.
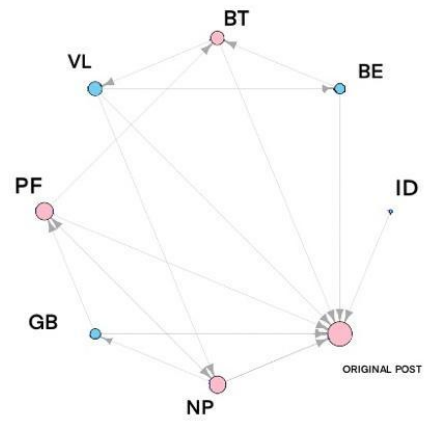
Table 7. Centrality measures, Phase 6.

|	Degree	In	Out	Transitivity	Eigen-centrality
Week 12	4	2	2	0.46	0.68
Week 13	3.3	1.7	1.7	0.435	0.56

Week 12

LL
IJ
SG
PW
CT
BD
ORIGINAL POST
QN
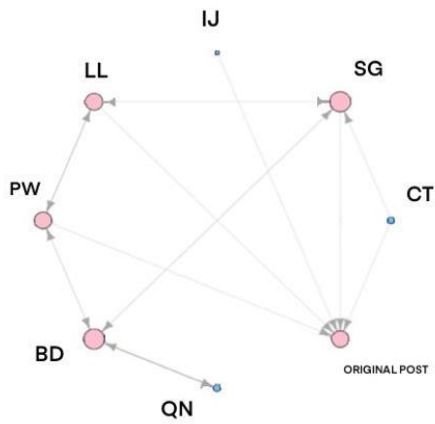
Is there truly such a thing as an unmotivated student?
Or does school the material simply not interest them?

BT
VL
BE
PF
ID
GB
ORIGINAL POST
NP

As educators, how is it possible to teach within
the curriculum while also making sure that the
material is interesting? To what degree is it our
responsibility to make sure it is interesting?

Week 13

ST SG
PW LL
BE
ID
GB
ORIGINAL POST
QN BD
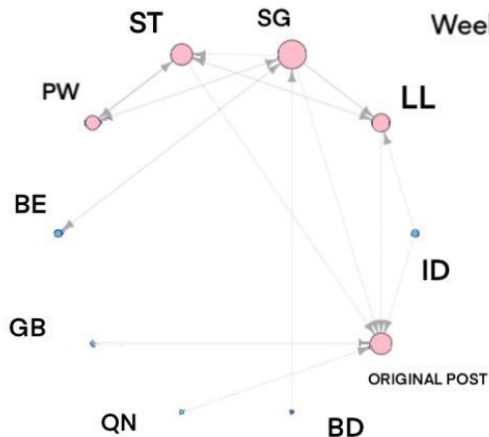
Should parents have proper representation (a formal
committee) as key stakeholders in policy decisions? How can
teachers involve parents in influencing their students' learning?

CT
BT VL
NP
PF
BD
ORIGINAL POST
WM
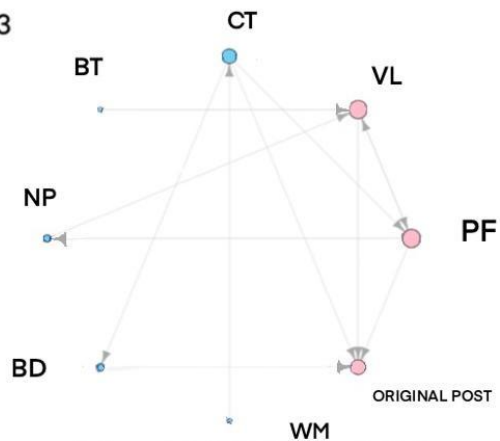
Should parents be involved the hiring process of staff in the
schools that their children attend? How can school districts
involve parents in decision making?

Figure 7. Sociograms, Phase 6.

Evolution of network metrics

Transitivity fell in Phase 2, when we tested asynchronous blogging, and rose until Week 7, when the instructor and designer decided to implement a subdivision of chats, seeing a critical mass in Week 6 (end of Phase 3). As Spring break neared in Week 9, students expressed exhaustion, with average transitivity dropping. In Phase 5, participants appreciated support from ongoing instructor commentary and began to actively post. Participation became more egalitarian in Phase 6 when the support of the instructor was complemented by the self-selection of prompts. This autonomy gave students agency to discuss the ideas they chose. Eigenvector centrality showed a steady increase, suggesting agents within the network were more likely to be connected to popular users. While the instructor was initially involved, he withdrew slowly from the conversation after modelling the conversation for a few weeks, gradually allowing talkative students to take over the role of bringing quieter peers into the discussion (legitimate peripheral participation; a key aspect of any Community of Inquiry; Lave & Wenger, 1991). Rewiring the network by random reshuffling produced a greater chance for positive co-dependence to guide the online discussion, amplified by self-selected groups. Changes in transitivity and eigenvector centrality are depicted in Figure 9.

With regards to the number of participating students, we saw despite the chat being voluntary, there was a rise in participation, with most students present partaking in the dynamic live discussion towards the end of the semester. Figure 10 depicts the percentage of present students participating in the discussion.

Results suggest redesigning the live chat in a technology-supported graduate-level class enabled the creation of a cohesive learning community that could co-construct online and face-to-face dialogues.
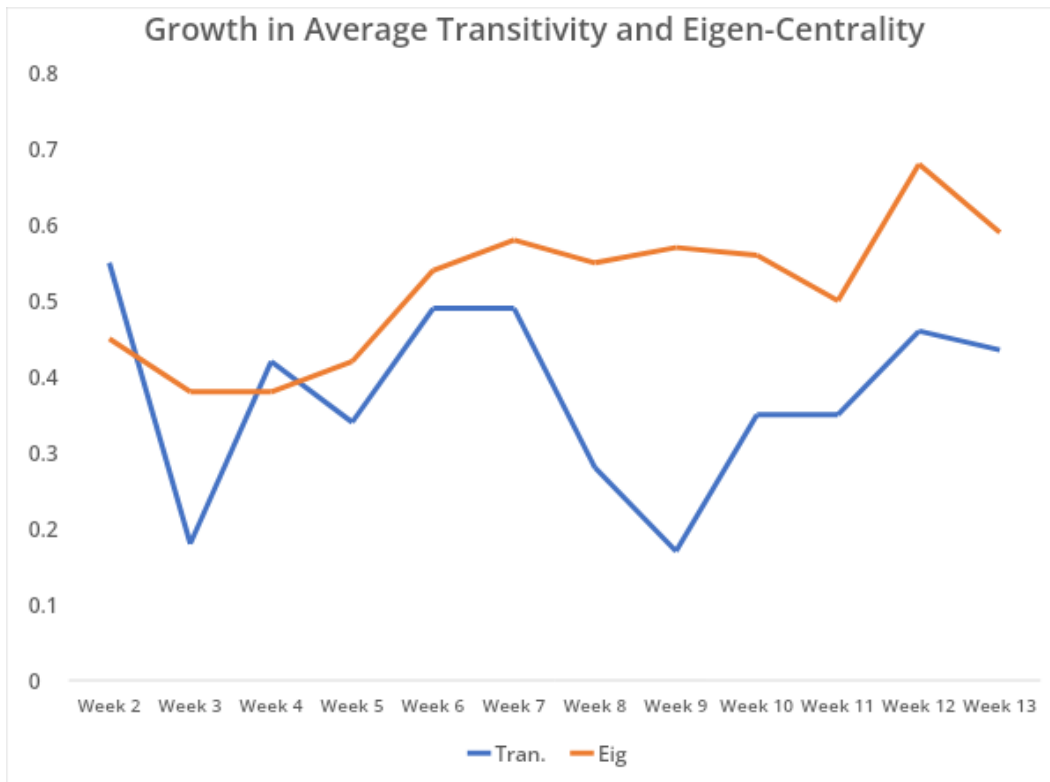
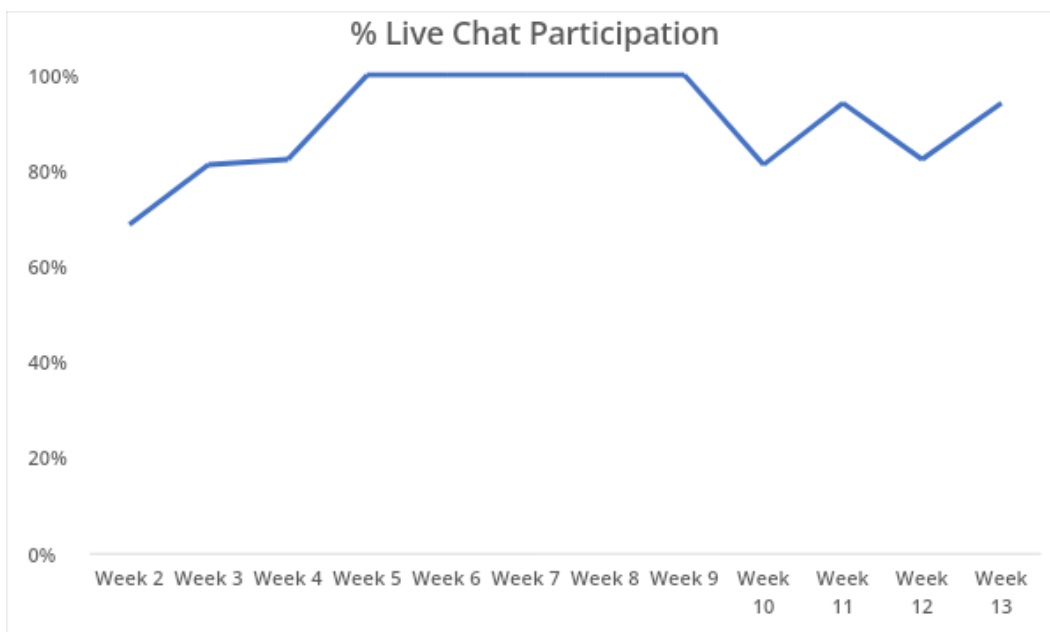Figure 9. Transitivity and eigenvector centrality.

Figure 10. % Students participating in live chat.

Discussion

Our study, which applies cybernetic interaction design to educational contexts using social network analysis as a mechanised modelling facility, answers four hypotheses. Our results answer H1, as transitivity became stable as the network was rewired, suggesting that closed ties between two or more individuals were encouraged by interaction design. Since nodes showing greater than average in-degree increased as autonomy and authority were balanced, and degree became more uniformly spread, our findings successfully fulfil H2, suggesting interaction design promoted egalitarian participation. The rise in eigenvector centrality indicates agents grew more likely to connect to influential others, answering H3. These findings align with the findings of Rand et al. (2010), which suggest that a rapid rewiring of ties in a social field may lead to social contagion to amplify or stabilise collaboration.

 Students were able to challenge the instructor and grapple with issues discussed in the chats during the lecture. As students began to realise linkages between presentations, the lecture, and their reaction papers could be strengthened through interaction in the optional live chat, the proportion of participating students increased despite the activity being ungraded. This created a space-place dialectic (Glassman & Burbidge, 2014), with online and face-to-face classroom interactions co-constructing one another, answering H4.

By following the agency displayed in the online interactions students engaged in on a weekly basis, the participant observer was able to use network analysis on live chats and write field notes from gauging weekly lectures/presentations to suggest how the Reddit activity could be rewired to allow a free flow of ideas between the chat and lecture. Restructuring online discussions on-the-fly enabled forming of a cohesive learning community with the passage of time and more consistently reflective lecture-based discussions. We thus follow Gordon Pask's (1971) idea of a modelling facility helping analyse and streamline observed systems in an evolving manner, treating them as dynamic by using the output produced from analyses to restructure online interactions iteratively. Such an approach may also be used by classroom instructors in classes assisted by similar online modelling facilities like discussion boards or social media. In the absence of a processing tool like RStudio, instructors may view

weekly interactions in their discussion forums or class social media tools and gauge whether distributed collaboration occurs in naturalistic interactions between more than two individuals. This may help understand what direction to take in discussion-based activities to augment class activity in-person and online.

Limitations

This study has a few limitations. While the sample size is small, the highly dynamic, organised, but complex nature of the analysis conducted in this study makes it more amenable to use in smaller classes. A large number of students may limit the freedom to modulate online activities to meet individual needs, especially if these weekly design changes are initiated by manual human assistance, as in this study. While we elaborate extensively on mechanisms of learning by explaining the link between network analysis, lectures, and student presentations using ethnography, we do not analyse the quality of chats or narrate them in this short paper using coding, by further adding attributes to our network analysis. Further research could understand whether post-reflectivity (Tilak et al., 2020) increased with time and fostered increased network ties, using coded metrics as a node attribute to map the growth of reflectivity using temporal exponential random-graph models (TERGM). However, our approach in this study adopts an observer-driven mixed methods design, which suggests that quantitative models and live observation can help design college classroom settings in an iterative fashion.

Conclusion

In the age of the Internet, where ubiquitous technologies create cybernetic feedback loops, responding through design approaches that mimic this feedback loop (Pangaro, 2008) to guide human agency towards the adaptive use of technology may be a sound way to equip individuals with skills to navigate an information-saturated society, and steer the algorithms they are exposed to towards guiding exploration and learning (Tilak & Glassman, 2020). Educational settings become norm-driven environments to understand the potential to foster these digital skills. To mimic this cybernetic feedback loop produced by new media in the classroom, our study uses interaction design, rewiring an online live chat activity based on a network analysis of student interactions and ethnographic notes of following lectures. We adhere to Gordon Pask's idea that a

machine may be used as a modelling facility (here, the ability to export Reddit chat interactions from a computer and to take field notes in lectures) to derive insights (from social network analysis and presentation of field notes) to (re)design a system (here, the live chat activity, which influences lectures). The presence of a participant observer enabled putting the weekly metrics into context, enabling the treatment of each student as a dynamic observer (Tilak et al., 2022) of the classroom setting and of their use of Internet tools such as Reddit. Our study, which utilises human assistance for iterative design, provides a basic entry point into possibilities to automate network analysis techniques in technology-assisted classrooms using APIs and other online tools.

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Appendix A: Field Notes

Week	Phase	Brief Field note
Week 2	Phase 2	In the lecture, students expanded ideas from the chat to challenge the instructor. They raised arguments pertaining to the merits and demerits of mastery and grades-driven models of education, insistent on splitting the difference.
Week 3	Phase 2	In the lecture, the instructor discussed the bioecological model of psychology to see how complex social systems affect learning and teaching. The class discussed the role of policy (macrosystem) in schooling. However, the interactions were largely instructor-led, perhaps as a result of less idea transfer arising from limited chat engagement when we used an asynchronous blog.
Week 4	Phase 3	In the lecture, the instructor screened videos of common techniques to instruct emotional management, spurring discussions about whether such skills should be fostered by providing information top-down or whether SEL should be embedded into organic processes of collaboration. Students agreed using prescribed toolkits may serve financial interests rather than meeting the needs of students, engaging in a back and forth with the instructor to navigate solutions to such issues.
Week 5	Phase 3	The chat transitioned well into the lecture on stage development and the social world. The lecture involved a discussion of Piaget. Students actively argued to understand whether social or innate factors play a primary role in development.
Week 6	Phase 3	In the lecture, the instructor challenged students' neutral stance. Students responded, stating the necessity to equip learners with content to meet the needs of rigid school systems and opportunities to engage in constructive discourse to allow navigation of social arenas students may occupy in their futures.

Week 7	Phase 4	The lecture expanded ideas from the live chat with students trying to develop strategies to engage in domain-general teaching, to allow students to develop transdisciplinary competencies.
Week 8	Phase 4	The lecture led to questioning about sensory and social bases of thinking and action, talking about nature and nurture. Students spoke about musical and theatrical talents as constructed by both these factors, and the instructor suggested emotional history as a contributing factor. Personal and situational factors affecting learning were brought into discussions of two student group presentations. The first screened videos of undergraduate students engaging in collaborative learning, and those watching the presentation critiqued the approach, hypothesizing mechanisms guiding concept development in collaboration. The second presented clips from the Abbott Elementary series to highlight how different pedagogies (direct instruction, collaborative learning) could be tailored to fit urban education, prompting students to ask how to adapt collaborative instruction to college settings, drawing links to the first presentation.
Week 9	Phase 4	The lecture, on training teachers to implement collaborative education, drew from ideas in both discussions but was instructor-led. Student presentations screened clips from the Dead Poet Society, showing how teachers can help students navigate their realities by allowing sharing experiences as equal agents, and visualizing solutions to real-life issues. Students critiqued the presentation and used scenes from the movie to understand the applications of understanding the role of social experience in learning.
Week 10	Phase 5	The chat transitioned into a lecture on the nature of the hidden curriculum, with the instructor moving ahead of the syllabus to explain how radical education, could relate to the idea of giving students the freedom to critique ideas through development of social capital. The instructor went into the history of radical education, which is rooted in the ideas of Ivan Illich and cybernetics. The following presentation on direct instruction and collaboration prompted links to promoting learning through critique, and

		presented video clips from Karate Kid. Students highlighted how Mr. Miyagi engaged in a direct instruction process, and how English language learning could best be carried out through organic conversations.
Week 11	Phase 5	The lecture that followed the live chat further discussed radical education, with students suggesting ways to apply it to the constraints of educational environments, trying to concretize ideas from the chat. Seeing how transitivity and participation stabilized when autonomy for free interaction was balanced by modelling, we maintained bipartite discussions and provided slightly higher autonomy to students in Phase 6.
Week 12	Phase 6	The related group chats complemented the lecture, which focused on biological, social, and cognitive aspects of interest in learning. The instructor mentioned the idea of integrating cognition, cultural history, affect and action (constructivism) as a counterpoint to motivation. Students and instructor tried to understand why grappling with sociomoral issues at a younger age may spur nascent citizens to develop emotional histories allowing critical thinking in their futures about societal hardships. The student presentation screened clips from Freedom Writers Movement, explaining how getting to know who students are can help practitioners engage them.
Week 13	Phase 6	The lecture transitioned well from the live chat understanding parents' roles in education. Students and instructor discussed how culturally relevant practices could be implemented in school. The student presentation screened clips from Remember the Titans, which described conflicts between all-black and all-white football teams when they were fused, to help understand how cultural experiences can be negotiated.