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Authors

Wilton, Mike
Maloy, Jeffrey
Beaster-Jones, Laura
et al.

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Instructional Influencers: Teaching Professors as Potential Departmental Change Agents in Diversity, Equity, and Inclusion

Mike Wilton,[†*@] Jeffrey Maloy,[‡@] Laura Beaster-Jones,[§@] Brian K. Sato,[‖] Stanley M. Lo,[¶] and Daniel Z. Grunspan[#*]

[†]Department of Molecular, Cellular, and Developmental Biology, University of California, Santa Barbara, Santa Barbara, CA 93117; [‡]Department of Molecular Cell and Developmental Biology and Department of Life Sciences Core Education, University of California, Los Angeles, Los Angeles, CA 90095; [§]Molecular and Cell Biology Department, University of California, Merced, Merced, CA 95343; [‖]Division of Teaching Excellence and Innovation, Department of Molecular Biology and Biochemistry, University of California, Irvine, Irvine, CA 92697; [¶]Department of Cell and Developmental Biology, Joint Doctoral Program in Mathematics and Science Education, and Research Ethics Program, University of California, San Diego, La Jolla, CA 92093; [#]Department of Integrative Biology, University of Guelph, Guelph, ON N1G 2W1

ABSTRACT

At many research-intensive universities in North America, there is a disproportionate loss of minoritized undergraduate students from Science, Technology, Engineering, and Mathematics (STEM) majors. Efforts to confront this diversity, equity, and inclusion (DEI) challenge, such as faculty adoption of evidenced-based instructional approaches that promote student success, have been slow. Instructional and pedagogical change efforts at the academic department level have been demonstrated to be effective at enacting reform. One potential strategy is to embed change agent individuals within STEM departments that can drive change efforts. This study seeks to assess whether tenure-track, teaching-focused faculty housed in STEM departments are perceived as influential on the instructional and pedagogical domains of their colleagues. To answer this, individuals across five STEM departments at large, research-intensive campuses identified faculty who were influential upon six domains of their instruction and pedagogy. Social network analysis of individuals in these departments revealed heterogeneity across the instructional domains. Some, like the teaching strategies network, are highly connected and involve the majority of the department; while others, like the DEI influence network, comprise a significantly smaller population of faculty. Importantly, we demonstrate that tenure-track, teaching-focused faculty are influential across all domains of instruction, but are disproportionately so in the sparsely populated DEI influence networks.

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*Address correspondence to: Mike Wilton (mikewilton@ucsb.edu) and Daniel Z. Grunspan (dgrunspan@uoguelph.ca)

INTRODUCTION

Despite increasing institutional commitments to diversify recruitment and enrollment practices for undergraduate students, departmental cultures, faculty attitudes, and campus climates have not necessarily embraced these goals to promote diversity, equity, and inclusion (DEI). In Science, Technology, Engineering, and Mathematics (STEM) fields, a particularly stark divide has emerged between institutional, departmental, and instructional commitments to DEI efforts (Mayhew and Grunwald, 2006; Park and Denson, 2009; Marchiondo *et al.*, 2023). These misalignments have contributed to continued minoritization and inequitable outcomes for large groups of undergraduate students, including Latine, Black, Indigenous, and People of Color; lesbian, gay, bisexual, or queer (LGBQ+); and transgender and gender nonconforming students

(Chang *et al.*, 2014; Estrada *et al.*, 2016; Hughes, 2018; Riegle-Crumb *et al.*, 2019; Maloy *et al.*, 2022). Even after controlling for prior academic performance, minoritized students are disproportionately likely to leave STEM fields, citing chilly academic environments, lack of representation, and decreased sense of belonging in their classrooms and departments (Riegle-Crumb *et al.*, 2019; Khan *et al.*, 2020). To combat STEM student attrition, education research has highlighted multiple approaches that can promote academic equity in STEM undergraduate majors. Bridge programs, immersive undergraduate research programs, student mentorship and sponsorship, as well as student-centered academic and social supports have all been demonstrated to reduce disparate academic outcomes for minoritized students (as summarized in Jackson *et al.*, 2019). Evidence-based classroom teaching strategies in STEM, including active learning (Felder and Brent, 2009), have been repeatedly demonstrated to promote student academic equity amongst a diversity of undergraduate students (Haak *et al.*, 2011; Steinfeld and Maisel, 2012; Eddy and Hogan, 2014; Freeman *et al.*, 2014; Ballen *et al.*, 2017; Gavassa *et al.*, 2019; McNair *et al.*, 2020; Theobald *et al.*, 2020). Despite the demonstrated impact of these approaches, STEM faculty still predominantly perform classroom instruction by traditional lecture (Stains *et al.*, 2018).

Adoption of evidence-based instructional approaches on promoting academic equity among diverse students remains slow in STEM fields. Multiple studies investigating instructor decisions regarding the development and implementation of equity-centered teaching strategies and structures have highlighted that individual faculty characteristics and local departmental contexts both play central roles in shaping undergraduate instruction within specific STEM majors at different institutions (Dancy and Henderson, 2008; Sturtevant and Wheeler, 2019; McConnell *et al.*, 2020a). The interplay between these factors are evidenced by the explanations of this pedagogical intransigence including perceptions of departmental cultures that prioritize research or time constraints on instructional revision (Michael, 2007; Walczyk *et al.*, 2007; Ebert-May *et al.*, 2011; Brownell and Tanner, 2012; Hora, 2012; Shadle *et al.*, 2017). To the extent that STEM faculty do engage in explicit efforts to promote equitable outcomes, these efforts often happen at the level of individual faculty or intradepartmental and interdepartmental collaborations between isolated equity-focused individuals, resulting in stunted discussions regarding DEI as well as sporadic reform efforts (Liera and Dowd, 2019).

EMBEDDING CHANGE AGENT FACULTY IN STEM DEPARTMENTS AS AN INSTRUCTIONAL CHANGE STRATEGY

To promote the implementation of evidenced-based instructional approaches, varied theories have been leveraged to design and enact pedagogical change strategies (Henderson *et al.*, 2011; Borrego and Henderson, 2014; Kezar *et al.*, 2015; Kezar, 2018; Reinholz and Apkarian, 2018; Reinholz *et al.*, 2021). Assessment of the impact of differing approaches demonstrates that not all interventions produce similar outcomes: some resulted in failure, while others led to varying degrees of reform resulting in faculty adoption of evidenced-based pedagogical approaches (Henderson *et al.*, 2011; Quardokus and Henderson, 2015). Importantly, insights from this research highlighted that many successful pedagogical change efforts focus on the departmental level. This result is perhaps not altogether surprising, given that academic departments are often siloed, share common cultural values, enable faculty interactions, and are resistant to externally, top-down imposed change (Kezar *et al.*, 2015; Lane *et al.*, 2019; McConnell *et al.*, 2020a).

A potential strategy in the adoption of evidenced-based instructional approaches is the embedding of pedagogical *change agents* within STEM departments (Andrews *et al.*, 2016; MacDonald *et al.*, 2019; O'Connell *et al.*, 2022). These individuals may be capable of generating departmental change because they are integrated among their colleagues, enabling them to influence their peers in a sustained, long-term manner (McConnell *et al.*, 2020a). Although these change agents can potentially be any STEM faculty member interested in driving instructional reform, there has been a growing trend toward the hiring of STEM faculty who specialize in teaching and pedagogy as the focus of their professional efforts (Bush *et al.*, 2008; Rawn and Fox, 2018; Bush *et al.*, 2020; Harlow *et al.*, 2022).

Perhaps the best characterized faculty specialization where scholarship overlaps with instruction and instructional change efforts is the Science Faculty with Education Specialties (SFES; Bush *et al.*, 2008; Bush *et al.*, 2011; Bush *et al.*, 2013; Bush *et al.*, 2016; Bush *et al.*, 2019; Bush *et al.*, 2020). Although the SFES have diverse scholarship activities, the vast majority of these faculty identify their greatest impact in reforming undergraduate STEM education, while also playing roles in discipline-based education research or K-12 education (Bush *et al.*, 2008; Bush *et al.*, 2011). The mechanism of change reported by most SFES was the influencing of 1) faculty colleagues' teaching practice through instructional collaborations, instructional practice, and/or cultivating faculty interest in teaching, 2) curricular change via development or revision of materials and, 3) Graduate Teaching Assistant training and support (Bush *et al.*, 2016; Bush *et al.*, 2019).

UNIVERSITY OF CALIFORNIA TEACHING PROFESSORS AS POTENTIAL DEPARTMENTAL CHANGE AGENTS

The University of California (UC) system also utilizes a unique teaching-focused faculty position, the Teaching Professor (TP; Harlow *et al.*, 2020; Xu and Solanki, 2020). While teaching-focused, TPs are expected to engage in teaching, scholarly activities, and service (Harlow *et al.*, 2020; Molinaro *et al.*, 2020). For scholarship, many TPs engage in DBER, evidence-based curriculum development, outreach, education-focused professional development, and/or student mentorship (Harlow *et al.*, 2020). In contrast to non–tenure-track lecturers hired on a fixed-term contract (American Association of University Professors, 2014, 2018; Carvalho and Diogo, 2018), the TP position has the security of tenure and individuals in this position are voting members of the Academic Senate.

Similar to the SFES positions, UC STEM TPs are embedded within STEM departments and thus are situated to influence undergraduate STEM education in their local context. Research into the characteristics of the TP faculty demonstrates their impacts as instructional leaders and innovators: These faculty are more likely to implement evidence-based approaches in the classroom, have more advanced conceptions of teaching and learning, are expected to be educational leaders, and are viewed as instructional experts by their colleagues and administrators (Denaro *et al.*, 2022; Harlow *et al.*, 2022; Rozenkhova *et al.*, 2023; Grunspan *et al.*, forthcoming). Collectively, these results suggest that TP faculty may have the potential to act as change agents who might be capable of influencing their departmental colleagues' approaches to instruction and pedagogy.

THEORETICAL FRAMEWORK: DEPARTMENTS AS COMMUNITIES OF PRACTICE

The Community of Practice theory has been often used to conceptualize change efforts (CoP; Lave and Wenger, 1991). Originally, CoP was conceived as a social learning theory situating learning as a process that occurs between individuals in a larger social structure (Lave and Wenger 1991; Wenger, 1998). A CoP is defined by 1) a shared domain of interest, 2) a community of joint engagement, and 3) a shared repertoire of practices (Wenger, 1998). These factors constitute a social network through which ideas and expertise are collectively developed and shared (Wenger, 2004).

Because the original theoretical proposal of the social learning CoP framework, it has expanded to be more applied and been adopted by diverse groups from business and management to academic and journalistic organizations (Lesser and Storck, 2001; Weiss and Domingo, 2010; Meltzer and Martik, 2017). Studies across these groups show that CoPs aid in knowledge transmission and professional development within organizations (Wenger *et al.*, 2002; Omidvar and Kislov, 2014). Within academia, this applied view of CoPs has been adopted to differing extents to help conceptualize and/or drive pedagogical change (Reinholz *et al.*, 2021). The CoP theory has been used to characterize temporary faculty learning communities that organize individual participants and galvanize change efforts around a shared goal of pedagogical change (Tomkin *et al.*, 2019; Kandakatla and Palla, 2020). Other grant or initiative motivated change efforts have also leveraged CoP theory to characterize varying levels of success of pedagogical change over time (Ma *et al.*, 2019; Quardokus Fisher *et al.*, 2019). Thus, we posit that the CoP theory might be applied to academic STEM departments (community of joint engagement) as they are composed of faculty who have shared disciplinary expertise (domain of interest) who interact and are organized to accomplish the educational mission (shared practices) of the university.

Given that STEM departments could potentially be an organizing locus for pedagogical change efforts, can one conceptualize how pedagogical change agents might affect their colleagues' instructional approaches? Academic departments are frequently considered a critical unit for pedagogical change because they maintain agency over curricular decisions, have their own culture, and include a community of members who discuss their instructional views in both formal and informal venues (Edwards and Hensien, 1999; Gibbs *et al.*, 2008; Wieman *et al.*, 2010; Quardokus and Henderson, 2015; Reinholz and Apkarian, 2018; Johnson *et al.*, 2021). Faculty who comprise departmental communities shape and influence the learning processes, beliefs, and values of those who interact with them, as well as with new members who enter this community (Borrego and Henderson, 2014). However, this only occurs to the extent that faculty have meaningful interactions about a shared practice, leading to a collective understanding and repertoire of resources centered on that practice (Wenger *et al.*, 2002).

In the STEM departmental context, meaningful interactions between faculty colleagues can center on any number of relevant skills or practices, including various pedagogical practices. Further, an individual department may form a strong CoP in one domain while engaging minimally in other domains; for example, faculty may foster a collective understanding of departmental policies surrounding research through frequent interactions, but lack the same level of engagement when it comes to strategies that promote equitable undergraduate academic outcomes.

FACULTY SOCIAL NETWORKS

Given how interactions within CoPs can impact the individuals within, a growing number of studies have examined the relationships of faculty housed in university STEM departments. These studies apply social network analysis, a methodological approach, to address how relational patterns between individuals influence their colleagues across multiple domains, including faculty pedagogy (Wasserman and Fause, 1994; Marin and Wellman, 2011; Quardokus and Henderson, 2015; Henderson *et al.*, 2018). Specifically, several studies describe how information about instruction may disseminate within a university through faculty interaction networks (Quardokus and Henderson, 2015; Henderson *et al.*, 2018; Lane *et al.*, 2019; Quardokus Fisher *et al.*, 2019), explore whether faculty who teach similarly tend to associate with one another (Lane *et al.*, 2019), and whether any individual faculty are particularly important in these networks (Andrews *et al.*, 2016, Grunspan *et al.*, forthcoming).

Research into the importance of individual faculty within university social networks has highlighted that faculty with pedagogical expertise, such as discipline-based education researchers, SFES (Andrews *et al.*, 2016; Bush *et al.*, 2016), and TPs (Grunspan *et al.*, forthcoming) are exceptionally influential on their colleagues' pedagogy. This suggests that embedding faculty in these types of positions into STEM departments may help build intradepartmental CoPs surrounding undergraduate instruction and ultimately drive pedagogical change (Andrews *et al.*, 2016; Bush *et al.*, 2016; Rawn and Fox, 2018).

THIS STUDY

While faculty with pedagogical expertise may influence their peers' instructional practice, a more descriptive account of the specific instructional domains they influence is lacking. To assess this, we investigated the structure of social interaction networks across STEM departments to determine 1) whether TPs are influential in these discussions and 2) which domains of instruction and pedagogy TPs might influence.

Specifically, we sought to answer the following questions:

1. To what extent do faculty in different STEM departmental communities discuss teaching and influence each other's instruction and pedagogy across six different pedagogical domains?
2. In STEM departmental networks, how do interaction networks vary across domains of pedagogy and instruction?
3. Are UC TPs more influential in the instructional and pedagogical networks relative to non-TP faculty?

TABLE 1. STEM department faculty response rates across study sites

Department	Respondents	Total	% Response	# Teaching professors
U1D1	29	32	90.6	3
U2D1	17	21	81.0	0
U2D2	25	30	83.3	3
U2D3	26	29	89.7	1
U3D1	29	41	70.7	1
Total	126	153	82.4	8

MATERIALS AND METHODS

Study Setting and Data Collection

To answer these questions, we collected faculty social network data across five STEM departments at three public, minority-serving, research-intensive institutions (instrument is included in Supplemental Materials). These departments span multiple disciplines and include molecular and cellular biology, developmental biology, ecology and evolutionary biology, environmental life sciences, and mathematics. The survey instrument asked faculty to identify colleagues within their departments who they have discussed instruction with over the past year. Upon selection of colleagues, the survey respondent then is piped to identify whether the identified individuals are influential in terms of various domains of instruction and pedagogy. These domains included teaching philosophy, instructional strategies, course logistics, materials, concerns, and topics on DEI. Social network analysis enables us to build and characterize pedagogy and instruction networks that identify faculty within STEM departments who are influential; further, this approach has the resolution to identify structural differences between the six influence networks as well as across departments.

Survey instruments were distributed in 2020 via Qualtrics and respondents were directed to answer solely focusing on pre-COVID-19 pandemic context to capture the in-person instructional experience. For each department, survey responses were collected over a 4-wk period with each department obtaining greater than 70% response rates. Response rates and the number of TPs in each department (D) at each of the three universities (U) can be found in Table 1. In total, 27 faculty did not respond to the survey but were still eligible to be identified as discussion partners; thus, we retained these individuals in our analyses.

Social Network Analysis

Survey data were used to create undirected 'instruction' networks for each department based on who faculty listed as having interacted with regarding teaching. Creation of these instruction networks treated both reciprocated and unreciprocated ties between two faculty as though they were reciprocal. Thus, two faculty were considered as having discussed instruction if either of them indicated the other as an interaction partner. In addition, six influence networks were created for each department, one for each of the six domains of instruction or pedagogy described above. These networks were treated as directed networks, based on the logic that influence is a directed relationship, where two individuals may interact with one another, but only one of them feels as though their teaching practice was influenced based on that interaction.

We examined differences in departmental influence networks by domain across several graph-level indices. For each department and influence network, we examined 1) *Mean indegree:* the total number of influence ties divided by the number of individuals in the department. This captures the average level of engagement in each department surrounding each domain and has been used as a proxy for influence in prior social network analyses (O'malley and Marsden, 2008; Benton and Fernàndez, 2014; Kolleck, 2016); 2) *Percent Isolates:* the percent of faculty within a department who are neither influential or, nor influenced by, any colleagues. This captures disengagement among faculty in each department surrounding each domain, and 3) *Edgewise Reciprocity:* The percent of dyads (pair of individuals i and j) where there is a tie from $j \rightarrow i$, given that there is a tie from $i \rightarrow j$. This captures the tendency of collegial conversations to be mutually constructive as opposed to more unidirectional in the flow of influence.

For each instruction and pedagogy domain, we calculated the conditional probability that an influence tie exists between two individuals given the number of other domains where at least one person in a dyad was identified as influential over the other. Thus, we examined five conditional probabilities for each domain: one where no influence ties exist in any of the five other domains, and then conditional probabilities for when an influence tie exists in one, two, three, four, or all five other teaching domains. Conditional probabilities were calculated independently for each department before aggregating results as means and SDs.

The statnet suite of packages in R, including "sna" and "network" were used to perform social network analyses, including the creation of sociographs (Handcock *et al.*, 2008; R Studio Team, 2024).

Mixed-Effect Models

Generalized linear mixed-effects models were used to test whether TP and non-TP faculty differed in the number of colleagues they influenced in each instruction and pedagogy network, and whether these potential differences were greater in the DEI network. The dependent variable in these models was total indegree. We used a mixed-effects model because of the nested nature of the data; each individual has an indegree for each of the six domains and is also nested within a department. Thus, we included random effects for participant ID and department in order to control for the nonindependent nature of these data (Zuur *et al.*, 2009). Because indegree measures are count data that follow a Poisson distribution, we used a log link function.

Five different models were specified. The most complex model included the following fixed effects as predictors: Models 1–4 include random effects; Model 1 - a binary variable indicating whether a faculty was a TP or not; Model 2 - a categorical variable indicating which of the six instructional and pedagogy domains the indegree comes from (Network); Model 3 included TP and network as predictors without the interaction term; Model 4 includes all terms, including interaction and random effects; Model 5 includes all terms except for the random effects. Akaike information criteria (AIC) were used to determine the best fit model, with a difference of 2 used as a cutoff to determine best model fit (Posada and Buckely, 2004). Models were fit using the lme4 package in R (Bates *et al.*, 2014).

RESULTS

Variation in Pedagogical and Instructional Influence Networks

All five departments have densely connected influence networks regarding instruction in general, with densities ranging from 0.22 to 0.66 (Figure 1, left column *Instruction*, Supplemental Figure S1). With the exception of University 2 - STEM Department 2 (U2D2) which had two faculty who were not indicated in any discussions with their colleagues about teaching, all departmental discussion networks were made up of one component, where all nodes share a path to each other. Influence networks on specific domains of pedagogy and instruction were necessarily less dense than the general instruction networks as a result of data collection methods (Supplemental Figure S1). An examination of these networks indicates that TPs tend to be fairly central within their departments, with the one TP in U3D1 the exception.

Compared with other domains, the DEI influence networks tended to be the sparsest, with faculty influencing fewer departmental colleagues on average compared with other pedagogical topics (Figures 1 and 2A; Supplemental Figure S1). This result is partially driven by the large number of isolated individuals across the DEI networks (Figure 2B), who neither influenced DEI-related teaching matters of any colleagues nor indicated being influenced by any colleagues regarding this domain.

The level of reciprocity within departmental DEI influence networks showed more variance. In two departments, U2D1 and U2D3, the DEI influence network was completely asymmetrical. In every case where there was a tie from faculty member 1 to faculty member 2, there was never a reciprocal tie from faculty member 2 to faculty member 1. Of note, these departments exhibited higher levels of reciprocity in all of the other five domains of pedagogy and instruction and also included either zero or one TP. Conversely, for the remaining three STEM departments, reciprocity in the DEI influence network appeared comparable to that of the other domains of pedagogy and instruction.

Instructional and Pedagogical Influence on Topics of DEI Requires Multiple Interaction Ties between Faculty

Given the sparse nature of connections between faculty in the DEI influence network relative to the other domains investigated, we further examined this relationship within the context of the other domains of instruction and pedagogy networks. Utilizing the multiplex nature of the social network data, we examined the conditional probability of a DEI influence tie from one faculty to another given that those faculty had no, one, two, three, four, or five other influence ties across the five other influence networks. We calculated similar conditional probabilities for the five other influence networks and averaged over the five departments (Figure 3).

When considering the probability that a faculty member influences a colleague in any one of the six domains, if no influence relationship exists between those faculty in any of the other five topics, then there was no chance that there was an influence tie in the sixth (Figure 3); alternately, whenever a faculty member was indicated as being influential on a colleague, it was always in two or more topics.

Comparing across domains of instruction and pedagogy, DEI influence ties had a higher threshold of dependence on overall tie strength as measured by the number of influence relationships between any two faculty. For example, given that two faculty exchange influence on four domains other than DEI, they have a probability just over 0.3 of also exhibiting a DEI influence tie. For any other topic, this probability would range from 0.6 to 0.85. It is not until a faculty dyad has influence ties in the five other domains of instruction and pedagogy that it becomes likely that a DEI influence between any two faculty would exist.

UC TPs are Influential Across Instruction and Pedagogy in STEM Departments

Use of mixed-effects models enabled us to test whether TPs were considered influential by a greater number of colleagues than non-TP faculty, and whether this difference was disproportionate in any of the six domains of instruction and pedagogy. The full model that included TP status, network, and an interaction between these terms was the best fitting model (Table 2, Model 4). Compared with non-TP faculty, the log odds of a TP being listed as influential on a colleague in the DEI network is significantly greater (log odds B = 1.67, $p < 0.001$). Controlling for whether or not a faculty is a TP, the log odds of influencing a colleague on their DEI practices is significantly lower than influencing them in any other of the five domains (Model 4, e.g., Concerns B = 0.43, $p < 0.001$; Strategies B = 0.76, $p < 0.001$); however, this difference between how many departmental colleagues an individual influences in the DEI network relative to the other domains is not equivalent between TP and non-TP faculty. Instead, a greater disparity between DEI and the other domains exists for non-TP faculty compared with TPs. This indicates that the greater influence of TPs in their departments is disproportionately large when it comes to discussing DEI. This is indicated by the log odds coefficients less than zero, with the strongest evidence coming from the Logistics and Materials influence networks which have significantly lower interactions with TP status, relative to the interaction between TP status and nomination as influential in the DEI influence network (Model 4, Interaction Terms: TP/Logistics B = –0.52, $p < 0.01$; TP/Materials B = –0.51, $p < 0.01$).

DISCUSSION

This study contributes further evidence that embedding teaching-focused faculty within STEM departmental contexts may be an effective strategy for instructional and pedagogical reform. Specifically, this work contributes to a growing body of research by 1) demonstrating variation of influence networks across STEM departments as well as instructional and pedagogical domains; 2) providing evidence that DEI influence networks critically lag behind other domains of instruction and pedagogy; and 3) highlighting that UC TPs are perceived as influential individuals across all domains of instruction and pedagogy, but disproportionately so in areas involving DEI.

Variation in Pedagogical and Instructional Influence Networks: a Dearth in DEI

Within academic departments, faculty may form CoPs in research, service, and instruction. This study focuses on the instruction CoP and demonstrates that faculty in STEM departments are forming robust networks of influence related to teaching strategies or logistics, but discussions are more limited

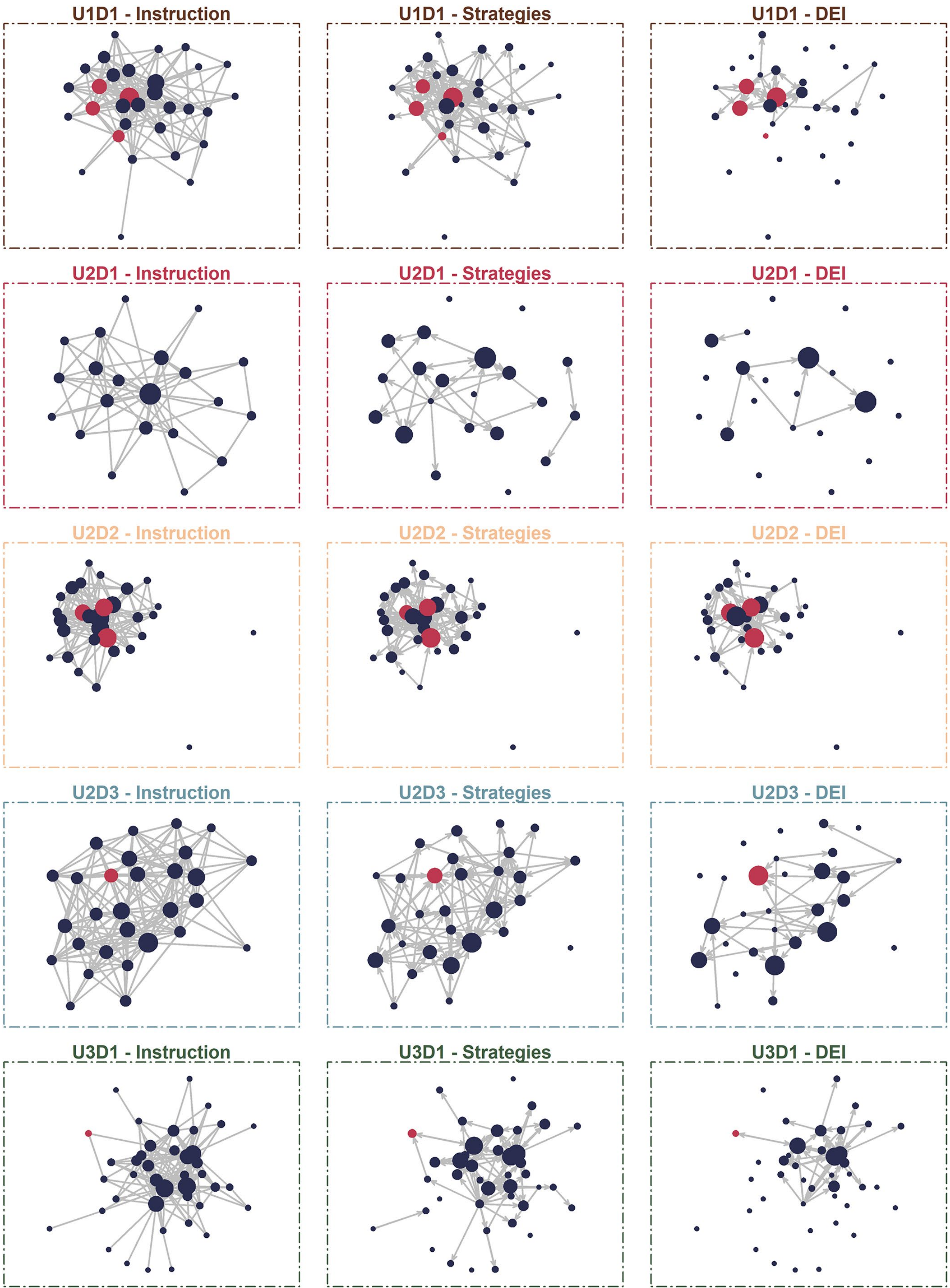

FIGURE 1. Sociographs of instruction, strategies, and DEI influence networks for each of the five STEM departments. Instruction networks (left column) were generated by having faculty identify colleagues with whom they had discussed instruction or pedagogy over the past year. Strategies (middle) and DEI (right) column networks were generated after identification instructional sociographs, wherein faculty identified colleagues who they perceived as influential across six domains of instruction and pedagogy. Nodes (circles) represent individual faculty members where larger node sizes correspond to more edges (gray lines indicative of an individual being nominated as influential) directed to the individual (more influential). Color of the node denotes research track faculty (blue) or TP (red).

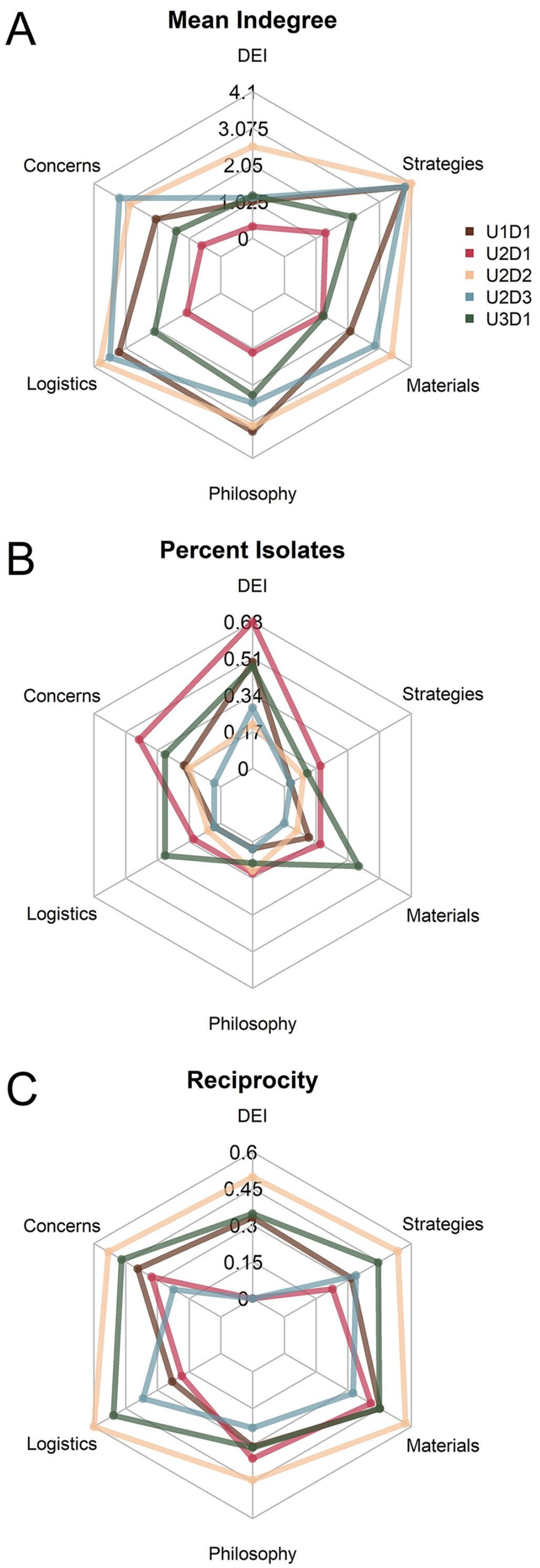

FIGURE 2. Graph-level indices for each of the six domains of instruction and pedagogy across five STEM departments. Each department is represented by different lines across each radar plot.

in the DEI domain of undergraduate education (Figure 1). This result corroborates prior research that across several instructional domains faculty could discuss, issues related to DEI are among the least likely to be discussed (Quardokus Fisher and Henderson, 2018). In our social network analysis, the limited discussion surrounding DEI issues was largely driven by a greater number of faculty who did not engage with any colleagues regarding this topic, appearing to be isolates (Figure 2). The lack of influence on the DEI domain across most of the study departments may suggest little coconstruction of DEI knowledge within the analyzed STEM departments.

But what might underlie this observation? Evidence suggests that the meritocratic and colorblind ideologies embedded within the current culture of STEM academic fields may be, at least in part, the answer (Carter *et al.*, 2019). Indeed, research into the genesis and persistence of these ideologies reveals heterogeneity among individuals in how they perceive the meritocratic judgments of eligibility and academic performance as levers for success and navigation through STEM spaces (Slaton, 2015; Seron *et al.*, 2018; Carter *et al.*, 2019; Grindstaff and Mascarenhas, 2019; Bird and Rhoton, 2021); in the context of instruction in academia, many STEM faculty hold color-blind and color-evasive ideologies that purport an attempted STEM neutrality and objectivity without directly confronting the underlying reasons for equity disparities in the undergraduate classroom context (Russo-Tait, 2022; Suarez *et al.*, 2022; Imad *et al.*, 2023; King *et al.*, 2023). Thus, if certain faculty believe that STEM disciplines are meritocratic and colorblind, it is perhaps unsurprising that the instructional domain related to DEI is not the most interconnected networks of influence across the study departments (Figure 2). This is a critical challenge as evidence highlights that how faculty conceive of equity (or relatedly meritocracy and colorblindness) in the context of instructional and pedagogical approaches ultimately influences STEM undergraduate student educational experiences (Aragón *et al.*, 2017; Suarez *et al.*, 2022; Russo-Tait, 2023).

Instructional and Pedagogical Influence on Topics of DEI Requires Multiple Interaction Ties between Faculty

In a large national survey, most faculty respondents across disciplines indicated that DEI is clearly articulated as a high priority value at the institutional level, but did not indicate that the same was true within their department (Maruyama and Moreno, 2000; Mayhew and Grunwald, 2006; Lattuca and Stark, 2009). Further, although individual faculty largely agreed that a diverse and equitable campus climate provides a host of benefits for students, faculty, and the campus community, less than a third indicated that they had adjusted their course syllabus or made changes to course structures or teaching practices to reflect changing student populations or promote equity among students (Maruyama *et al.*, 2000). This reflects a disconnect between stated institutional goals and individual faculty instructional priorities. These insights might inform interpretation of our results wherein discussing instructional topics related to DEI requires a deeper relationship with considerable trust, which may be unnecessary for discussion of the other domains of instruction and pedagogy (Figure 3). This conjecture is bolstered by evidence that shows that some faculty are unsure of, or even anxious about, how to discuss and/or implement instructional practices in the DEI domain

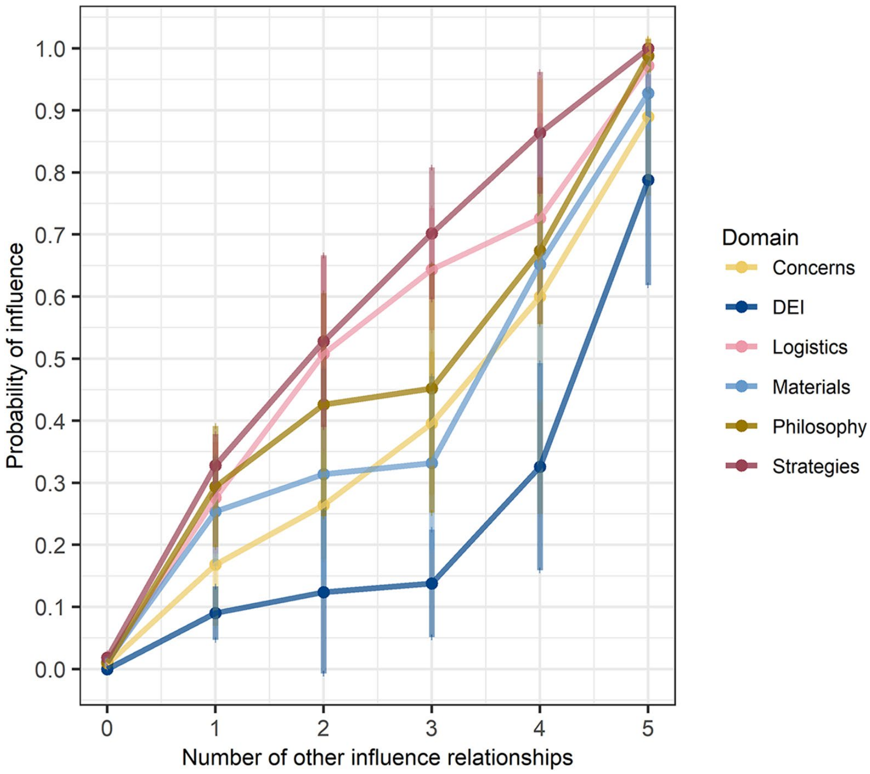

FIGURE 3. The conditional probabilities of faculty influencing one another across six domains of instruction and pedagogy. The probability of influencing a colleague in DEI remains low unless the individual already shares multiple influence ties with a given colleague.

(Wing Sue *et al.*, 2009; Aster *et al.*, 2021; Erby *et al.*, 2021; Thomas *et al.*, 2022; White *et al.*, 2022; White *et al.*, 2023; Williams *et al.*, 2023).

Given that the conditional probability of faculty influence on the DEI domain improves with increased extant faculty-faculty ties, this result suggests a potential path to addressing this challenge: promoting socialization across domains of instruction and pedagogy within academic departments may eventually contribute to positively influencing faculty beliefs about the relative importance of advancing equitable student outcomes (Biglan, 1973; Braxton, 1995; Bernal and Villalpando, 2002). Indeed, this approach of providing opportunities to engage faculty in discussions or professional development centered on topics of DEI in instruction is a strategy that has been previously demonstrated to promote faculty change (Harrison-Bernard *et al.*, 2020; Erby *et al.*, 2021; Macdonald *et al.*, 2019; Kennedy *et al.*, 2021; Williams *et al.*, 2023).

UC TPs are Influential Across Instruction and Pedagogy in STEM Departments

This work contributes to the growing literature on the potential instructional and pedagogical impacts of the TP faculty line at the UC. Our results reinforce a parallel body of literature that focuses on characterizing the SFES at the California State Universities. Like SFES, TPs are a growing and evolving population of education-focused faculty who are embedded in STEM departments on their respective campuses (Bush *et al.*, 2008; Bush *et al.*, 2019; Harlow *et al.*, 2020). Prior research demonstrates that SFES perceive their greatest impact in reforming undergraduate education (Bush *et al.*, 2016; Bush *et al.*, 2019). This aligns closely with our results where TPs are disproportionately nominated as influential in discussions on instruction and pedagogy (Table 2), and like SFES have been described as leaders in these professional domains by administrators and colleagues (Bush *et al.*, 2019; Bush *et al.*, 2020; Harlow *et al.*, 2020; Harlow *et al.*, 2022). The perceptions of TPs as instructional and pedagogical experts may be warranted given that recent evidence points to these faculty as more likely to hold complete conceptions of teaching and learning that emphasized student ownership of learning and are more likely to use evidence-based instructional practices (Denaro *et al.*, 2022; Rozhenkova *et al.*, 2023). Thus, like SFES, UC TPs are positioned within departments to be potential change agents who may be influencing their colleagues on instruction and pedagogy.

Embedded in STEM departments, TPs may be leveraging social networks within the instructional CoP to promote this instructional and pedagogical change (Wasserman and Faust 1994; Burt, 2000; Kezar, 2014; Andrews *et al.* 2016; Henderson *et al.*, 2018; Lane *et al.*, 2019; Skvoretz *et al.*, 2023). This would account for the significant nomination of TPs as individuals sought out for discussions on teaching and pedagogy (Table 2). Prior work demonstrates that peer interactions facilitate the exchange of information, ideas, and awareness of instructional practices, and provide sustained interactions required to promote change (Andrews and Lemons, 2015; Lund and Stains 2015; Quardokus and Henderson, 2015; Dancy *et al.*, 2016; McConnell *et al.*, 2020a). Although evidence suggests that faculty may influence colleague's instructional decision-making process by 1) sharing information about instruction and pedagogy, 2) reinforcing or changing peer attitudes, and 3) shaping and communicating instructional climate (McConnell *et al.*, 2020b), this study does not distinguish amongst these three approaches.

LIMITATIONS AND FUTURE RESEARCH

Our results should be interpreted cautiously given the limitations of the study design. Although the overall response rate was 82.4%, with a greater than 70% response rate across all five departments, our approach does not capture survey nonrespondents and treats these faculty as though they do not discuss instruction, or are not influenced by any colleagues. Therefore, this work might be missing important faculty interactions given these isolates. Our choice to have survey respondents identify influential colleagues, as measured indirectly by indegree, can be influenced by STEM department size; thus, it is important to acknowledge that this measure can be affected

TABLE 2. Mixed-effects regression analysis of influence across faculty type and instructional and pedagogical domains. Values presented are the log-odds

	Model 1 indegree	Model 2 indegree	Model 3 indegree	Model 4 indegree	Model 5 indegree
Predictors	*Log-Mean*	*Log-Mean*	*Log-Mean*	*Log-Mean*	*Log-Mean*
(Intercept)	0.33	–0.03	–0.12	–0.18	0.37***
TP: No	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
TP: Yes	1.35***		1.35***	1.67***	1.39***
Network: DEI	*Reference*	*Reference*	*Reference*	*Reference*	*Reference*
Network: Concerns		0.37***	0.37***	0.43***	0.43***
Network: Logistics		0.64***	0.64***	0.73***	0.73***
Network: Materials		0.38***	0.38***	0.47***	0.47***
Network: Philosophy		0.52***	0.52***	0.55***	0.55***
Network: Strategies		0.70***	0.70***	0.76***	0.76***
Interactions					
TP:NetworkConcerns				–0.31	–0.31
TP:NetworkLogistics				–0.52**	–0.52**
TP:NetworkMaterials				–0.51**	–0.51**
TP:NetworkPhilosophy				–0.19	–0.19
TP:NetworkStrategies				–0.30	–0.30
Random Effects					
σ^2	0.50	0.50	0.50	0.50	
τ_{00}	0.80 $_{\text{ID}}$	0.96 $_{\text{ID}}$	0.80 $_{\text{ID}}$	0.80 $_{\text{ID}}$	
	0.32 $_{\text{Department}}$	0.28 $_{\text{Department}}$	0.32 $_{\text{Department}}$	0.32 $_{\text{Department}}$	
ICC	0.69	0.71	0.69	0.69	
N	191 $_{\text{ID}}$	191 $_{\text{ID}}$	191 $_{\text{ID}}$	191 $_{\text{ID}}$	
	15 $_{\text{Department}}$	15 $_{\text{Department}}$	15 $_{\text{Department}}$	15 $_{\text{Department}}$	
Observations	1146	1146	1146	1146	1146
Marginal R^2/Conditional R^2	0.062/0.711	0.029/0.721	0.090/0.719	0.095/0.721	0.399
AIC	3993.880	3878.913	3859.504	3857.362	5451.610
AICc	3993.915	3879.040	3859.663	3857.734	5451.886

*, $p < 0.05$; **, $p < 0.01$;***, $p < 0.001$
Note: The best fitting model included TP status, instruction and pedagogical domains, and an interaction between these two variables.

by extremes in terms of department sizes where larger departments have the potential to have more interactions on instruction and pedagogy.

These social networks are context-specific since they represent only five across the dozens of STEM departments housed at these three campuses. Additionally, the represented institutions are large enrollment, public, research-intensive universities. We found that TPs are loci of pedagogical influence in their departments (Table 2); however, this does not preclude research-oriented faculty who are deeply engaged in DEI conversations from being equally influential and enacting change within their communities of practice. This limitation is reflected in our data: one department had no TPs while the others varied between one and three TPs (Figure 1). In the same vein of faculty positions, since six of our eight TPs hail from only two of the five sampled STEM departments, it is important to temper the extent to which our results apply to other departmental, disciplinary, or even campus contexts. Although these biases are limiting, they also encourage future exploration to assess whether teaching focused faculty are disproportionately influential more broadly; should this be a general phenomenon, then this would bolster the evidence that embedding teaching focused faculty in STEM departments may be an effective instructional and pedagogical change strategy.

Communities of Practice can be conceptualized to evolve over time and include stages (Wenger *et al.*, 2002) that can ultimately result in transformation of the individuals within this social learning structure. Our results highlight existing instructional and pedagogical influence networks between individual faculty, but whether these networks represent a robust STEM department instructional CoP is uncertain. Further, if these analyses do indeed characterize instructional and pedagogical CoPs across the departments, at what stage are each department? And to what extent are TPs driving change? To this point, the influence that TPs have within the various pedagogical networks, especially on topics of DEI, does not necessarily suggest a causal connection between embedding teaching faculty in departments and shifts in faculty values or practices. In addition, whether reported influence of TPs promotes faculty change *over time* still remains to be characterized. Last, how faculty conceptualize influence, and the limits to which influence might be able to generate instructional and pedagogical change needs to be defined. These questions are important to address as prior social network analyses of STEM departments illustrate that nomination as a leader does not always correlate with the number of ties to other faculty, nor is simply the presence of faculty leaders in instruction and pedagogy a sufficient driver of instructional change (Knaub *et al.*, 2018; Reding *et al.*, 2022).

RECOMMENDATIONS

Prior studies have found that meaningful discussions about the DEI domain in undergraduate education require faculty to not only share values surrounding DEI efforts, but also to have the professional trust of their colleagues (Martinez-Acosta and Favero, 2018). Communities of practice that form between members of an academic department necessarily involve both shared values and professional trust. Our results indicate that TPs embedded within STEM departments may provide a promising avenue to promote change by utilizing existing departmental structures to build robust new communities of practice surrounding DEI efforts in undergraduate education. Given the need to accelerate change to better promote equity in undergraduate STEM education, we recommend centering tenure-track teaching focused faculty members in departmental structures to influence discussions and form robust communities of practice surrounding pedagogy and DEI efforts in undergraduate education. Considering the influence they can have on colleagues' instructional approaches, these faculty could foster discussions in these departmental structures about DEI issues in the classroom to better serve the next generation of scientists.

However, in order to achieve this goal, it is important to recognize that many UC TPs are trained in disciplinary PhD programs and likely do not have scholarly training in DEI (Harlow *et al.*, 2020). Previous research suggests that promoting change on topics of DEI relies on embedding and training leaders on these topics through targeted professional development opportunities (Jemal and Frasier, 2021). Given the influence networks of the analyzed STEM departments, tenure-track teaching focused faculty are already situated as central hubs and are viewed as influential on their peers' instructional approaches. Thus, we recommend targeting professional development opportunities to these potential change agents to allow these uniquely positioned individuals to exert even greater influence on their colleagues.

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