Modeling Organizational Structure of Scholarship of Teaching and Learning Program: Transition from Consumers to Producers of Knowledge

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ABSTRACT

Similar to a community-of-practice, the members of Scholarship of Teaching and Learning (SoTL), an institutional infrastructure, are driven by a shared interest and enthusiasm to improve their teaching and learning. Representing time-varying SoTL events and relationships between SoTL members as a community network introduces challenges in data linking, data model, and network analysis. In particular, it is essential to design solutions to preserve the network topology, temporal information, member status transformation, and diverse relationships between nodes. In order to account for the SoTL network complexity, we design a heterogenous graph model in the Neo4j graph database. The graph database offers a novel research method to the growing interdisciplinary SoTL field. This paper will describe the model design, challenges, and network analysis to evaluate the effectiveness of the current SoTL strategies in attracting new members and supporting the sustainability of existing cohorts and provide data-driven decision support for SoTL programs in their development and priorities.

Keywords: Scholarship of Teaching and Learning, social network, neo4j.

1. INTRODUCTION

In the last few decades there has been a proliferation of institutional initiatives to promote faculty excellence and innovation in teaching and learning. Faculty development activities range from traditional programs (e.g., workshops, seminars, short courses, fellowships, conferences) to alternative approaches, such as self-directed learning, mentoring, peer-coaching [1]. Among the top-down and bottom-up approaches, the teaching innovation is effectively shown with "a participatory, collaborative methods to identify problems and solutions" and sharing leadership among all stakeholders [2, p.29]. From an organizational perspective, faculty development has been conceptualized as a taxonomy with three levels of engagement: good teaching, scholarly teaching, and the scholarship in teaching and learning [3]. Good teaching can be described as a practice, scholarly teaching is a practice of a teacher engaged with scholarly literature, whereas the scholarship in teaching and learning is conceptualized as a community of practice (see Figure 1).

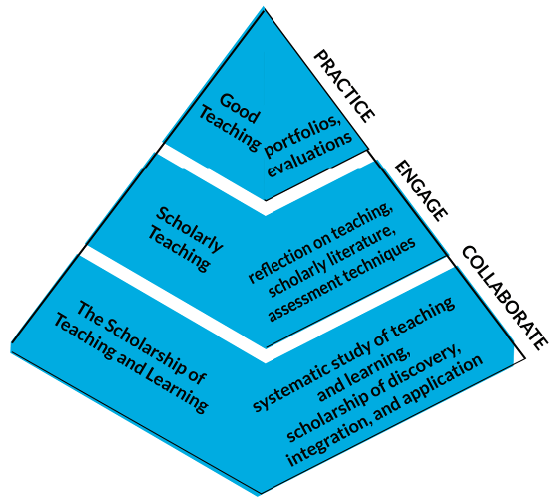

Figure 1: The taxonomy of faculty development from a single practitioner toward a community of practice (adapted from [3]).

Teaching taxonomy can also be represented on a two-dimensional plane, as suggested in the Dimensions of Activities Related to Teaching (DART) model [4]. The DART classification places teaching activities on a continuum from private to public and from systematic to informal: good teaching is positioned in the lower left quadrant (private and informal), scholarly teaching is on the top left quadrant (private and systematic), sharing about teaching activities is positioned in the bottom right quadrant (informal and public) and scholarship of teaching and learning is located in the top right quadrant (systematic and public), as illustrated in Figure 2.

Since its origin [5], the term *Scholarship in Teaching and Learning* (SoTL) has evolved into a complex multidisciplinary institutional infrastructure ensuring the support of research related to teaching and learning and high quality in education on three levels: micro-social (individual educators), meso-social (collaboration between educators), and macro-social (institutional policies) [6]. Several factors have been attributed to successful integration of SoTL into institutional culture: institutional support (funding and fellowship), departmental support (encouraging climate), collegial interaction (discussions, teams), professional development

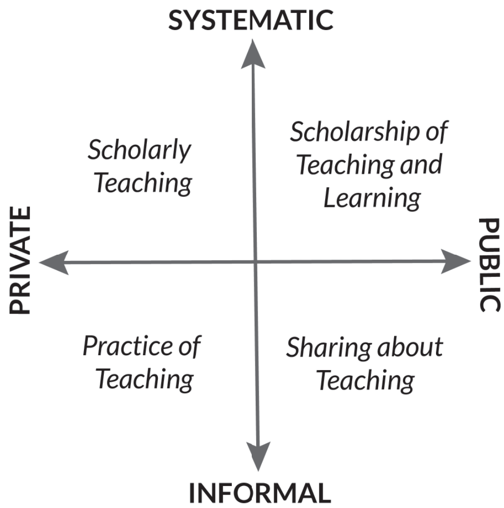

Figure 2: The DART model organizes teaching-related activities as a two-dimensional plane with four quadrants: from private to public and from systematic to informal [4, p.5].

opportunities (workshops and seminars) [7, 8, 9]. The departmental support has been identified as one of the strongest institutional motivators for individuals to become engaged into a SoTL inquiry [10, 11, 12]. Within the department, Roy et al. identified three key roles facilitating the SoTL integration: 1) initiators with strong ties or in the position to bring changes, 2) implementers or participators in changes, and 3) cultivators or creators of groundwork [11]. The sustainability of SoTL research must be cultivated "by nurturing significant networks" at the institutional level [13, p.59]. In this view, SoTL community can be perceived as a community-of-practice (CoP) driven by shared interests and enthusiasm to improve their teaching and learning. Within each community, members share characteristics of social networks, where individuals build strong or weak connections, influence other members or become isolates, create bridges between communities, grow community or disappear over time [14].

In this paper, we will examine the formation, practice and evolution of SoTL communities at Indiana University, a research institution which celebrated the 20th anniversary of the SoTL program. The study of the SoTL communities as network offers a novel and promising approach to 1) evaluate the effectiveness of current SoTL strategies in attracting new members and supporting the sustainability of existing cohorts, 2) provide data-driven decision support for SoTL program development and priorities, and 3) identify patterns of the internal structure of CoPs. The second aim is to gain insights from the internal structures of these network communities and subsequently identify SoTL influencers, active members, who help diffuse the knowledge and awareness about SoTL among their peers. Of particular interest is whether there exists a transition pattern from passive members into active influencers. This information will have a practical contribution to SoTL program and will be used to obtain qualitative data via interviews with influencers about SoTL experiences in the second stage of this research. Finally, we will look at the co-authorship network using the publication database by SoTL members. Scholarly publication metrics can be further used to measure the academic return of investment (ROI), whereas the financial ROI is represented by SoTL funding [15]. The ROI insights are essential on a meso-social level for measuring financial and academic impact of the SoTL program and securing institutional support.

The remainder of this article is structured as follows: Section 2 will summarize the characteristics of SoTL communities, the graph design and dataset are outlined in Section 3. Section 4 presents the results of network analysis and Section 5 concludes with future direction of research.

2. BACKGROUND: SOTL SOCIAL NETWORKS

Faculty tend to become aware of SoTL and learn to do SoTL through networking with peers. This organic learning is often referred to as "personal learning networks" - social communities that provide their members with guidance to advance skills and knowledge in a particular area via the benefit of collective knowledge as well as create the network of connections. These networks have been shown to be more effective at enhancing teaching than more traditional models of professional development [16]. This is unsurprising given that experienced faculty members tend to have larger personal learning networks than junior faculty [17]. Recent research also suggest that faculty development programs could serve as mediators to connect members [18]. For example, CoPs are created from the Faculty Learning Communities organized by Centers of Innovative Teaching and Learning (CITL) and CITL consultants/mentors embedded within CoPs connect across members other communities [19, 20]. On the other hand, isolation has been identified as one of the most challenging barriers facing SoTL [9]. Thus, it becomes crucial to develop "a critical mass of SoTL champions" who will create and maintain social networking, help diffuse ideas and sustain SoTL communities [9, p.53].

SoTL communities are viewed as small tightly bonded networks with a few members that can connect between network communities [9]. Each member can participate in a variety of SoTL events: keynote speakers series, book reading groups, faculty learning communities, grant initiatives, and co-authored publications. While participation in some events is passive (a.k.a attendance), other events require active involvement (e.g., writing and collaboration). Using the DART model (see Figure 2), active involvement can be further described as a private-public and informal-systematic continuum [4].

The following schema represents the DART placement for research related activities on a continuum from less systematic to more systematic and from less public to more public: 1) Systematic: published case studies/published essays $<$ literature review $<$ textbook $<$ meta-analysis $<$ peer-reviewed presented or published research, and 2) Public: published case studies $<$ published essay/literature review $<$ meta-analysis $<$ peer-reviewed research $<$ textbook.

SoTL membership often starts with a passive involvement via attending professional workshops or seminars, where new members become aware of SoTL initiatives and networks. At this stage, members are 'consumers' of shared knowledge. This status may subsequently change to a 'producer' if they get involved in a scholarly SoTL research via funding, fellowships, and publishing. In fact, producers are the main driving force for public dissemination and continuity of shared knowledge and innovations. They are also in a position to become strong links within SoTL networks. We expect these individuals carry similar characteristics of strong nodes in network. For example, they have many connections, bridge between disciplines or programs, and have influential publications (measured by the number of citations they generate). Social network design makes it possible to explore the temporal trajectory of those "influencers" from a consumer to a producer, their characteristics, collaboration with others, and scholarly work.

3. DATA AND METHODS

Current SoTL SQL database contains 6 tables covering the period between 2011 and 2019: Funded SoTL Projects (64 records), SoTL Funded/non-Funded Proposal (102 records), Reading Groups (65 records), SoTL Event Attendance (513 records), Faculty Learning Communities (19 records) and SoTL Faculty List (142 records). The publication data (680 records) is extracted from the web server and provides publication records starting from 1974, as these records also include scholarly teaching and sharing activities prior the conceptualization of the scholarship of teaching and learning field. One of the main challenges in this dataset is the absence of usernames in publication dataset. Second, the co-author can be a graduate student, faculty outside of IU, faculty who left IU or a consultant from Center for Innovative Teaching and Learning (CITL). If the paper has multiple co-authors, we identified a username only for the first author or a faculty author from IU by searching IU web faculty lists (115 unique names). Note that if the faculty left the institution, we were unable to identify their username. For the SoTL graph model, we use only the 2011-2019 period (115 records) whereas the full set (680 records) is used for a co-authorship network. Next, 7 tables are merged into one CSV file with the total of 785 records. While each dataset has a username field, the merger on username created null values, since we used a join outer merger. In addition, we added ranking values for each events and calculated the total number of events attended per SoTL member. Our next step is to convert the relational database (a set of tables with rows and columns) into a graph database where data is stored as a network with nodes and edges (links). Table 1 provides a summary of variables that will be used to build the network schema.

In our approach, we design a SoTL network based on the following functionalities similar to the Content-Filter recommendation approaches: 1) membership - there is a unique account for each user, 2) communities - each user belong to one or more groups (workshops, reading groups, faculty learning communities), 3) product - each user can produce a scholarly item (grant proposal, publication), 4) collaboration - each user can interact with others producing scholarly items, 5) rating - each user is rated on the scale 1-5 based on the commitment with 5 being the highest rating (Workshops - 1; Reading groups - 2; Faculty Learning Communities (FLC) - 3; SoTL proposal - 4; SoTL Publication - 5). We included an additional weight variable for publication based on the publication format: Visualization/Other -1, Report -2, Poster - 3, Presentation - 4, Journal Article/Conference paper/Book/Book Chapter - 5. The graph model design is presented in Figure 3. SoTL members and events are mapped into nodes with a variety of properties. The states of attending, submitting and producing (a.k.a publishing) form edges. We have also dedicated a node for a school which could be used to measure interdisciplinarity and collaboration. One of the issues working with the merged dataset was null values. In our current solution, we added a new value "Unspecified" or FALSE or zero as well as created unique indices for each variable that will be a node even if the value is null (e.g. publications, events, proposals).

To store the SoTL network model and query across nodes and edges, we chose Neo4j [21], an open source graph database, which is flexible and particularly suited for heterogeneous datasets [22]. With the defined schema, 7 nodes are created in Neo4j and uniqueness constraints are placed on usernames and on each event ID using Neo4j Cypher plugin. We created 6 relationships with the rank properties, which would allow us to specify a rank (from less commitment to more commitment) while querying for events attended. As a result, our network has 4,490 nodes and 4,710 relationships.

To gain insights on the internal structure of SoTL communities and their characteristics we will perform network and co-authorship analyses. The network analysis is performed using SoTL graph database and APOC Cypher plugin. Particularly, we aim to examine whether there exist any similarities between "consumers" (attending only) and "producers" (publishing). First, we retrieve their characteristics and search for any members who changed their states from a consumer to a producer. Second, we use Neo4j Data Science Graph library and

Table 1: SoTL datasets summary of variables for Network Model

Dataset	Variables
Funded SoTL Projects	Project ID (unique), User name (PI), Amount, Year
SoTL Funded/non-Funded Proposal	User name (PI), Year, Funded (boolean), Rank
Reading Groups	User name, First year Joined, Total of groups joined, Rank
SoTL Event Attendance	User name, Total keynote speakers attended, Rank
Faculty Learning Communities (FLC)	User name, Total FLC attended, Rank
SoTL Faculty List	User name, School, Rank, Fellowship (boolean)
Publication data	User name, Format, Rank, Discipline, Year

Note: Fellowship status can include Mosaic, Learning Analytics or Mack fellowship.

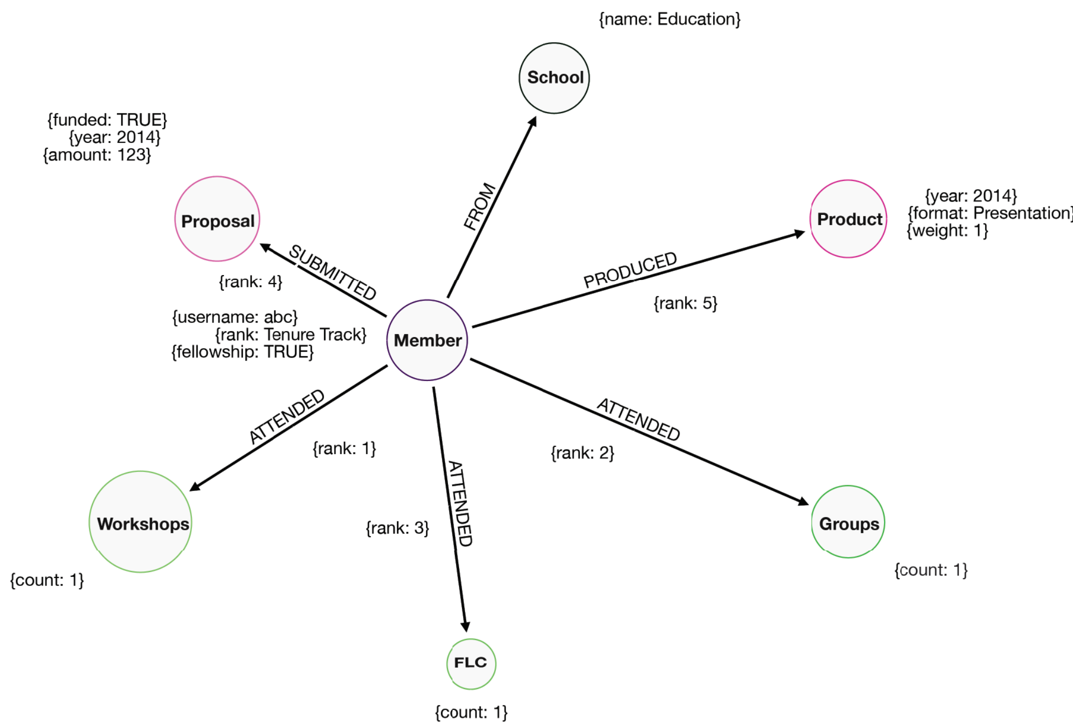

Figure 3: Neo4j Model of SoTL network. Members and events are represented as nodes. The relationships between nodes are shown as edges. Node and Edge attributes are enclosed into curly brackets.

apply Jaccard algorithm to measure similarities within members [23].

Co-authorship network analysis is performed using Sci2 [24] and Gephi [25]. The publication data is pre-processed merging all co-authors into one column while separating them with "|". At this stage, we used only Authors names information. Sci2 has a functionality to generate a co-occurrence network which is then exported into a graph xml format.

4. RESULTS AND DISCUSSION

We used the Sci2 Tool to extract a co-author network and network analysis toolkit to examine network components [24]. The undirected weighted network consists of nodes representing a unique author and edges showing authors co-occurrences. The resulting co-author network has 297 nodes, 11 isolates (nodes that do not connect to other authors) and 573 edges. After removing 11 isolates using Sci2 built-in feature, we obtained the network with 286 nodes and 573 edges. The ForceAtlas2 layout with Noverlap was applied to graph data and visualized with Gephi [25] (see Figure 4).

The co-authorship network structure exhibits several types of co-networks: 1) a small network with one influential node (George Kuh), 2) a larger dense network with several mid-size nodes and strong connections, and 3) small networks. These patterns point to several initial hypotheses that will be tested in the second stage of this research. First, a dense network seems to be time contingent. Several large nodes represent faculty members who started at the same time and seem to continue working together. Secondly, several nodes are represented by Center for Innovative Teaching and Learning consultants. As nodes, they connect with faculty, however they are not

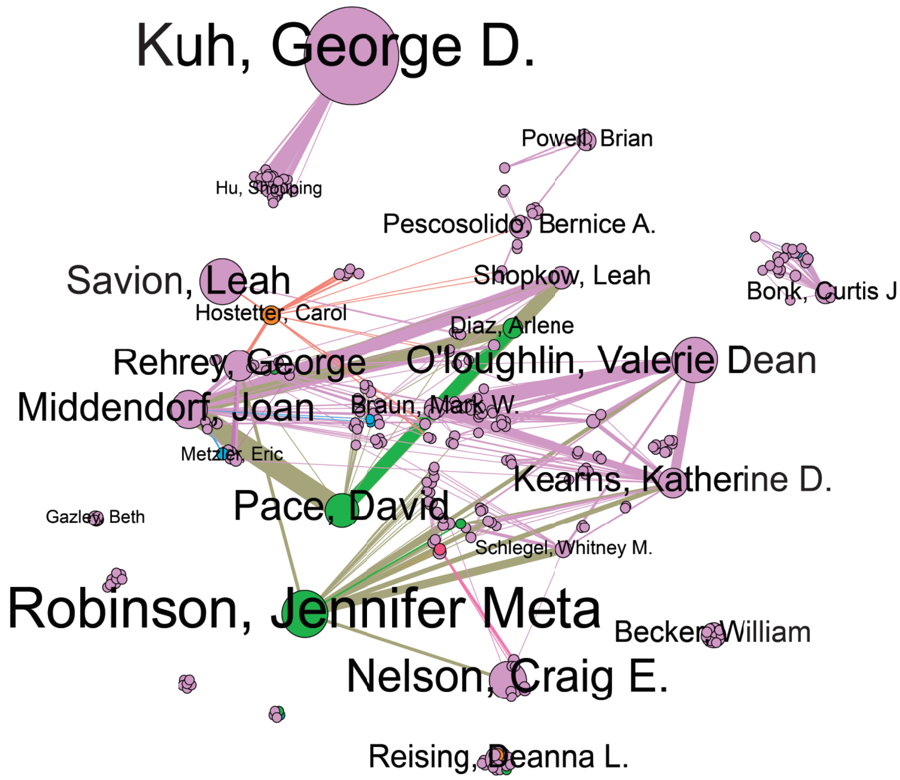

Figure 4: Co-authorship network. The size of nodes represents the number of scholarly work with the largest node = 147 and the smallest node =1. The largest component consists of 157 nodes. The labels are shown only for authors with 10 or more publications. The thickness of edges indicate the number of co-publications. The node color indicates authors' school: purple - unidentified (authors were not in the current SoTL database), green - College of Arts and Science, brown - Social Work, red - Public Health, blue - Informatics.

connected to each other, which suggests that they may be important connection points for faculty work. Third, a large influential node in a smaller cluster is a former SoTL program director, suggesting a key position for creating and sustaining SoTL networks. Finally, there are many isolated nodes, leading to a strategic question on what initiatives need to be implemented to connect them with a larger network.

We have also designed an interactive co-authorship network, available at https://obscrivn.github.io/SOTL/. The visualization is built using JavaScript GEXF Viewer for Gephi [26]. This platform offers several practical functionalities for SoTL researchers who might be searching for collaborators or exploring published research on teaching and learning, e.g., authors information (school, discipline, rank, publication counts), search options, and links information.

Our initial hypothesis is the existence of two types of membership (consumers and producers), where consumers may transition to producers after learning about SoTL via informal events. Using the count property [count > 0] for FLC/Reading Group/Workshops, funded property [funded = 'TRUE'] and weight for publications [weight > 0], we identified only two members who attended SoTL events, submitted a proposal and also published scholarly work (see Figure 5). Most of the membership falls into 1) consumer only - 71 members, 2) producers only - 49 members. In the producer category, 13 members have a fellowship. However, the consumer group has only 1 member with a fellowship, suggesting that fellowship is an important institutional initiative that can lead to publications and proposals.

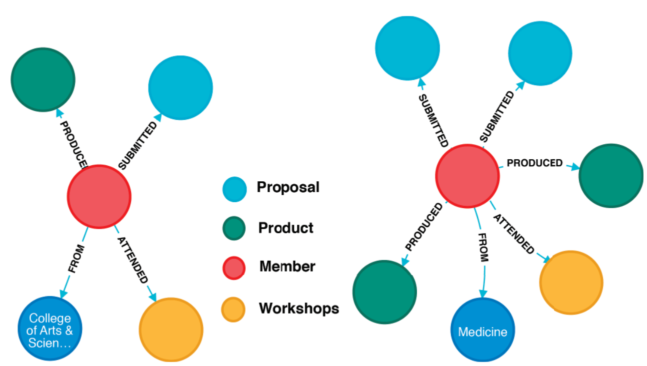

Figure 5: SoTL members who are consumers (attended events: rank 1-3) and producers (submitted proposal and published: rank 4-5

On the departmental level, we examined 7 communities. Note we have a large "Unspecified" value for missing entries. These values will be manually entered in the next stage. The current top three schools are College of Art and Sciences include 39 SoTL members, Education - 34, Public Health - 19. These information can be used externally to help new faculty connect with their SoTL departmental CoPs.

Next, we examined the faculty development events (workshops, groups, and FLC). The most attended event is workshops series (300), followed by Reading groups (65) and FLC (19). This finding supports our proposed taxonomy from less commitment to more commitment and if we include fellowships (14), the SoTL taxonomy can be represented as a 6 level scale: Workshops < Reading groups < Faculty Learning Communities (FLC) < Fellowship < SoTL Proposal < SoTL Publication.

To measure the similarities, we applied the Jaccard algorithm to all members including all relationships. For this query, we replaced the previously assigned three types of relationships (ATTENDED, SUBMITTED, PRODUCED) to just one - LINK with a rank property that identifies the type of event (workshops - 1, reading groups - 2, FLC - 3, proposals - 4, publication - 5). The Jaccard algorithm is implemented as follows [27]:

```
MATCH (p1:Member)-[:LINK]->(m)
WITH p1, collect(id(m)) AS p1m
MATCH (p2:Member)-[:LINK]->(m2)
WITH p1, p1m, p2, collect(id(m2))
AS p2m
RETURN
p1.name AS from,
p2.name AS to,
gds.alpha.similarity.jaccard(p1m, p2m)
AS similarity
```

SoTL members as individuals do not show any similarities in the choices of events, suggesting that each faculty member has their own trajectory based on the current teaching needs. It also points to the weakness of our current model where events are not interconnected.

5. CONCLUSION AND FUTURE DIRECTIONS

This paper extended the recent work on SoTL as a Social Network [9]. We used a co-authorship network to identify influencers playing a key role for SoTL dissemination and sustainability. The co-authorship network analysis demonstrated the existence of several dense isolates clusters. Our recommendation to SOTL program is to identify strong links via our co-authorship network and develop initiatives connecting those leaders. Second, we contributed to the SoTL field by introducing a novel Neo4j graph database approach to explore the SoTL characteristics. The graph model allowed us to confirm our hypothesis on the existence of two subgroups: consumers and producers, with only two members who transitioned from consumers to producers. That is, attending informal events (passive involvement) does not necessarily lead to proposal and publication (active involvement). However, we found that fellowship initiatives seem to encourage scholarly work dissemination, as it was one of the main distinctions between consumers and producers based on our data. We suggest that the SoTL program increase the outreach initiatives to promote the awareness fellowships. We also propose to develop a collaboration recommendation system helping connect weak links with possible strong connections and allowing new members to become actively engaged in collaborative work based on their shared interests. Finally, SoTL consultants should be viewed as core influencers building CoPS and identifying strong leaders from faculty to sustain those communities [18].

At present, the neo4j model is centered on SoTL members and their individual activities. In particular, this model does not account for event sequences and event networks. Future work should examine event dependencies and analyze clusters within and between each event. Similarly, the current model connects members only via schools. Future model should interlink members via event, shared interest, and their collaboration (presentations, proposals, publications) allowing for a more complex network analysis of SoTL communities. Furthermore, the co-authorship network model could be enriched with additional attributes: 1) node level features (e.g., number of citations, publications), 2) multiplex level relationships (e.g., co-authoring and supervising students), and 3) cognitive network (e.g., similarity between papers). These attributes would help us examine the role of mentorship and team-based collaboration. Finally, the results from the social network analysis should be used for a qualitative analysis of SoTL influencers, thus contributing to the field with a mixed-method social network approach.

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