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Exploring The Impact of Discussion Interfaces on Diversified Interconnectivity in Online Learning Communities

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Abstract: *Asynchronous online discussions are widely recognized as potent pedagogical practices for actively involving learners in the process of constructing knowledge and cultivating a thriving learning community. This study examined how the types of online discussion threads (i.e., student-based vs. topic-based) moderate diverse of social interconnection in discussions and how it changes over time. An upward trajectory in the diversification of interconnectivity was discerned. In spite of the shift from student-based to topic-based, students continue valuing the power of diversified interconnecting with their classmates. The significant drop, but transitory, from Week 3 to 4 can be explained by the switch to another discussion type. Both the student-based and topic-based threads were observed to facilitate comparable levels of diverse connectivity. However, they accentuated subtle attributes within the learning communities. Instead of deciding upon any asynchronous online discussion tools given by institution's LMS, instructors should critically assess different discussion thread interfaces and integrate a relevant one to create and facilitate their ideal and effective, yet diverse learning community. Future research should explore diverse interconnectivity traits and extend the timeframe beyond three weeks to observe the enduring impacts on learning community development.*

Keywords: asynchronous online discussion, learning community building, discussion thread interfaces, diverse interconnectivity, social network analysis

Introduction

While battling digital learning challenges, oftentimes educators seek solutions through various digital technologies or tools, platforms, devices, and equipment. The COVID-19 pandemic obliged many educators to transition from face-to-face instruction to remote, online, or HyFlex teaching and learning, revealing issues related to inadequate technology infrastructure and improper design and practices. Some learners and educators are replete with advanced technologies available to them while some were left with paucity or none. Regardless of the challenges faced, all stakeholders were quickly disabused of the fanciful notion that technologies, tools, and devices alone could not serve as a savior for teaching and learning. This fundamental understanding reaffirmed that teaching and learning are always fundamentally grounded in rich social and cultural interactions and connections with others.

Owning to the capability and ability of asynchronous online discussions (AOD) in fostering the synergetic voices heard, creative ideas exchange, optimal identities facilitated, distributive networks interconnected, cohesive communities built, organic environment established and sustained, subsequently teaching, and learning goals optimized and attained, AOD evolves from an old practice to one of promising instructional practices. In essence, online discussion instruction transcends mere socio-cognitive learning; it is the amalgamation of socio-cognitive and socio-cultural learning that educators aim to elucidate in this discourse. With the versatile nature of AOD features and design, community learners undergo transformative journeys marked by profound shifts in thinking and perspective, referred to as 'metanoia' experiences.

Fostering a Stronger Learning Community

Fostering a stronger community

Rovai (2001) emphasized the significant impact of integrating online discussions to foster a cohesive learning environment and a sense of community. Through these ongoing community-building processes, members develop deeper trust relationships, resulting in increased engagement as learners initiate more frequent inquiries, interactions, and connections with community members, instructors, and facilitators. The positive communal learning experience accentuates the value of instruction in assailing the students' diverse needs. Going beyond formal learning in an academic context, the acquired cooperative and collaborative skills will equip learners with essential lifelong learning abilities for non-formal and informal learning, including sustained self-regulation and dynamic problem-solving gained through authentic learning experiences.

Through effective online discussion activities, learners not only distinguish the values that hold significance for individuals, groups, networks, communities, and learning environments but also ensure that processes, structures, and solutions align with, respect, and embody these identified values. Therefore, online discussion instruction becomes a powerful facilitator in addressing the social, cultural, emotional, and educational needs of students (Aderibigbe, 2021; Chen et al., 2023) while catalyzing positive transformations within online collaborative learning communities.

Diverse Exploratory Learning

When learners engage in online learning discussions, they gain a deeper understanding of their own cultural context and the opportunity to employ their cultural

values in the exploration of multiple and diverse perspectives (Clark et al., 2009). By using their peers as sounding boards, online discussions, as online learning activities, empower learners to compare and contrast their own understandings to others to foster effective, diverse exploratory learning to generate creative learning solutions.

Participating in online discourses encourages learners to fully comprehend and appreciate their own learning cultures and contexts. They achieve this objective through the utilization of empathetic techniques (Jarvis et al., 2022) that employ positive and appreciative reflective inquiry (Quintana et al., 2021) for evidence-based learning (Kim et al., 2016). Through the application of these strategies, online discourse instructions can involve learners in a comprehensive understanding of their present situations, encompassing individual experiences, network dynamics, community interactions, and environmental factors, all within the context of place-based education practices. While all students are encouraged to share their cultural perspectives, they are also immersed in the multitude of perspectives presented by their peers. These extensive practices are imputed to the involvement of a broad spectrum of voices where they contribute an unparalleled composition of life experiences, personal belief, and varied background, and cultural richness.

Having assessed their own cultural and contextual awareness through online discussion instructions, learners are equipped with the capacity to define and understand problems within the community collaboratively and intentionally. Subsequently, students are able to excogitate innovative approaches, fostering meaningful collaboration among diverse community members.

Challenges in Understanding Interface Impact

While educators are continually in search of efficacious methods and design to advance online discussion instruction, they transition to varying discussion board technologies. Beyond the discussion boards provided by Learning Management Systems (LMS), many have endeavored to understand the capabilities and features of different discussion tools, such Web 2.0, as social networking sites like Facebook, X.com, or Yellowdig, to invigorate new forms of online discourse. However, the thread interface of online discussion tools may remain static and unalterable from the perspective of learners, instructors, and administrators.

Often, students and instructors alike may hold the misconception that the thread interface designs of all online discussion board technologies operate uniformly. Consequently, students and instructors engage in online discussions without a full awareness of how the discussion thread interface design may render their discussion behaviors and impact their learning outcomes. The current body of literature exists a notable gap in the examination of how student-based discussion threads and topic-based discussion threads (Figures 2&3) may influence the diverse interconnectivity observed in online discussion board activities. The discussion board in BlackBoard Learn is equipped with several thread-interface features such as Collapse/ Expand, Search, Sort, and Tag, among others. However, it's important to note that both students and instructors might not be fully aware of or utilize these available features. The course instructor in this study crafted both the design and prompts of the discussions in both student and topic-based formats.

Literature Review

Fostering Learning Communities

In the evolving landscape of educational technology and pedagogical approaches, the importance of fostering strong, collaborative learning communities cannot be overstated. Within this framework, asynchronous online discussion boards stand out as instrumental components. As highlighted by research, these platforms are not merely digital spaces for communication; they are deeply grounded in educational theories. Asynchronous online discussion boards have emerged as potent instructional tools, deeply rooted in constructivist (Hambache et al., 2018) and connectivist (Azmuddin et al., 2022; Dziubaniuk et al., 2023) learning theories. Online forums are propitious in cultivating dynamic interaction, and engagement, advancing the exposure of diverse social and cultural perspective, and facilitating knowledge construction through collaboration.

Cultivating Dynamic Interaction and Engagement

Online discussions function as quintessential design to engage students, and instructors in interactive and yet engaging learning activities. This interaction is the cornerstone of building a profound sense of belonging and connection within a robust learning community (Wong et al., 2021) and community of practice (Scott & Schonfield, 2022). These discussions foster regular and high-value interconnectivity and engagements to advance learner-learner and learner-instructor interaction (Jin et al., 2022). These constructive engagement enables learners to acquaint themselves with their classmates, to forge their social interconnection to galvanize a genuine sense of community. Zhong and Norton (2019) concluded that active discussion involvement is paramount to cultivate a collective inquiry and result in an elevated content proficiency. Students in a team must read, reflect, and respond thoughtfully to their peers' contributions, promoting a deeper understanding of the course material and acted as a motivator, inspiring and motivating their collaborators to actively contribute to online discussions and foster a sense of community.

Advancing the Exposure of Diverse & Cultural Perspectives

Online discussions provide learners and instructors with invaluable opportunities to engage in profound social interconnections with peers from diverse backgrounds (James, 2022). These exchanges challenge, refine, and synthesize existing knowledge, fostering heightened awareness of ambiguity and a greater appreciation for diversity (Xie et al., 2014). Discussions promote the sharing of opinions, perspectives, and the cultivation of a broader worldview (Chen & Chen, 2023). Building social presence is essential in an online course. By nurturing ideal social presence, effective discussion design renders students to express themselves, share personal experiences, and get acquainted with their classmates. Yen et al. (2022) reveal that learners with higher social presence often assume influential roles within communities of learners, acting as influencers, liaisons, transmitters, social strategists, and prestigious figures. Studies by Chiu (2014) and James et al. (2022) attributed students' cultural background can influence their learning experiences, especially in the context of information technology.

Facilitating Knowledge Construction Through Collaboration

To facilitate knowledge construction,

AOS are frequently incorporated to promote collaboration and the creation of effective learning networks and communities (Chen & Yeh, 2021). Discussion activities transcend hierarchical structures and profoundly influence learners' engagement, reflection, and synthesis of ideas (Hamadi et al., 2023). They actively promote collaborative learning (Perinpasingam & Krishnan, 2022) and shape peer identity dynamics (Spence et al., 2023) during the process of socially constructing knowledge. It is imperative to acknowledge that the processes of social sharing and knowledge construction do not inherently manifest within the realm of online. Instead, they entail instructors and designers careful and precise designing and devising, and skillful facilitation throughout the collaboration in constructing knowledge (Zhu, 2006).

Discussion Thread Interfaces

The choice of discussion thread type significantly influences how learners read, reflect upon, and synthesize diverse ideas and viewpoints. The learner-interface relationship in the realm of online discussion instructions assumes paramount significance, as it profoundly influences the roles of the learner-interface in shaping interaction and connectivity dynamics (Butz & Stupnisky, 2017; Hillman et al., 1994). Effective learner-interface design in the context of online discussions is known to impact learners' ability to engage in effective interactions (Chang, 2010), cultivate positive experiences (Osborne et al., 2018), nurture higher-order thinking skills, foster better collaborations (Dissanayeke et al., 2014), and facilitate the formation of online communities (Tu et al., 2010).

While online discussion boards inherently present various challenges with different factors in achieving effective interaction, collaboration, and community building, researchers drive their knowledge to comprehend online asynchronous discussion thread interface design to address these challenges. Matahari et al. (2022) embarked on an initiative that illustrates this endeavor, utilizing a user-centered interface design approach within the context of a learning-centered design framework for online discussion. User-centered interface design served as a catalyst for an initial activity and four stages of learning inquiry, therefore advancing learners' efficacy in online discussions. Chen (2022) concluded that different discussion interface designs post a significant impact on learners' academic achievement, not their overall satisfaction on the course.

From a technical standpoint, Dissanayeke et al. (2014) highlighted the imperative need for enhanced technical support and the incorporation of more effective interfaces to facilitate collaborative learning within online discussion activities. Looking at community building, the integration of less restrictive and more flexible learner-interface options in online discussions emerges as a crucial consideration, serving to foster collaboration and stimulate the formation of vibrant learning communities (Dos Reis et al., 2009). Furthermore, various discussion interfaces, namely threaded and flat-structured, exerted significant influence on students' participation in online discussions. Tu et al. (2010) elucidated the effects of both threaded-structured and flat-structured interfaces on online discussions. They observed both interfaces enhancing and inhibiting discussion in the aspects of discussion context density, context-oriented environments, social network features and mechanism, collaborative effectiveness, and sense of community. It is noteworthy that Hewitt (2003) conducted

observations that revealed the nuanced impact of specific learner-interfaces, at times leading to the phenomenon known as "single-pass effects," which, in turn, could result in thread abandonment.

While previous research has indeed recognized the significance of learner-interface design in the context of online discussions, there remains an unexplored dimension concerning the specific design considerations for learner and discussion thread interfaces. This includes interfaces that are student-based and topic-based, which may be instructed or initiated differently through discussion instructions, thereby diverging from the constraints imposed by the unalterable design and features of the discussion tools. This notable gap in the literature underscores the need for a more comprehensive examination of learner and discussion thread interfaces, particularly where instructors exercise control over the discussion processes, transcending the limitations posed by inherent designs and functionalities of the discussion tools.

Within AOD boards, new threaded discussion topics can be instigated by instructors or learners, with subsequent responses from others, leading to two distinct discussion formats: "student-based" and "topic-based." In the student-based format (see Figure 1 & 2), each student introduces a new thread for discussion activities, metaphorically resembling poster, or roundtable presentations. Conversely, topic-based discussions (see Figure 3 & 4) imitate paper presentations or face-to-face classroom discussions, initiated by instructors or moderators. These two thread types utilize different visual interfaces to display postings, potentially influencing students' interconnections with their peers.

Each approach results in different visual interfaces, potentially influencing students' interactions with peers. Instructors and instructional designers should be aware of the effects of both formats, as they can be implemented without altering technical specifications (Hummel et al., 2005). Both formats may impact how students weave and synthesize postings, engage in organizational scaffolding (Kear, 2001), adopt learner-centered learning activities, and foster collaborative learning communities (Rovai & Jordan, 2004).

Analyzing Social Network Interaction (SNI)

Social Network Interaction (SNI) permits educators to attain better knowledge into the multifaceted synergy of social interconnectivity within online discussion forums to benefit students to forge a sustainable learning community. Research explored the dimensions that SNI analysis offers and how it enriches educators' understanding of social behaviors (Kent, 2018), social roles (Krishnan et al., 2020; Oh et al., 2018), problem-solving performance (Cheng, Long, & Koehler (2022), learner diversity (Rook, 2018), and the community-building process (Msonde et al., 2017).

The application of Social Network Analysis (SNA) in the context of SNI extends beyond the quantification of the number of postings conducted by learners and includes an analysis of the interactions and connections they establish. It offers an intricate view of each participant's role within the network and community, considering not only the frequency but also the nature of their interaction and connection or interconnection, their prominence, and the facilitation of resource flow (Haas, 2009). This granular approach transcends a mere tally of postings and unveils the intricate traits and patterns of interaction and connection that define each participant and collectively shape the network

and community (Freire-Vidal et al., 2021; Lämsä et al., 2021). Moreover, it enables the examination of these network and community traits over time, providing insights into their temporal development and trends (Chen & Huang, 2019). Lim (2023) proffered that SNA is a conducive analytics tool to observe the complex online discussion interconnection among learners and to galvanize instructors to provide timely and pertinent instructional interventions.

Exploring Diversity of Closeness Centrality

Closeness centrality: Uncovering diverse interconnectivity

One of the key community characteristics represented by SNI is the degree of diverse interconnection among learners. Closeness centrality emerges as a fundamental index in this regard (Wasserman & Faust, 1994). It functions based on the principle that individuals possessing the most direct pathways to access other members can establish connections and engage with them more expeditiously. Higher closeness centrality signifies a participant's ability to connect with others through fewer intermediary connections (Otte & Rousseau, 2002). Such individuals play a prominent role in facilitating resource flow between members (Haas, 2009) and demonstrate advanced self-regulated learning skills (Lee & Lee, 2016). de Marsico et al. (2014) have harnessed closeness centrality to investigate the communicative network processes within communities of practice, successfully eliciting hidden information embedded within these processes.

Identifying social roles

Norman et al. (2015) employed closeness centrality to identify distinct social roles among community learners, including lurkers, mastering/passive members, prominent individuals, and coaches. Chan et al. (2013) have also employed SNA to explore gender differences in socio-interconnectivity, particularly within collaborative learning settings. Findings reveal that males often wield control over information flow while female students actively demonstrate an inclination to interconnective communications. This dynamic cultivates trust within learning communities, enabling participants to express their thoughts with ease, thereby enhancing sustained engagement (Hew & Cheung, 2012). Ye and Pennisi (2022) have ventured into cross-examining diverse interconnectivity through closeness centrality and its correlation with learning performance in online discussions. Notably, social interconnectivity is positively linked to learning performance, with knowledge construction primarily occurring when participants read and comment on others' postings, integrating external information to reinforce internalization.

SNI research within online discussion communities extends beyond the identification of social roles to community development. In cases where students exhibit high diverse interconnectivity, as indicated by high closeness centrality scores, researchers have actively encouraged these students to connect with less active peers, aiming to enhance the overall quality of the learning community (Garcia-Garcia et al., 2023).

Dissecting temporal granularity and effects

Beyond static snapshots of communities, Chen and Huang (2019) have embraced temporal study designs, enabling a deeper understanding of learning network and community development within specific time frames. This approach unravels micro-level temporal patterns of student's social activities, elucidating on the timely nature of responses, which, if delayed, may hinder reciprocating

responses from peers (Jeong & Frazier, 2008). Specifically, Chen and Huang (2019) found that students with lower closeness centrality scores not only demonstrated less diverse interconnectivity but also with less timely responses and more compressed time intervals.

Research Questions

1. How will the diverse interconnectivity of student social interconnections in online discussions change over time?

2. How will the types of online discussion threads (i.e., student-based vs. topic-based) moderate the diverse interconnectivity of student social interconnections in online discussions?

3. How will mean of the diverse interconnectivity of student social interconnections change after the switch from student-based discussion thread to topic-based discussion thread?

Materials and Methods

Participants

In a public university located in the Southwestern U.S., thirty-two master's students (N = 32) enrolled in two identical graduate-level online courses in the field of educational technology taught by the same instructor. These students engaged in mandatory weekly online discussion activities and subsequently volunteered to complete an online demographic survey. The students' weekly interactivities in discussion boards were gathered and analyzed by the instructor via NodeXL pro software. The demography survey of the students showed that most participants were women (n = 25, 78.13%), Caucasian ethnicity (n = 20, 62.50%), and within the age range of 26 to 45 years old (n = 25, 78.13%). The demographic details are in Table 1.

Research Variables

Level-1 temporal variable

Closeness centrality (Bavelas, 1950) reflecting students' online social interconnections were collected weekly throughout weeks 1 to 6. The data were subject to analysis through NodeXL Pro, a SNA software (Hansen et al., 2019). Consequently, the temporal variable "Time" encompassed six distinct levels. To establish week 1 as the reference point, Time was centered at this initial stage (Singer & Willett, 2003).

1. $$C(x) = \frac{N}{\sum_y d(y,x)}.$$

Level-1 predictor variable

Type of discussion threads was the level-1 predictor regarding the use of different types of discussion threads (i.e., student-based vs. topic-focus) in the online courses. The test of type of discussion threads would evaluate if there was discontinuity in closeness trend over time (Singer & Willett, 2003) after the switch from student-based discussion threads in weeks 1 – 3 to topic-based discussion threads in weeks 4 – 6.

Criterion variables

Students' closeness centrality of social interconnectivity was analyzed using NodeXL Pro during weeks 2 - 7 of that online course (see Table 3; Figure 6-10).

All network edges were coded as "directed" edges in the form of "single modal" networks. The postings made by all participants, including those of the instructor,

during the span of six weeks were subject to coding. These edges represent the directional connections between two participants. To illustrate, if Participant1 responded to Participant2, it would be encoded as Participant1-Participant2. Given the nature of online discussions, which involve directed responses, it is crucial to distinguish between Participant1's response to Participant2 (Participant1-Participant2) and Participant2's response to Participant1 (Participant2-Participant1).

Social network analyses were conducted using NodeXL Pro (Hansen et al., 2019) which enabled the calculation of "closeness centrality," a metric that measures a node's proximity to all others by calculating the average shortest path distance within the network (Freeman, 1978). To assess network and community developments, community detection algorithms were employed. The outcome was a set of quantifiable indicators related to these developments. These characteristics' data were subsequently visually depicted in sociograms, employing a variety of visual properties such as vertex size, color, shape, and opacity.

$$C(x) = \frac{N}{\sum_y d(y,x)}.$$

Quantitative Data Analysis

Quantitative data analysis was executed using IBM SPSS 28, and a threshold of .05 was established for all tests of significance.

Descriptive statistics and line graph

Descriptive statistics were computed for the weekly closeness from week 1 to week 6. Similar descriptive statistics of closeness were also computed weeks 1 - 3 and weeks 4 – 6, respectively. A line graph depicting the weekly closeness in online social interconnection was created to visually examine the evolving trend of closeness over the duration.

Linear mixed models

Linear mixed models. The linear mixed models of growth (Heck et al., 2014; Singer & Willet, 2003) were fitted to evaluate the evolution of closeness over time by examining parameters related to initial status and rates of change. Moreover, type of discussion threads as the level-1 predictor was tested to see if the overall level of closeness changed upon the switch from student-based discussion threads in week 3 to topic-based discussion threads in week 4.

In comparison with general linear models, linear mixed models can explicitly address the violation of the independence assumption in nested data (van der Leeden, 1998), relax the requirement of the sphericity assumption in repeatedly measured data (Hedeker & Gibbons, 2006), and accommodate for the data with unbalanced measurement occasions and missing cases (Hox, 2002).

Model specification. A linear growth model with the time variable but no other level-1 predictors (i.e., an unconditional linear growth model) was specified to examine the change of social interconnection closeness over time in online discussions. Next, the linear growth model with the level-1 variable of time and variable of type of discussion threads was specified to test if the transition from student-based discussion threads to topic-based discussion threads would introduce a disruption in the trend of student closeness over time or not (Singer & Willett, 2003):

Unconditional linear growth model

Level-1 model: 2. $Y_{ij} = \pi_{0i} + \pi_{1i} TIME_{ij} + \varepsilon_{ij}$

Level-2 model: 3. $\pi_{0i} = \gamma_{00} + \zeta_{0i}$

4. $\pi_{1i} = \gamma_{10}$

Conditional linear growth model (Type of discussion thread (TDT) as the level-1 predictor)

Level-1 model: $Y_{ij} = \pi_{0i} + \pi_{1i} TIME_{ij} + \pi_{2i} TDT_{ij} + \varepsilon_{ij}$

Level-2 model: $\pi_{0i} = \gamma_{00} + \zeta_{0i}$

$$\pi_{1i} = \gamma_{10}$$

$$\pi_{2i} = \gamma_{20}$$

Model estimation. Relative to the estimation method of Full Maximum Likelihood (FML) estimation method, Restricted Maximum Likelihood (RML) could generate more precise covariance parameter estimates and standard errors from the data with small number of the level-2 units (Singer & Willett, 2003). Therefore, considering the number of students in the current study, RML was adopted as the estimation method.

Tests of model parameters. The statistical significance of fixed-effect parameter estimates was assessed using the *t*-test (Heck et al., 2014).

Dependent t test

The dependent t test (Norusis, 2012; Sprinthall, 2012) was conducted to compare the mean student closeness between the first 3 weeks of online discussion with student-based discussion threads and the last 3 weeks of online discussion with topic-based discussion threads.

Results

The analysis of the data indicates that there was an upward trend in the closeness of students' online social interconnections over time $t(155.36) = 3.99$, $p < .001$. During the first three weeks with student-based discussion threads, the trend shows a rise in student closeness. This upward trend continues from week 4 to 6. However, a significant drop in closeness is observed when students transitioned from student-based discussion threads to topic-based discussion threads at the end of week 3. Despite this dip, the line graph reveals a consistent pattern, corroborating this observation. The Linear Mixed Models of Growth further supports this, revealing an overall upward trend in student closeness in their social interconnections over time. The overall weekly rate of change in student closeness is 0.04, which increases to 0.15 after controlling for the types of discussion threads. Furthermore, the overall weekly rate of change in student closeness was 0.04.

When examining the effect of the type of discussion thread on student closeness, in order to answer the second research question (How will the types of online discussion threads moderate the diverse interconnectivity of student social interconnections in online discussions?), the results show a noticeable decline in student closeness when transitioning from student-based to topic-based discussion threads at the end of week 3, $t(155.17) = -6.85$, $p < .001$. Specifically, the decrease in overall student closeness from week 3 to week 4 was 0.43. This suggests that the transition to another discussion thread plays a significant role in moderating the closeness of student interconnections in online discussions.

After the switch from student-based discussion threads to topic-based ones, the mean closeness values for the two types of threads were found to be similar (0.56 vs. 0.59). Therefore, the dependent t-test results further revealed no significant difference in student closeness between the two types of threads. This indicates that, in terms of mean closeness, to answer the third research question (How will the mean of the diverse interconnectivity of student social interconnections change after the switch from

student-based discussion thread to topic-based discussion thread?), students participating in either type of discussion threads showed comparable levels of closeness in their online social interconnections.

Discussions

Both discussion thread interfaces, whether student-based or topic-based, contributed to an upward trend within each thread and overall. The switch between these interfaces did not impede this upward development. Even when transitioning from student-based to topic-based threads, students continue to prioritize diverse interconnections with their peers to facilitate social knowledge construction and community building. The noticeable decrease in closeness observed from Week 3 to 4 can be attributed to the shift in discussion type, but this transient phenomenon does not impede the overall upward trend. Students rapidly regain their momentum of interconnectivity and continue to demonstrate an upward trajectory. When examining the upward trends within each thread type separately, it is evident that the trend within each interface surpasses the overall six-week trend. Furthermore, both discussion types exhibit upward trends within their respective categories. Importantly, no significant disparity exists between the two interface types concerning diverse interconnectivity.

Diverse Interconnectivity in Cultivating Learning Communities

The observed phenomenon of the steady yet ascendant development demonstrates students' propensity in strategizing diverse interconnectivity to cultivate their ideal learning community throughout the course. Conspicuously, the diversity of interconnection peaks during specific class instructions, indicating the value and empowerment students derive from online discussions in building an effective learning community. This need intensifies as the course progresses, possibly due to students working on their group final projects, which may require extensive interconnectivity to support the completion of these projects. The weekly discourse additionally aids in upholding a feeling of course coherence, notwithstanding the transition to varied discussion thread interfaces.

Community Diversity Traits

Both students-based and topic-based threads facilitated different community diversity traits. Intriguingly, the further in-depth SNA revealed no significant differences between both thread interfaces based on closeness centrality. By expanding the SNA to encompass broader community indices, nuanced acumens into diverse interconnective communities emerged. The topic-based thread interface appeared to foster a densely connected community (see Table 3 & Figure 6), highlighting the emergence of two distinct community types. Student-based threads exhibited a higher level of two-way interaction, as measured by the Reciprocated Vertex Paired Ratio. This occurrence aligns with the characteristics of student-based threads, where students tend to engage individually and then transition to exchanging ideas in a two-way or reciprocated fashion.

Topic-based threads, on the other hand, facilitated a diverse community with specific traits. These threads displayed lower Average and Maximum Geodesic Distances, indicating that students were interconnected with shorter steps or distances. The higher graph density observed in topic-based threads substantiates the facilitation of a greater level of interconnection. These community metrics afford researchers perspicacious insights into

how learners interconnect to create a cohesive learning community.

The modularity metric, which measures the strength of community division, suggested that topic-based threads (0.18-0.19) resulted in slightly less divided clusters within the community compared to student-based threads (0.18-0.21). In other words, student-based threads exhibited stronger internal connections but greater isolation between and among clusters in the class community (see Figures 7-10). Evidently, student-based threads yielded a greater number of clusters (3.00 vs. 2.33) within the class community compared to topic-based threads (see Table 3). In the observation, minimal diverse interconnectivity and coherence were noted among these clusters and between the two discussion threads, indicating imperceptible community characteristics.

Visual impact

The lack of significant differences in diverse interconnectivity between both discussion thread interfaces prompts consideration of how students decide whom to connect with. This raises questions about whether students are influenced visually by the thread interface or if they strategically select whom to interconnect with.

In student-based threads, students see all contributions within a particular thread but not those in other threads. In contrast, topic-based threads display contributions from more or all students within the thread. An unanswered question is whether topic-based threads encourage more diverse interconnectivity due to increased visibility of classmates' postings within a single thread. In the former, students engage in a sequence of Read-Reflect-Reply, while the latter necessitates students to navigate between individual threads using a sequence of Click thread-Read-Reflect-Reply-Change thread. In larger classes, discussions with over 20 student threads may impact visual interconnection.

Features and behavior

Online discussion boards equipped with various thread-interface features, such as Collapse/Expand, Search, Sort, and Tag, among others, raise uncertainty about students' familiarity with these features and their application for navigating discussion activities. Unfortunately, behavioral data related to these features are frequently unavailable on discussion boards.

Selective interactions

Besides being influenced by the virtual thread effect, students may strategically decide with whom to connect to optimize and employ diverse interconnections for the purpose of community building. Students may choose specific classmates to connect with based on their preferences, although the types of classmates they prefer to interconnect with remain unclear. Research does suggest that students who demonstrate higher levels of diverse interconnectivity tend to exhibit greater social presence, exercise self-regulated skills, and a high level of gratitude (Yen et al., 2022; Yoshida, 2022).

Transition effects

The substantial descent on diverse interconnectivity from shifting student-based thread to topic-based indicates students need time to adjust and to understand topic-based interface. The sudden and temporary drop in diverse participation did not discourage a vestige of students from pursuing their ideal community through various forms of interconnection. More specifically, after the drop, the students continued exhibiting a

predilection for diverse interconnection and showing an upward trend with topic-based threads until the end of Week 7 discussions particularly noteworthy phenomenon is that both threads started at a low level, but in the following week, they demonstrated a notable rise in interconnective diversity. From Week 2 to 3 decreased slightly while remaining flat from Week 6 to 7.

Implications

Assessing and selecting relevant discussion thread interfaces must be given precedence to integrating. Rather than employing them without scrutiny, educators and instructors should be engaged in the meticulous and effective evaluating, selecting, and integrating online discussion threads and interfaces would redound to the development of efficacious online learning community building.

Critically examining various discussion thread interfaces would warrant instructors to align and to select relevant interfaces to support their desired instructional learning goals. For instance, student-based is more appropriate for individual idea presentation, and project sharing while topic-based can facilitate broader discussions and idea brainstorming among all community members.

Educators should also distinguish between hard and soft discussion thread interfaces. Hard interfaces, characterized by fixed features like Collapse/Expand, Search, and Sorting, offer limited flexibility, as instructors and students have little control over customization. Conversely, soft thread interfaces grant instructors the autonomy to select thread formats based on their instructional needs. It is worth noting that some discussion board tools restrict the use of only one type of thread interface. Additionally, Alwafi (2022) suggests that incorporating learning analytics into discussion activities would propagate students' overall experiences in the online learning community, thereby reinforcing positive cognitive presence.

Limitations

The variations in class dynamics and participant demographics should be noted and these instructional contexts may potentially lead to divergent outcomes in similar studies. The participants were k-12 classroom teachers in a completely online master level course with a moderate class size, ranging from 15 to 16 students per session and 7.5 weeks instructional duration. Distinctively, the instructor-led discussion activities constituted a substantial portion of the course assessment, accounting for 14% of the total course grade. Any different class and participant context may yield different results. The framework of SNA was employed exclusively to examine behavioral data. It focused on students' interconnection with their discussion postings at the externalization level.

Future Research

Future research should extend the scope beyond closeness, which merely represents one aspect of diverse interconnection. Exploring variables like in-degree, out-degree, and eigenvector centralities can provide different perspectives of diverse interconnection in community building. In addition, it is imperative to investigate how students decide whom they should interconnect with within different discussion thread interfaces. The examination of diverse interconnection in a community should encompass various community metrics, such as community density, geodesic distance, and modalities between or among sub-clusters. By

scrutinizing these community characteristics, it can reveal the intricacies of an interconnected community in detail. Moreover, extending the duration or time frame of interface integration beyond three weeks may unveil distinctive community development effects and illuminate the evolution of distinct community traits over time.

Conclusions

The significant effects of asynchronous online discussion thread interfaces cannot be ignored, particularly when diverse interconnection is the paramount goal for community building. The effective discussion integration does not solely rely on technology-driven design; it affirms the crucial role of design-driven discussion instruction augmented by discussion board technology and analytics etc. Considering evolving online technologies, such as learning analytics and artificial intelligence, educators are poised to provide students with a spectrum of online discussion design-driven instructions. These nascent technologies potentially offer a more individualized, personalized yet adaptive learning environment. These adaptive learning environments affect learners to exercise critical thinking skills with diverse interconnectivity to build cohesive and collaborative learning community which would enrich their erudite learning experiences with networked peers. A profound philosophical inquiry to project: Does there exist an optimal threshold for nurturing diverse interconnections within online learning communities? While the promotion of diversity is undeniably imperative, it beckons contemplation regarding the possibility of an excessive degree of interconnection leading to counterproductivity.

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a) data availability statement:
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d) ethics approval statement:
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e) participant consent statement:
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g) clinical trial registration: N/A

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Table 1

Demographic Information of Participants (N = 32)

Variable	Frequency	Percent
Gender		
Female	25	78.13
Male	6	18.75
No response	1	3.13
Ethnicity		
White	20	62.50
Hispanic	8	25.00
Asian	1	3.13
American Indian	1	3.13
Two or more races	1	3.13
No response	1	3.13
Age		
18-24	4	12.50
25 - 35	19	59.38
36 - 45	6	18.75
45 +	2	6.25
No response	1	3.13

Table 2

Descriptive Statistics of Weekly Closeness in Online Social interconnection

Week	N	M	SD
1	33	.35	.30
2	31	.70	.11
3	32	.65	.14
4	30	.38	.33
5	30	.69	.10
6	31	.69	.11
1 - 3	96	.56	.26
3 - 6	91	.59	.25

Table 3

Community Indices Over Time

Metric	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Vertices	33	32	32	31	30	31
Unique Edges	161	153	144	123	125	147
Reciprocated Vertex Pair Ratio	0.56	0.61	0.58	0.48	0.53	0.60
Maximum Geodesic Distance	3.00	3.00	3.00	2.50	2.50	2.50
Average Geodesic Distance	1.45	1.48	1.48	1.46	1.40	1.42
Graph Density	0.35	0.35	0.35	0.33	0.38	0.39
Modularity	0.18	0.21	0.19	0.19	0.18	0.18
# of Clusters (Section I/II)	4/3	3/2	3/3	2/2	2/3	2/3

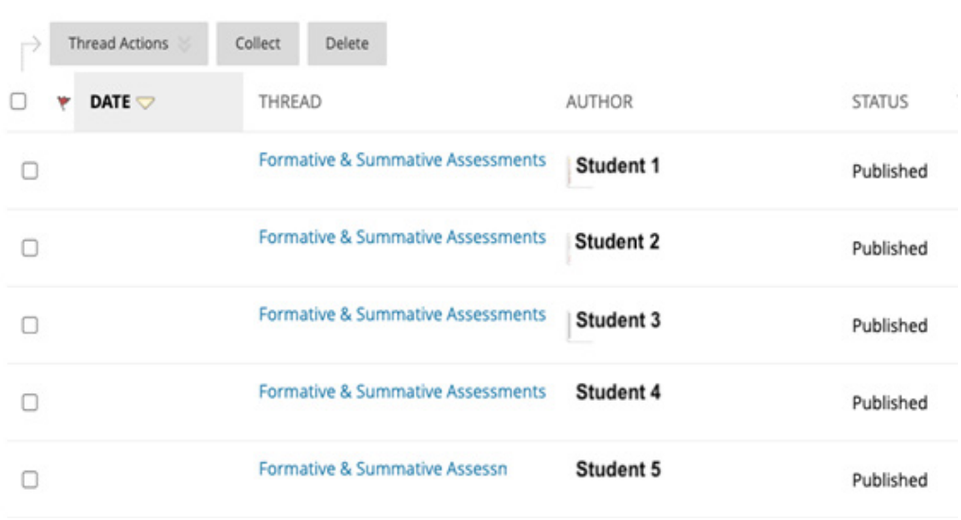

Figure 1

Student-based discussion threads on Blackboard Learn

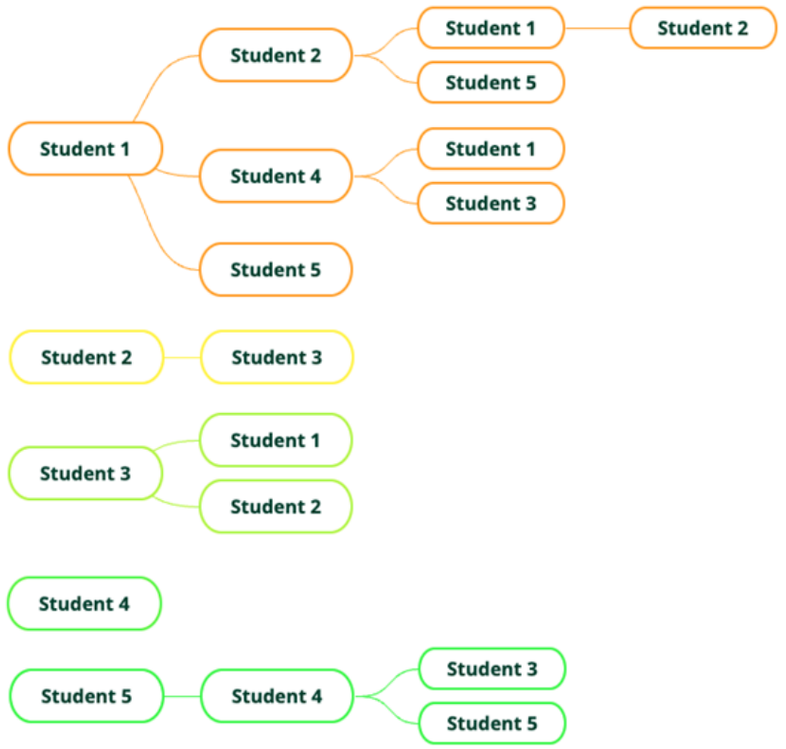

Figure 2

Student-based discussion threads with replies

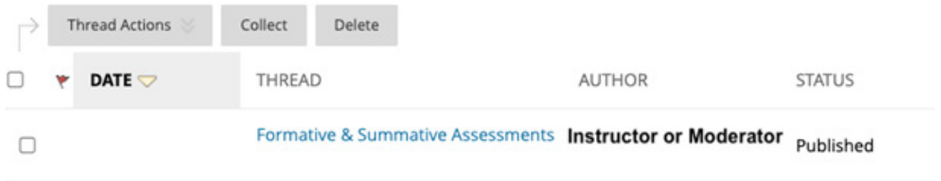

Figure 3

Topic-based discussion threads on Blackboard Learn

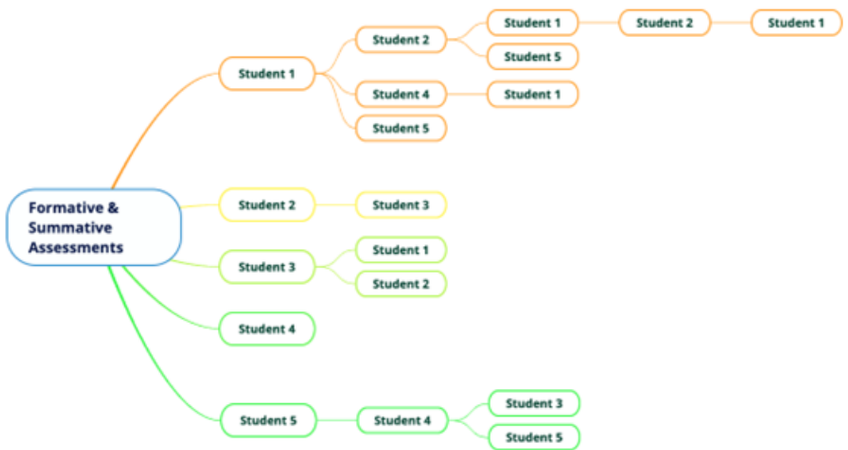

Figure 4

Student-based discussion threads with replies

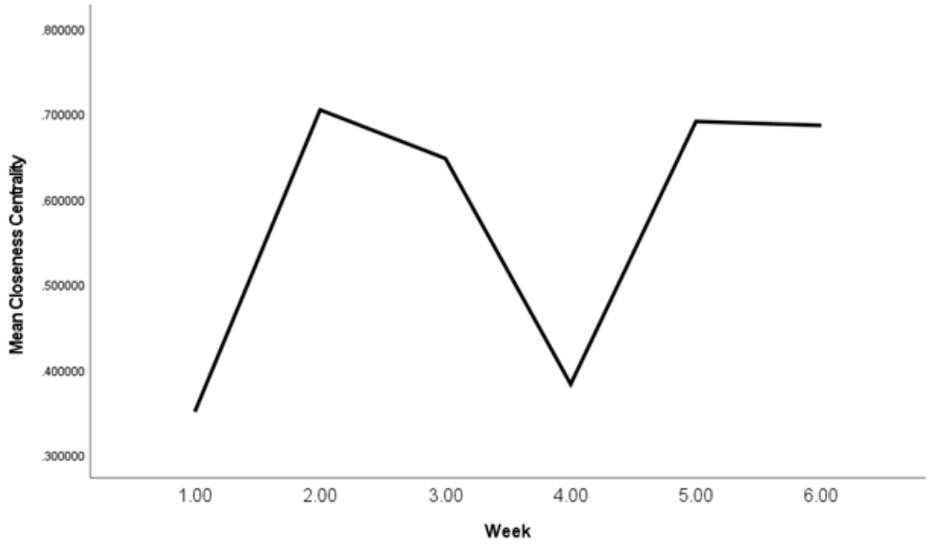

Figure 5

Line graph of closeness in online social interconnection over time

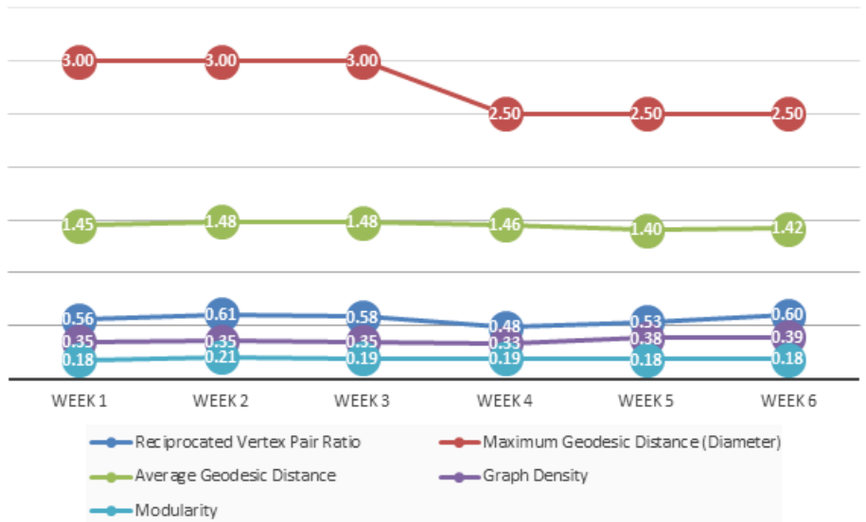

Figure 6

Community metric: Community Development Week 1-6

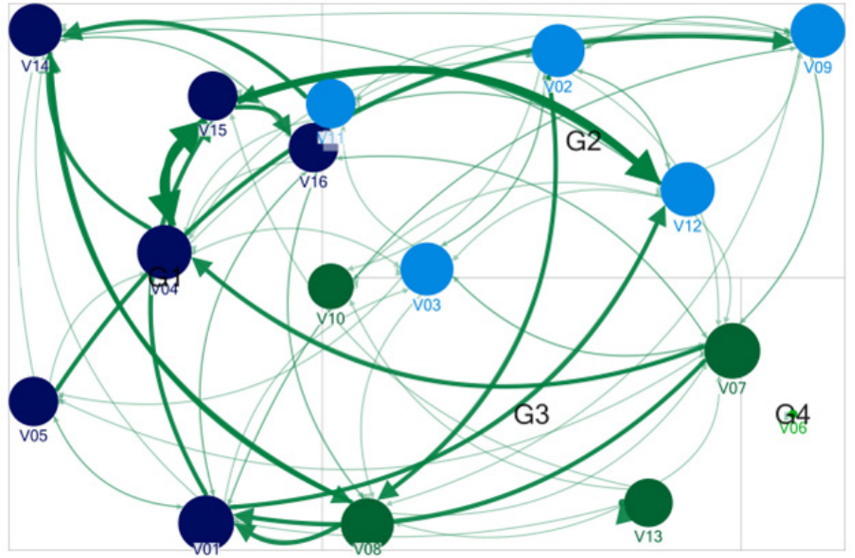

Figure 7

Session I; Week 1 Student-based Thread: Closeness Centrality Sociogram: Vertex size, color & the location based on closeness centrality.

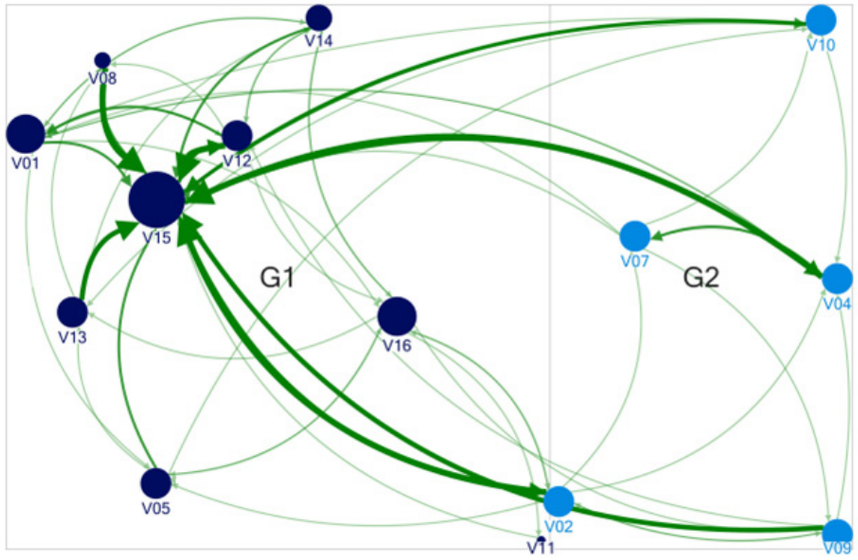

Figure 8
Session I; Week 4 Student-based Thread: Closeness Centrality Sociogram: Vertex size, color & the location based on closeness centrality.

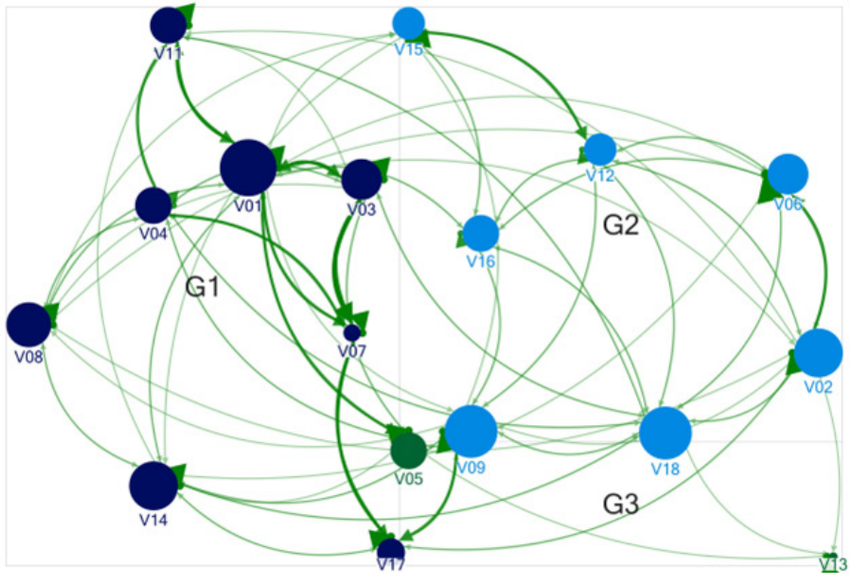

Figure 9
Session II; Week 1 Student-based Thread: Closeness Centrality Sociogram: Vertex size, color & the location based on closeness centrality.

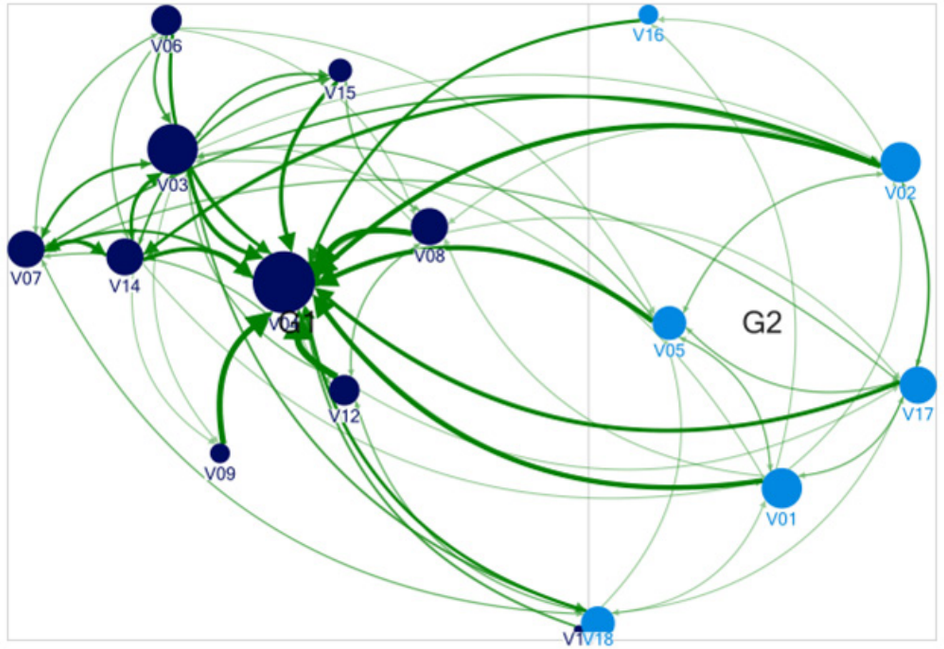

Figure 10
Session II; Week 4 Student-based Thread: Closeness Centrality Sociogram: Vertex size, color & the location based on closeness centrality.