

Exploring Epistemological Beliefs and Network Associations of STEM Faculty

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ABSTRACT

Interactions among faculty members play a critical role in the diffusion of research-based instructional strategies (RBIS). Prior research suggests that non-tenure-track faculty differ significantly from their tenured counterparts in teaching practices and engagement with instructional reform. This study explores how faculty members' teaching-related epistemological beliefs influence their engagement with RBIS and their relationships in collegial networks. Using an interpretive phenomenological approach, we analyzed faculty narratives to capture their beliefs about teaching and RBIS. These qualitative insights were combined with sociometric measures from social network analysis to identify individuals who hold central positions in a faculty network. A focused case study of a pivotal faculty member illustrates how epistemological beliefs shape interpersonal influence and credibility across faculty status lines. Findings highlight the significance of individual beliefs in fostering collegial connections and advancing the institutional spread of RBIS.

Keywords: epistemological beliefs; social network analysis; active learning strategies; collaboration

Introduction

The use of research-based instructional strategies (RBIS) is widely recognized as a means to improve academic performance and retention in STEM fields (Freeman et al., 2014). STEM departments operate under distinctive conditions, such as high research expectations, hierarchical roles, and heavier teaching loads for non-tenured faculty, that uniquely shape faculty epistemologies and social interactions. These factors make STEM contexts especially important for examining how epistemological beliefs and social networks influence the adoption of RBIS. However, the extent to which faculty adopt these practices may vary by tenure status (Kezar, 2013). While non-tenure-track faculty often face constraints in adopting research-based instructional strategies, tenured faculty typically have greater autonomy in their teaching, more established collegial networks, and broader access to institutional resources (Baldwin & Wawrzynski, 2011; Umbach, 2007). These factors can facilitate the adoption of active learning and collaborative instructional strategies by tenured faculty, as well as faculty engagement in professional discourse around teaching innovations. By contrast, non-tenured faculty may have limited influence over curricular decisions and fewer opportunities for sustained collegial interaction, which can hinder their participation in instructional reform efforts. Studies have shown that non-tenure-track faculty are generally less likely to employ active learning

techniques than tenured faculty, often viewing themselves more as employees than as agents of pedagogical change (Baldwin & Wawrzynski, 2011; Umbach, 2007). Additionally, part-time or contingent faculty have been found to use collaborative instructional strategies less frequently. Collegial interactions have been shown to facilitate the adoption of RBIS (van Staaden and Raubenheimer, 2015), but such interactions may be constrained by institutional hierarchies. Perceived disparities in working conditions between tenured and non-tenured faculty can limit opportunities for meaningful collaboration (Schwartz, 2017). Non-tenured faculty often report feelings of marginalization and a lack of clarity around their professional roles, prompting a desire for stronger peer networks and a greater sense of belonging in the academic community (Levin & Shaker, 2011). Yet the hierarchical nature of academic institutions often inhibits such collegial integration (Kezar, 2014).

One underexplored factor that may influence collegiality is epistemology, specifically, individual beliefs about knowledge and learning (Daniels, 2014). Epistemological beliefs are known to shape knowledge-sharing behaviors and engagement in professional discourse (Nussbaum & Bendixen, 2003; Weinberg, 2015). However, little research has explored the link between these beliefs and the social dynamics among faculty, particularly in relation to RBIS adoption. This study examines the interplay between epistemological beliefs and collegial interactions among tenured and non-tenured faculty members. By exploring this relationship, we aim to better understand how faculty beliefs about knowledge influence their participation in teaching-related discourse and, by extension, the spread of RBIS. Insights gained from this study may inform institutional strategies for supporting faculty development and enhancing instructional reform.

Theoretical framework

Role of Epistemology in Social Interactions

Social Exchange Theory (SET) posits that individuals form and maintain relationships based on the exchange of valued resources, including knowledge (Umbach, 2007). Applied to higher education, this suggests that faculty may engage in collegial interactions to share teaching-related knowledge, which can in turn promote the adoption of RBIS (Freeman et al., 2014; Kreber & Castleden, 2009; Weinberg, 2015). Knowledge-sharing involves the mutual exchange of both tacit and explicit knowledge, often resulting in the co-creation of new ideas (De Vries et al., 2006). Prince et al. (2013) outlined three stages of RBIS diffusion: **awareness**, **information**, and **reflection**. The awareness and information phases are inherently social, involving discussion, observation, and the active pursuit of pedagogical insights. The reflection phase, while more internal, is shaped by prior social exposure to teaching strategies. These stages highlight the centrality of knowledge-sharing in fostering instructional reform.

Given this reciprocal interplay between epistemology and knowledge-sharing behavior (Daniels, 2014), the epistemological beliefs of faculty members appear to be fundamental to understanding both faculty disposition to forge social connections generally and to engage in discussions centering on teaching practice in particular. Hence, there is a far-reaching need to investigate the association between the epistemological beliefs and the social networks of individual faculty members.

Epistemological Beliefs

Epistemological beliefs, defined as individuals' conceptions of knowledge, teaching, and learning, offer valuable insights into behavior that are not captured by content knowledge alone (Pajares, 1992). Unlike knowledge, which evolves with experience, beliefs are more stable and deeply ingrained, shaping memory, perception, and behavior (Nussbaum & Bendixen, 2003). Researchers variously describe these as *beliefs*, *attitudes*, or *teaching conceptions* (McKay & Rozee, 2004; Wong et al., 2009), but all suggest that such beliefs play a significant role in knowledge-sharing and teaching behavior. Whether treated as beliefs, attitudes, or conceptions, teaching-related epistemology may be relevant to faculty members' disposition to engage in social exchange. For instance, Nussbaum and Bendixen (2003) demonstrated that epistemological beliefs significantly influenced students' willingness to engage in discussion and argumentation. Specifically, students who believed that knowledge was simple and certain were more likely to avoid intellectual disagreements and less likely to participate in knowledge-sharing interactions. While that study focused on students, its relevance to faculty lies in the underlying mechanisms of belief: whether among students or professionals, epistemological beliefs shape individuals' openness to new ideas and their engagement in collaborative discourse (Weinberg, 2015). This parallel is particularly relevant to understanding differences between tenured and non-tenured faculty. Tenured faculty, who often experience greater professional security and autonomy, may feel more comfortable engaging in intellectual disagreement and adopting new instructional practices. In contrast, non-tenured faculty, whose positions may depend on student evaluations or administrative approval, might exhibit more cautious epistemological orientations—favoring established methods and avoiding contentious pedagogical debates. Thus, while originating in studies of students, these constructs remain relevant and transferable when examining how faculty beliefs influence social and collaborative behavior in academic settings.

Nespor (1987) developed a theoretically grounded, empirically supported framework for distinguishing teaching-related beliefs from factual knowledge. His work drew on two types of interviews: one focused on teachers' general principles about teaching and students, and the other on their specific explanations of instructional practices. From this analysis, Nespor identified four key features that differentiate beliefs from knowledge: *existential presumptions*, *alternativity*, *affective and evaluative loading*, and *episodic structure*. These dimensions form the foundation for our analysis of faculty epistemologies and their relationship to social interactions within academic networks.

Existential Presumptions. Epistemological beliefs refer to individuals' deeply held assumptions about the nature of knowledge, knowing, and learning. Unlike knowledge, which is typically based on evidence and can be revised in light of new information, beliefs are often more resistant to change and may not require empirical justification. One key feature of epistemological beliefs, according to Nespor (1987), is that they often include *existential presumptions*, assumptions about the existence of certain entities or truths that are treated as self-evident and unquestionable. Stark examples of existential presumptions are represented by beliefs in God or various conspiracy theories. In the context of teaching practice, existential presumptions might revolve around strong beliefs relating to student 'ability' and motivation, or lack thereof. For instance, one of the teachers interviewed by Nespor believed that students who failed to learn math did so because they were "lazy".

Alternativity. Another defining feature of epistemological beliefs is *alternativity*, the tendency to envision idealized realities that contrast sharply with present or past experiences. Nespor (1987) described these "alternative realities" as aspirational constructs, often ungrounded in empirical evidence or lived experience. Such beliefs reflect an individual's vision of what could or should be, rather than what currently is. For instance, one teacher Nespor interviewed imagined a classroom that

was child-friendly and fun, a vision that stood in sharp contrast to her own experience as a student. In this way, *alternativity* captures how educators conceptualize ideal conditions that may be far removed from their actual teaching contexts.

Affective and Evaluative Loading. Nespor (1987) argued that beliefs are often shaped by emotions and personal judgments and thus tend to carry more affective and evaluative weight than knowledge statements. These emotional and value-laden aspects of belief influence how individuals prioritize certain teaching practices. For example, in Nespor's study, three of four history teachers believed that teaching historical facts had little lasting impact on students' understanding of history, and as a result, they devoted less instructional time to factual content. This illustrates how affective and evaluative judgments can guide teachers' decisions about where to invest their time and energy in the classroom.

Episodic Storage. Nespor (1987) argued that beliefs often gain strength and legitimacy from personal episodes—memorable events or experiences that shape how individuals interpret subsequent situations. These episodes may stem from classroom encounters, formative teaching moments, interactions with students, or broader professional experiences. Unlike abstract knowledge, which is often generalized and decontextualized, episodic memory is tied to specific situations and emotions, making it more influential in guiding future behavior. For instance, a math teacher interviewed by Nespor, who had been teaching in a vocational school, frequently drew upon personal anecdotes when explaining certain concepts—highlighting how past teaching episodes directly informed his instructional approach to school, and was more willing to employ anecdotal evidence relevant to teaching certain topics.

Social Networks

Because social exchange theory is grounded in the idea that relationships involve the reciprocal exchange of valued resources (Emerson, 1976), it is essential to examine how faculty are socially connected. Social network analysis (SNA) provides a powerful method for exploring these connections, based on the premise that social life is shaped by patterns of relationships rather than isolated individuals (Marin & Wellman, 2011). In the context of higher education, SNA offers a valuable tool for investigating how faculty interact professionally and how these interactions may align with their epistemological beliefs (Carolan, 2013).

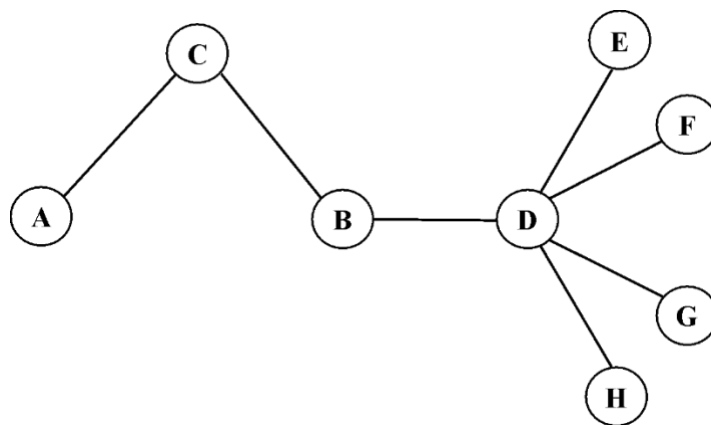
A core premise of social network analysis (SNA) is that an individual's position within a social structure shapes their opportunities and outcomes (Carolan, 2013). From a sociometric standpoint, individuals who are centrally located in a social network are thought to possess strategic advantages, such as access to information, influence or visibility. To capture these aspects of centrality, researchers commonly use measures such as **degree**, **closeness**, **betweenness**, and **eigenvector value**. These metrics help identify those individuals who are highly connected, centrally located, and potentially influential within the network.

The easiest way to conceptualize these measures is through the use of a graphic representation to illustrate each measure (Figure 1 below). *Degree* is in some sense a measure of the popularity of an individual and is equal to the number of node neighbors a focal individual possesses. For instance, in Figure 1, node D is linked to five neighboring nodes and thus has a degree of 5 (the highest in this network), whereas node A with just one connection has a degree of 1. *Closeness* represents how close an individual is to other actors in a social network and serves as an indication of the number of steps (i.e., how fast) information will spread from one actor to everyone else in the social network (Freeman,

1979). Examining closeness for node A gives us the following: the distance from node from A to C is 1 step, A to B is two steps, from A to D is 3 steps, from A to E (F, G, H) is 4 steps. To calculate closeness for node A then, we take the inverse of the sum of all distances (steps). *Betweenness* can be viewed as a measure of the extent to which a vertex plays a bridging role in a network. Bridging positions reflect power, because the person in this position serves as a gatekeeper of information (Freeman, 1977). For instance, node D is along the shortest path between nodes B and E, F, G, and H, and has a strong bridging position since it is in total control of information flow through the network. Finally, *eigenvector values* measure a nodes importance while taking its neighbors into consideration i.e., it measures how many connections its neighbors have (Bonacich, 1987). Thus, nodes A and E (F,G, H) have the same degree value being directly connected to one node (C and D respectively), but their eigenvector values differ based on the nature of those connections. Node D (directly linked to node E) has more connections than does node C (linked to nodes A and B). As a result, node E has a higher eigenvector value than does node A, despite having a similar degree.

Figure 1

A Sample Social Network Graph in Which Each Circle (node) Represents an Actor, and Lines Between Nodes Indicate Relationships.



Note. Centrality measures such as degree, closeness, betweenness, and eigenvector value can be derived from the structure of these connections.

This study examines the alignment between faculty members' epistemological beliefs and their sociometric measures of centrality to better understand individual contributions to the diffusion of research-based instructional strategies (RBIS) at the institutional level. Then, drawing on Nespor's framework, we explore teaching-related epistemological beliefs as expressed through faculty members' reflections on their experiences with RBIS and teaching more broadly. By applying social network analysis, we aim to uncover how these beliefs may relate to their sociometric measures of centrality.

Methodology

This study is part of a broader initiative funded by the National Science Foundation to improve undergraduate STEM education. The specific goal of this project was to foster cultural change among

faculty and administrators by promoting the diffusion of research-based instructional strategies aimed at enhancing students' quantitative literacy. To catalyze this shift, we adopted a generative approach that included a range of semi-structured opportunities for professional discourse. One of these involved regular bi-weekly, casual lunch-time sessions with unique topics of discussion centered around STEM pedagogy. At these events, STEM faculty were able to interact with colleagues from a broad range of disciplines other than their own. Although the ostensible intention of these events was to provide information about teaching innovations, the primary purpose was, in fact, to create opportunities for faculty networking and sensemaking. This paper presents a focused case study of one department—Physics—whose faculty participated most consistently in these pedagogical discussions.

Research Design

This study employed a qualitative design, using semi-structured interviews to explore emerging themes related to faculty members' epistemological beliefs and pedagogical practices. This approach is particularly well-suited for exploratory research and enables in-depth thematic analysis of participant perspectives.

The focal department comprised 13 full-time faculty members, of whom 11 participated in interviews conducted between 2019 and 2021. Each interview lasted up to 40 minutes and followed a semi-structured protocol, allowing for both consistency across participants and flexibility for follow-up questions and reflective dialogue (Patton, 2002). The interview protocol included a set of standard questions around curriculum decisions, approaches to teaching, views on student learning and departmental dynamics, which were designed to elicit their epistemological stance on pedagogy, including the use of research-based instructional strategies (Raubenheimer, 2004).

All participants were faculty affiliated with the Department of Physics and Astronomy at a large university in the Midwestern United States, and pseudonyms were used to protect their identity. Amongst these were seven tenured and four non-tenured members, who varied with respect to their teaching and research responsibilities. Except for one, non-tenured faculty members had no formal research load, while tenured faculty members carried discipline-focused at either level I (the highest research load) or II research load (a moderate research load). The single non-tenured faculty had research level III which refers to educational research within the discipline and thereby provides greater exposure to pedagogy related scholarship.

All interviews were transcribed and subsequently analyzed using qualitative data analysis software NVivo (Version 12.6). In the first phase of interview analysis, we examined the transcripts to determine faculty preference for teaching methods as a main vehicle to engage students and a starting point to categorize instructors as either lecture-oriented or active teaching-oriented. To capture the preferred pedagogical approach, we focused on phrases in the transcripts that explicitly outlined favored teaching strategies. In the second phase of interview analysis, we relied on Nespor's framing features which distinguish epistemological beliefs from knowledge. Since this was a novel application in studying epistemological beliefs of faculty, the semi-structured strategy was appropriate to enable spontaneity in shaping the dialogue and to stimulate additional details, such as existing social connections with other faculty members.

Using a deductive approach, we coded narratives based on Nespor's four features or broad codes (Miles & Huberman, 1994). With the broad codes entered as nodes (i.e., existential, alternativity, affective, and episodic storage), two authors jointly coded one interview to produce an initial version of the coding system. This analytical step in thematic coding, marking the inductive coding (Glaser, 1992), revealed potential sub-themes for which a set of sub-codes were developed within each broad

category. Sub-codes were entered as child-nodes in NVivo and used to match the sub-codes with the appropriate segments of text (Table 1). Using this system, the first and the second authors independently coded the transcript of another faculty member and met to compare coding and discuss any discrepancies. In general, the coders identified the same passages and the same broad codes but differed in some of the categorizations at the level of sub-codes. All of these discrepancies were resolved through discussion and definitions for sub-codes were further refined. To establish interrater reliability, these same authors coded broad- and sub-codes for a further two interview transcripts. Interrater concordance was 90% and 82% at the level of broad and sub-codes, respectively, a level of agreement that gave us confidence that the coding system could be reliably applied to the balance of the interviews. A summary of the coding scheme is presented in table 1 below.

To complement interview data on social ties and to gain measures of centrality, we employed a sociometric method, social network nomination approach, which has been shown to have high validity (Rogers, 1995). Faculty were asked to complete a sociometric questionnaire distributed via email across all STEM departments. This questionnaire was used to collect professional information and the “who talks to whom” about teaching practices across STEM fields, so-called network nomination data. Each faculty member was offered a series of questions related to the use of RBIS and asked to nominate faculty members with whom they most often discussed teaching related issues. Responses from the social nomination survey were compiled into an adjacency matrix representing teaching related interactions among faculty. Using these data, we constructed a network graph and calculated centrality measures of network position (for example, degree) to capture participant’s embeddedness in the teaching discussion network.

In the final stage of the data analysis, we aligned epistemological sub-codes with faculty preference for the dominant teaching approach and matched these associations with the sociometric data for each faculty member. Rather than analyzing these datasets in isolation, we iteratively compared and interpreted centrality measures alongside the epistemological profiles. This interpretative integration allowed us to examine whether individuals with similar epistemological orientations occupied comparable network positions, and how specific belief patterns might influence social connectedness and knowledge-sharing behaviors.

Table 1

Application of Nespor's (1987) Epistemological Frame to STEM Teaching

Description of Broad Codes/Domains	Emerging Sub-codes	Descriptions of emerging sub-codes	Identifying words for broad domain	Reflection statements representing emerging sub-codes
Existential Presumptions: assumptions treated as concrete truths, often categorical or non-negotiable. Statements are usually structured as facts that are not subject to dispute. Some radical or categorical ideas may serve as a good example of existential presumption.	Firm	Statements reflect instructor's intent to assume sense of ownership and instructor's expectations from students	"in my view", "I believe", "I think"	"I think, actually, my view is that we need to focus on teaching students skills, especially in STEM." (Finley interview)
	Fatalistic	Statements reflect instructor's intent to relinquish ownership		"So, the curriculum is lacking." (Finley interview)
	Declarative	Statements reflect instructor's intent to limit their involvement in tasks		"And I see those invitations to the lunch meetings. I keep ignoring them simply. This is my choice." (Azariah interview)
Alternativity: representations of alternative reality that a person had not experienced or that contrasts lived experience. This feature of belief systems plays an important role in defining a goal and task. Statements are structured as if information is still being processed and can be disputed. They convey a tone of wishful thinking with respect to reality.	Divergent	Statements representing alternative realities without experiential basis (without rationale).	It is less about buzzwords and more about the overall speculative tone of the statement that longs for alternative solution	"Yeah. I don't know who it has to go to after this, but we cannot implant it right away. We might have to add more hours for the student." (Finley interview)
	Convergent	Statements representing alternative realities based on experience (rationale is provided).		"Yeah, I'm kind of troubled, we have to graduate the students in four years or as best as possible. Why?" (Finley interview)
Affective and Evaluative Aspects: important regulators of the amount of energy expended (by teachers or learners) on certain content or activities.	Skeptical	Statements that communicate teaching is not	Less about buzzwords, more about tone of the statement that either	"So just going out and trying to invite people, bring people to us, didn't work so far." (Azariah

		worth the expended energy.	encourages or discourages an individual to spend time doing something	interview)
	Constructive	Statements that communicate that teaching is worth the expended energy.		“So, I think for the major it's always good to have a project [...] so we give them a project and ask them to work on this project, this could be helpful for them.” (Finley interview)
Episodic Storage: critical episodes that color the comprehension of subsequent events	Cursory	Surface-level statements referencing critical episodes without providing a rationale.	“for an example”, “I used to know”, “some time ago” some word that explicitly references the past	“Yeah, because in one class four or five years ago I had similar questions on Mars.” (Dana interview)
	Detailed	Detailed statements referencing critical episodes as a rationale for teaching choices. (goes beyond teaching)		“I can tell you an example. I had a student, actually an undergraduate student who worked in my lab [...]” (Finley interview)

Note. Broad codes and emerging sub-codes were derived from detailed analysis of faculty interviews.

Research Findings

Overview

The purpose of this study was to investigate associations between faculty epistemological beliefs and the social network of faculty members, discussing teaching, learning, and potentially RBIS. By focusing on a single department, experiences are not oversimplified. Rather, in-depth examination of faculty beliefs of teaching practices provides a chance to identify institutional strategies that can promote social interactions among faculty members.

Overall, we found that non-tenured faculty expressed a concern with teaching overload and insufficient institutional support. Yet much of the analysis shows that tenure is not the predictor of a faculty member's disposition to engage in research-based instruction and to create a strong peer network. Contrary to prior research, non-tenured members see active practices as being more central to their teaching methods, whereas their tenured colleagues value lecture as a dominant approach that covers content. At the same time, tenured members are more likely to see authentic research as a crucial element that engages students' long-term commitment to the field of physics. The porous boundaries for non-tenured faculty encourage some faculty to engage in activity other than teaching, for instance disciplinary research. Through research involvement, non-tenured faculty may gain social connectivity with tenured peers, which enables them to act independently, engage in curriculum development, and diffuse research-based instruction.

We organize our results below according to the two different types of analyses conducted (namely, qualitative and social network analysis) and include illustrative passages from interviews and sociometric measures to support our findings.

Interview Findings and Discussion

Categorization of Faculty Based on Their Dominant Teaching Approach

We identified six instructors who preferred lecture as the dominant teaching method in physics, and who were thus categorized as lecture-oriented (LO). This group of instructors is represented exclusively by tenured faculty. Notably, this group of instructors also valued content coverage and clearly expected students to meet the class standards and follow the class structure. While they had higher expectations of their students, they were also concerned with students' ability to keep up with the pace at which the lecture material was presented. Although these instructors prioritized lecture as the primary mode of material transmission, they did not necessarily regard themselves as an authority in the classroom. Moreover, these instructors promoted deeper learning by facilitating independent thinking and having students derive formulae on their own. This group of instructors engaged heavily in physics research and strongly argued for student laboratory experiences and authentic research engagement as indispensable to maintaining student commitment to the study of physics. They also noted the distinction between students in the physics major who needed to have greater mastery over the subject matter, compared to those taking courses for general education purposes. However, they recognized the value of authentic experience as being valuable for both majors and non-majors alike.

Faculty who prioritized research-based instructional strategies as the preferred way of engaging students (5 out of 11) were categorized as active teaching-oriented (ATO). These instructors were less focused on simply covering content. Only one of these five faculty was tenured, with two having an explicit research load (tenured faculty, Ashley, at level II-disciplinary research and non-tenured, Emery, at level III-physics education research). To promote deeper learning, some of these instructors occasionally argued for student research opportunities, while others sought to

connect physics to real-world contexts. Some of these instructors did voice concern about needing to cover content but prioritized students' needs and learning above content coverage.

These results are partially concordant with some prior research which examined differences in the faculty academic expectations of students and the instructional styles of contingent and tenured faculty. While previous research identified definitive differences between tenured and part-time non-tenured faculty in the likelihood of their using active learning strategies (Baldwin & Wawrzynski, 2011; Umbach, 2007), no differences were found in fidelity of implementation between tenured and full-time contingent colleagues in that respect (Baldwin & Wawrzynski, 2011; Umbach, 2007). Umbach (2007) found that full-time non-tenured members differ from their tenured counterpart in only one respect: their expectations of students. Given that the non-tenured instructors described in this proposed study all hold full-time contingent teaching positions and continuing affiliations with a single institution, it logically follows that they should be as likely to engage in research-based instructional styles as research has previously shown for tenured colleagues at other institutions. Consistent with this prior research and rationale that follows, non-tenured faculty in this study do indeed exhibit a preference for active learning strategies as the dominant teaching mode. However, contrary to prior research, our results show that tenured colleagues are more likely to prefer lecture as a dominant method of teaching to cover the necessary content. At the same time, in this study tenured faculty also strongly argue for laboratory experiences and authentic research as a main vehicle for student commitment to physics. On a related note, they tend to have higher academic expectations of their students than do non-tenured faculty, especially of students who plan to major in physics, which is strongly corroborated by prior studies (Baldwin & Wawrzynski, 2011; Umbach, 2007). Examination of epistemological differences between lecture and active teaching-oriented faculty unmasks important epistemic differences between colleagues at the individual level and provides additional insight into how to support interactions between faculty at different ranks to induce social exchange and adoption of RBIS at the institutional level.

Categorization of Faculty Epistemological Beliefs Based on Nespor's Frame

The general categorization of faculty members into broad groups of lecture-oriented (LO) and active teaching-oriented (ATO) proved to be a fair predictor of epistemological beliefs of faculty members, which were analyzed as previously described, using Nespor's delineation of four features namely, existential, alternativity, affective and evaluative, and episodic storage (see table 1 above).

Existential presumptions were prominent in the interviews of all 11 faculty colleagues (see examples for exact quotes in Table 1). However, faculty manifested different dimensions of existential or indisputable presumptions; some tended to assume full responsibility for learning outcomes (*firm*), some were more likely to place responsibility for learning outcomes on students or the curriculum (*fatalistic*), while still others marked out their priorities (*declarative*).

Finley, a tenured faculty participant, emphasized that instructors need to focus on developing students' STEM skills to enhance their learning experiences. She explained that faculty are responsible for ensuring students acquire the skills necessary to succeed in undergraduate Physics. These statements were categorized as *firm*. Finley stated:

I think, actually, my view is that we need to focus on teaching students skills, especially STEM. I believe some affect the way we teach classes but doesn't really give the student skills. They need more than just information. So, in my view, science teaching is different – how to develop their skills, how to learn the method of teaching and thinking, more than just information. ... We show a student how to solve the problem, but I understand they

need very much help to know how to solve it because we don't teach them how to think. They never see it before. They can't do it, ...

The second dimension of existential presumptions was manifested through statements that placed responsibility for learning outcomes on students or on the curriculum. Karlo (pseudonym) expressed a belief that students invest little to no time into a course and fail to learn as a result. These statements were categorized as *fatalistic*. As Karlo explained, “[students are encouraged to practice more in class] since they really seem to struggle doing anything outside class to figure things out.”

A third dimension of existential beliefs involved faculty members' inclination to get involved in certain tasks not strictly research-oriented or more teaching focused. Azariah (pseudonym) decisively stated that their time is spoken for, therefore they did not get involved in meetings where faculty discuss reformed pedagogical strategies. These lunch meetings, organized by the department to foster discussion around teaching innovation, were perceived by some faculty as peripheral to their core professional responsibilities. Azariah's comments reflected a clear boundary between research and teaching commitments. These statements were categorized as *declarative* because agency for performance outcomes is being assigned to neither the instructor nor the students. Nonetheless, faculty clearly express their disposition toward certain tasks. Azariah explained: “And I see those invitations to the lunch meetings. I keep ignoring them simply. This is my choice.”

Alternativity was a less conspicuous feature in the interviews overall. While wishing for an alternative reality, some faculty members provided a detailed description of alternativity based on actual experiences (*convergent*). In contrast, others offered more hypothetical or idealized accounts detached from real practice (*divergent*). Finley was one of the few members whose narrative was rich in alternative statements. They believed that changing the way students are assessed would impact the quality of learning. During the interview, Finley reflected on departmental assessment practices and described specific ways they would modify examinations to emphasize conceptual understanding over rote problem-solving. These statements were coded as convergent because they were supported by evidence of being experienced or implemented. As Finley explained:

For example, if you made our exam to test a student's understanding just to really see what the student understands. It might be tough in the beginning, but if the student sees they are not going to pass this course and have an understanding of material, they would do this. In my view, actually, if [I] really want to make a change, I would change the exam. ... I would make the exam depend on the concept.”

In contrast, when Emery recalls their graduate experience, they remember wishing for a different type of teaching. Although they wanted it to be different, they could not define in what specific way it should be so. Statements consistent with this expression of alternativity were coded as *divergent* because they lacked evidence of being experienced. As Emery reflected, “So, I learned about active learning by taking higher [education] courses while I was in grad[uate] school. I did that because I didn't like the way I was being taught throughout my degree program, up until that point. At least that, you know, in part, knowing that there was something better that could be done, just didn't know what to call it.”

Affective and evaluative beliefs were less prominent than existential beliefs, but still conspicuous in faculty interviews. Since affect and evaluation regulate the amount of time and energy expended on teaching certain content in a particular way, interviews were screened for text consistent with this category. When faculty considered some material or activity worth doing, we coded it as *constructive*. As one faculty member stated, “And what we believe in our committee is just doing our job—

teaching really well—is what we need. It’s important that we communicate to the student. How we communicate to the students. Are we making them see the value surrounding physics?” (Finley).

In contrast, when faculty expressed doubt about the value of a particular activity, we coded such statements as *skeptical*. For instance, one participant questioned the usefulness of departmental outreach efforts, saying:

So, we’re to do that. But at the same time, we realize that really good, strong teaching is probably the best advertisement for our department. So just going out and trying to invite people, bring people to us, didn’t work so far [our colleagues felt that good teaching is the best advertisement rather than marketing the department] (Azariah).

This skepticism reflects the participant’s belief that effective teaching, rather than outreach or marketing, is the most reliable way to attract and retain students. Therefore, their doubt about outreach efforts led us to code these statements as *skeptical*.

Episodic storage was pronounced in all interviews. When faculty members explicitly drew on past episodes from their life to frame their responses, we coded it as *detailed* or *cursor*y depending on the level of detail provided. Some faculty were extremely detailed in drawing on past experiences. For instance, Dana (pseudonym) used several specific examples from the past in response to any question posed to them. In response to a question focused on priorities for undergraduate teaching and learning, Dana went into extensive description about their early teaching experience when they incorporated daily assignments into a grading system to encourage students to be diligent about homework. These comments were coded as *detailed*:

I had that problem last year before they decided to screw with the system is, for whatever reason, they stuck me in an active learning classroom where the tables were sort of like this big, but then three of them stuck together. And then at each one of those three people sat, which for group work is perfect. But I want to give an exam, there’s no way to do that. So, I said, well, I can teach in this room, but for each one of those little things I can only have one student, so I could only have one third the number of students the room is designed for. Oh, no, that’s not acceptable. So fortunately, I got moved. But it’s like, why do I have to fight this fight, getting a classroom to teach a class seems like a default for the university, not something you have to struggle for every semester (Dana).

In contrast, *cursor*y comments were less elaborate and circumstantial, providing quick reference. For example, one participant noted the challenges of classroom modernization, saying:

Well, they’re aware of the issue of the lack of modernization in classrooms, right? They’ve been trying to address that, but they’ve been addressing that while they’ve been tearing down buildings. So now we don’t have enough classrooms (Gabe).

This response illustrates a *cursor*y recollection because it refers to past events without detailed description or personal elaboration.

Table 2 shows the percentage of passages associated with each of the sub-codes. All faculty members' responses contained epistemology consistent with existential or indisputable presumptions. That is not surprising given that existential presumptions are related to beliefs about teaching practice and student ability. Moreover, the percentage of text consistent with *firm* existential presumptions was the highest across all sub-codes once averaged among participants (22. 2%). It was also the most frequently encountered code for over half of the participants (Table 2). Moreover, most of those participants were coded as lecture-oriented (LO) during the first phase of the data analysis. Interview narratives of all participants that were categorized as LO manifested at or above 20% of passages consistent with the existential presumptions *firm* code.

Shaded in grey in Table 2 is the sub-code that was most highly expressed in each participant. Most of the passages were categorized as representing the *firm* existential presumptions sub-code, which characterized their sense of ownership for learning. The episodic storage sub-code, which characterized over-reliance on past experiences in interviews, was frequently found but does not serve as a fair predictor of faculty orientation towards research-based instruction.

Table 2

Passages of Text Coded in Each Category and Sub-Category (Expressed in Percentage)

Broad Codes			Existential			Alternativity		Affective		Episodic Storage	
Sub-codes Percentages			Firm	Fatalistic	Declarative	Convergent	Divergent	Constructive	Skeptical	Detailed	Cursory
Name	Tenure status	LO or ATO*	Percentages								
1. Miles	T	LO	40.6	2.6	1.9	2.4	0.5	8.0	0	9.7	3.5
2. Layne	T	LO	23.5	8.9	1.7	1.3	0	4.7	2.3	4.2	5.0
3. Finley	T	LO	27.6	17.2	0	19.1	2.6	10.2	4.6	9.2	5.6
4. Dana	T	LO	26.2	4.2	2.3	6.3	0	14.3	13.0	65.0	3.6
5. Azariah	T	LO	30.0	3.5	28.1	3.0	0.6	17.2	10.5	13.5	1.5
6. Harper	T	LO	19.3	13.8	0	0	0.2	10.6	3.6	9.9	0.4
7. Emery	NT	ATO	31.2	0.5	0.5	10.2	6.0	23.7	4.1	21.8	0.5
8. Avery	NT	ATO	13.8	12.1	0	8.0	0.9	14.8	9.9	26.8	0
9. Karlo	NT	ATO	12.1	12.5	0	8.6	0	18.1	3.1	12.0	4.3
10. Gabe	NT	ATO	7.9	3.6	1.4	1.4	0	11.9	11.7	21.9	0.9
11. Ashley	T	ATO	12.3	2.8	0.6	20.4	4.6	33.6	14.9	15.2	2.8
Average %			22.2	7.4	3.2	7.3	1.4	15.2	7.0	19.0	2.6

*LO or ATO = lecture-oriented or active teaching-oriented
Note: Because some lines were assigned to multiple emerging sub-codes simultaneously, percentages may not add up to 100 for a given faculty member.

In summary, all LO faculty members (with one exception, Dana) were characterized by their *firm* epistemological statements reflecting their intention to assume ownership for learning outcomes and higher expectations of their students. While Dana was just as high in their expression of ‘firm’ epistemology (26.2%) as the rest of their LO colleagues, *firm* was not the most expressive epistemology for them. The only ATO faculty member who was similarly highest in *firm* epistemology was Emery.

Participation records for biweekly lunch time presentations and discussion around STEM pedagogy show that non-tenured faculty tended to participate more regularly in networking opportunities than did tenured faculty (Table 3).

This suggests that non-tenured faculty are willing to devote time to learn about new active learning pedagogies and to network with colleagues. All of those who did not attend any session were tenured faculty with higher research and service obligations. Only one of the lecture-oriented faculty, Finley (tenured), was a regular attendee, suggesting an openness to the possibility of new teaching approaches. Dovidio et al. (1988) demonstrated that differential power factors influence nonverbal power displays. It could also be that differences in tenure status and ensuing power relations may affect event participation of faculty members. Status differences have been shown to emerge from various sources or dimensions (Thomas-Hunt et al., 2003). In this study, colleagues differ with respect to tenure status and sub-disciplinary affiliation. It is possible that perceived expertise associated with tenure status influences the likelihood of faculty attending networking events (Thomas-Hunt et al., 2003). Whereas the majority of attendees were not tenured, all non-attenders were tenured. Sub-disciplinary affiliation (physics or astronomy) may serve as a tentative explanation for differential attendance of events and socialization, since the majority of the attendees were astronomy faculty (Karlo, Gabe, Avery, Ashley) and the majority of non-attenders were physics colleagues.

Table 3

Faculty Participation in Networking Events Over Several Years

Name	Research Level	Teaching Orientation	Tenure Status	Events Attended	Subdiscipline
Karlo	None	ATO	NT	29	Astronomy
Finley	I	LO	T	27	Physics
Avery	None	ATO	NT	24	Astronomy
Ashley	II	ATO	T	23	Astronomy
Gabe	None	ATO	NT	16	Astronomy
Emery	III	ATO	NT	6	Physics
Layne	II	LO	T	1	Physics
Leslie	I	-	T	1	Physics
Dana	II	LO	T	0	Astronomy
Harper	II	LO	T	0	Physics
Murphy	I	-	T	0	Physics
Azariah	I	LO	T	0	Physics
Miles	I	LO	T	0	Physics

As noted previously, it has been suggested that epistemological beliefs affect individuals’ disposition to engage in knowledge-sharing behavior and networking (Weinberg, 2015). Our analysis of epistemological beliefs showed that tenured faculty advocated for research and lab experiences to

engage students in physics and showed higher representation of *firm* existential beliefs than did non-tenured colleagues. Both findings potentially point to a more fundamental epistemology in tenured faculty relative to the majority of non-tenured members. Given the reciprocal interaction between epistemology and knowledge-sharing behavior, differences in *firm* existential epistemology may differentially influence participation of members and their attendance at networking events. An additional explanation possibly addressing the latter is the time constraint that both tenured and non-tenured members mention in interviews. According to Emery, time constraints are especially true for faculty who are active in research (level I or II) and handle upper major courses. While tenured members with active research are expected to have a higher engagement in cognitive discourse and networking (Jehng et al., 1993; Kienhues et al., 2008; Thomas-Hunt et al., 2003), time constraints may explain lack of engagement in networking events.

Social Network Analysis of Faculty Teaching Relationships

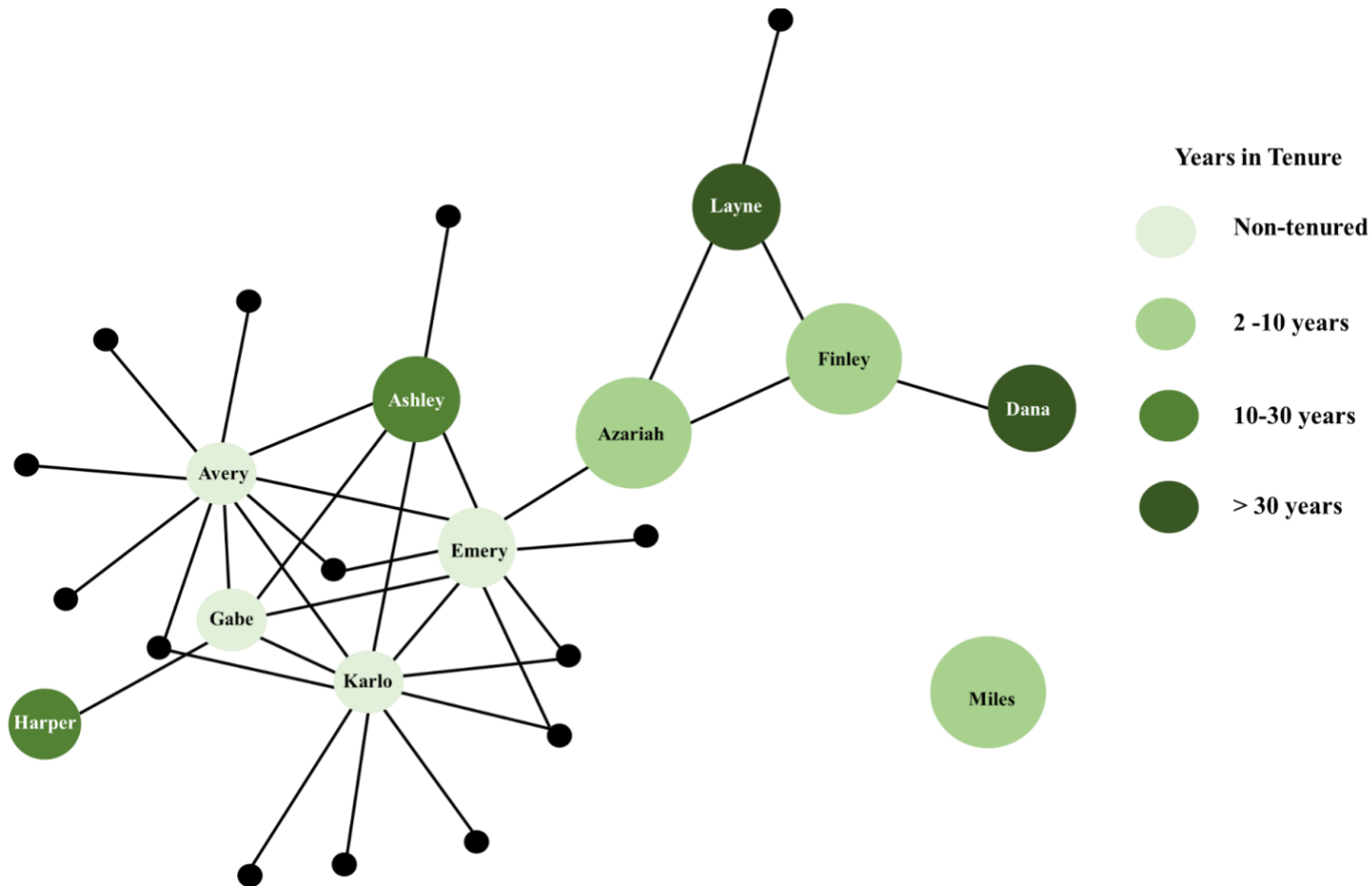
Having established the epistemological orientations of the faculty, we next examine how these orientations align with the structure of the teaching-related social network. Because the goal of this study is to understand the relationship between epistemology and social connectedness, our analytical design treats the qualitative and quantitative components as interdependent rather than parallel. The epistemological profiles provide the interpretive framework for understanding patterns in the centrality measures, and the network metrics, in turn, offer structural context for the epistemological stances. Thus, the analyses that follow reflect an integrated mixed-methods approach in which both datasets are interpreted jointly rather than separately.

Social Network Relationships. The social network in this study (Figure 2) illustrates interactions among faculty members with respect to teaching. Social survey responses provided us with data concerning faculty teaching connections to others in their department as well as with STEM faculty outside of the unit. Using this information, we created a social network graphic (Figure 2) including indicators for the number of years in tenure and research responsibilities. Thus, Karlo, Avery and Gabe are non-tenured faculty with no research responsibilities. Emery is the non-tenured faculty with the research responsibility (hence larger circle size). Small dots in the image are external STEM faculty that have been identified as connections by the faculty of interest in this study, i.e., some faculty also maintain connections to colleagues outside of their department.

Using this graphic, it is possible to visualize the network patterns and to conceive of the avenues through which physics faculty members are engaged in conversations related to innovative teaching pedagogy. For example, Dana, Finley, Layne and Azariah, all categorized as lecture-oriented faculty on the basis of interview data, form a distinct social cluster on the basis of social network survey data, whereas Avery, Karlo, Gabe, Ashley, and Emery, characterized primarily as active teaching-oriented faculty, along with Harper (LO), form a second distinct cluster. Miles was categorized as lecture-oriented but forms a separate and isolated node. We can infer from the configuration that any interaction between these two main clusters likely occurs through Emery; categorized as active teaching-oriented faculty but who shares the higher percentage of *firm* epistemological beliefs common to lecture-oriented colleagues. Since Emery is connected to just one faculty member in the lecture-oriented cluster, any dissemination of active teaching-oriented ideas is entirely dependent on the link between Emery and Azariah.

Figure 2

Teaching Related Social Network in the Physics Department



Note. Circles indicate faculty members within the Physics department, and small dots represent STEM faculty identified as external contacts. Circle size reflects faculty research load (the larger the circle, the heavier research responsibilities). Circle color corresponds to the number of years post-tenure (the darker, the longer).

Measures of Centrality. To examine how well the social network matches epistemological orientation, we measured several centrality parameters for each faculty member (Table 4) namely, degree, betweenness, and eigenvector value. As previously explained (see Methods section) Calculating closeness requires that we sum up all the distances (steps) that separate faculty members and take the inverse of it. However, since Miles is not connected to anyone, that distance is infinity, the inverse of which yields zero, rendering it impossible to use closeness as a measure for the current network.

Table 4

Centrality Measures Reflecting Social Connectedness

Name	Miles	Layne	Finley	Dana	Azariah	Harper	Emery	Avery	Karlo	Gabe	Ashley
Teaching orientation	LO	LO	LO	LO	LO	LO	ATO	ATO	ATO	ATO	ATO
Degree	0	3	3	1	3	1	9	10	10	5	5
Betweenness	0	22	22	0	76	0	122.5	92.5	80	22	22
Eigenvector value	0.00	0.05	0.05	0.01	0.21	0.14	0.97	0.96	1	0.74	0.74

Centrality metrics were interpreted in relation to participants' epistemological orientation, allowing us to examine whether individuals with similar epistemological profiles occupied similar structural positions in the network. The analysis reveals that epistemological orientation is not only correlated with but may shape social network positioning by influencing individuals' engagement in teaching conversations. As can be seen in Table 4, lecture-oriented faculty (Miles, Layne, Finley, Dana, and Harper) holding more *firm* beliefs may be less inclined to form diverse teaching-related connections, thus resulting in lower centrality. Azariah is a lecture-oriented faculty but measures relatively high in betweenness because they influence the information flow between the rest of the lecture-oriented faculty and Emery. Avery, Karlo, Gabe, and Ashley (categorized as active teaching-oriented) have the highest number of ties to faculty within physics and across other STEM departments, as reflected by the highest degree values for all five of them. Three of these faculty (Avery, Karlo, and Emery) also have noticeably high betweenness measures, indicative of their influence on the information flow, as well as high eigenvector values, which signifies that they are more approachable members. This pattern suggests that epistemological stances act as filters or boundaries for social interaction, where openness to alternative teaching methods (reflected in active teaching-oriented epistemologies) facilitates broader network ties and centrality.

Although Emery may not have the highest number of connections of the three social faculty, they possess the highest betweenness value of all faculty members (122.5), marking them as a compelling social influencer. What is particularly interesting about Emery is that while broadly categorized as active teaching-oriented, the epistemological orientation in their interview narrative manifests a high

percentage of *firm* beliefs, a characteristic otherwise observed among lecture-oriented faculty. Their *firm* epistemological beliefs also reflect higher expectations of students who they are convinced benefit from early research experiences. Since epistemology may be one of the sources that influence knowledge-sharing behavior among individuals (Nussbaum & Bendixen, 2003; Weinberg 2015), variation in *firm* existential beliefs may explain differential social measures among faculty. This variation may serve as an explanation for Emery's high betweenness value due to their unique connection to an LO member (Azariah). One plausible explanation for Emery's unique connection to an LO member is their graduate teaching background and current investment in physics education research, which places them in a unique position to suggest viable teaching alternatives to the LO group. Since they are actively engaged in educational research, Emery has dedicated time and resources to the development of course curricula and teaching strategies. Together these create a strong educational and research base from which to interface effectively with both LO and ATO faculty members.

In the last section which follows, we delve deeper into Emery's narrative using passages from their interviews to explain their unique position as a bridge or 'connector' between active teaching oriented and lecture-oriented colleagues in the unit. In contrast, Harper, broadly grouped with lecture-oriented faculty on the basis of their interview text, is not linked to any member of this cluster, but is connected to a single ATO faculty member (Gabe). Notably, epistemological orientation in Harper's interview manifests a lower percentage of *firm* beliefs than is characteristic of lecture-oriented members in general, which may go some way to explain their relative removal from the LO cluster. It appears that individual faculty epistemologies, specifically *firm* existential beliefs, may explain members' affiliation with certain social groups.

Emery's Case and General Discussion

Our research question asked how teaching-related epistemological beliefs of faculty members explain their knowledge-sharing behavior and sociometric values. Prior work supports a relationship between epistemological beliefs and individual engagement in intellectually stimulating environments that provide opportunities for reflection (Jehng et al., 1993; Kienhues et al., 2008; Valanides & Angeli, 2005), suggesting that such beliefs contribute to social interactions among individuals and drive knowledge-sharing behavior (Weinberg et al., 2015). Consequently, to the extent that faculty members differ in their teaching-related epistemological beliefs, they are hypothesized to differ in their likelihood of engaging in social exchange of knowledge related to pedagogy.

In this study, faculty differed in their prioritization of lecture over active teaching methods as a way of engaging students, dividing them into two broad groups of lecture-oriented and active teaching-oriented members. The majority of active teaching-oriented colleagues are non-tenured faculty members with heavy teaching loads, who are interested in employing innovative teaching strategies. Despite the fact that tenured faculty professed their commitment to lecture as the dominant teaching mode, they were more likely to advocate for active research and authentic lab experiences as two settings indispensable for the stimulation of student commitment to, and engagement with, physics. Early experience with research opportunities has been shown to impact STEM student retention, attitudes, and beliefs (Goodwin et al., 2021; Huziak-Clark et al., 2015). For instance, course-based undergraduate research experiences (CURE) provide undergraduates access to early research experiences, generally in psychologically safe class settings. Students who participated in a CURE reported higher levels of authentic learning than did inquiry students, where

software simulations were part of both experiences (Goodwin et al., 2021). In our study, tenured faculty familiar with the learning benefits of mentoring students in their research advocate for such experiences as a vehicle for student engagement and commitment to physics. It may be that mentoring in the context of authentic research experiences further grounds tenured faculty in the structure of the discipline, resulting in a higher expression of fundamental ‘firm’ epistemology and a more nuanced understanding of how to enhance the learning experiences of students (Schommer-Aikins & Hutter, 2002).

Thematic analysis of interviews demonstrates that tenured faculty members were more likely to assume responsibility for student learning outcomes than their non-tenured colleagues, and in return, expected more skills and commitment from majors and non-majors alike. These findings are consistent with prior research confirming that tenured faculty have higher expectations (Umbach, 2007) and may serve as evidence supporting more fundamental epistemology among lecture-oriented tenured faculty. At the same time, sociometric values for lecture-oriented faculty were lower than that for active-teaching oriented members, suggesting that the former are less engaged in interactions than the latter. Since epistemology drives knowledge-sharing behavior (Weinberg et al., 2015), it becomes important to address this dissonance. One possible explanation for the divergence between sociometric values and epistemology is the fact the LO group of faculty has a heavy research load and less time to attend networking events and to engage with colleagues in knowledge-sharing around STEM pedagogy. Non-tenured faculty, on the other hand, have no research load and dedicate virtually all of their time to teaching-related matters. Coincidentally, non-tenured faculty may have a paucity of research experiences that have been proven beneficial for students. The importance of striking a balance between the unique contributions of tenured and non-tenured faculty should be evident. Emery’s case is a telling example of how to balance the countervailing tensions imposed by the time constraints of a heavy teaching load and expertise integrating early authentic research experiences into undergraduate coursework.

Emery represents an interesting case that may provide some insight into how best to navigate this dichotomy. Having been grouped with the active teaching-oriented cluster, and having shared similar sociometric values, they appear also to manifest fundamental ‘firm’ epistemological beliefs typical of the lecture-oriented faculty. In common with the latter, Emery assumes ownership for student learning outcomes, explicitly advocates for early undergraduate research experience as a vehicle for greater student commitment, and has higher expectations of students than do their non-tenured colleagues.

[W]e provide a capstone experience, for example, for the majors to help them get that research experience started early. Have some outcome from it. You either [do] scholarly work, or at least exposure to being part of a research team, to prepare them for that graduate experience (Emery).

Their epistemology, reflected in ‘firm’ existential presumptions, allows them to transcend institutional boundaries imposed by faculty ranks and to exercise agency in collaborating with tenured faculty in designing curricula. Below they describe their interaction with a tenured faculty member (unique link to Azariah) in developing a new course. Emery explained:

I think we have good course offerings for our majors. But ... as a department, we've recognized that there are places we could really improve these courses that are ...being offered and change our curriculum. ...another professor and I went to ... a workshop over the summer, a couple years ago. And one of the courses we were working on ... a

computational physics course for undergraduates to help them get some experience early ... So that we could give them the basics and, ah, so that arose because of conversations we had.

What appears to support Emery's 'firm' existential presumptions is their involvement in physics education research, which in turn, ensures their credibility and status in the research community within the unit (that is, with Azariah, Finley, Layne and Dana). Their commitment to research as a vehicle for student engagement provides them a stronger lead into the lecture-oriented faculty camp. Like the majority of the other non-tenured colleagues, Emery is bounded by institutional limitations imposed by rank (Levin & Shaker, 2011) but appears to be finding a way around these constraints through their own educational research. One of the constraints mentioned by most faculty, regardless of their rank, was lack of time. Emery's involvement in physics education research creates the time and space needed to develop curricula or teaching approaches.

Non-tenured faculty tend to assume a heavy workload of teaching duties (Carvalho & Diogo, 2018), usually at the expense of research opportunities. Heavy workload impacts time and resources available to non-tenured faculty to engage in research on teaching strategies (Kezar, 2013). Additionally, there is little institutional incentive for these faculty members to engage in such work. The bulk of their teaching comprises introductory courses for non-majors, which affects the type of student enrollment (Baldwin & Wawrzynski, 2011). Many students enrolled in these courses consider them a requirement, rather than as offering something useful to learn. It is possible that this commonplace student perception and attitude in turn deters faculty from developing higher student expectations and manifests in lower expression of fundamentally 'firm' existential presumptions. Non-tenured faculty feel that they have little influence over students who do not wish to fully participate in a given course. Moreover, unsupportive institutional and departmental policies toward non-tenured faculty can result in poor curricular design and impact instructor preparation (Kezar, 2013), thereby removing social platforms that can promote discourse and solidarity across faculty ranks (Schwartz, 2017).

Emery's continued involvement in instructional development, driven largely by their research in physics education, may be producing a galvanizing effect which encourages ties with tenured faculty and allows them to serve as a potential bridge between non-tenured and tenured faculty. Additionally, this explanation resonates with Granovetter's (1973) theory supporting boundary-spanning relationships and their effect on the acceptance of alternative strategic choices by actors. Contacts who share the same operating contexts often provide little information different from actors' knowledge base. For instance, Finley and Dana share research-oriented context and their views are likely to resemble each other's. By contrast, Emery operates in both contexts, research-oriented and active teaching, and can provide the insight that is more novel, imparting significant informational influence on research-oriented faculty.

This strategy of enabling individual faculty agency within institutional limitations is supported by Karlo in their final response about engaging non-tenured faculty in research-based instructional development. They suggest reducing teaching loads to facilitate non-tenured faculty involvement in physics education research might support the adoption of research-based instruction by faculty more broadly. Karlo explained:

Yeah, I don't know. It's a tough thing, right? I mean, time is also an issue, right? Trying to maintain a research program and if nothing else. I mean, one way might be course releases or something so that you have a little bit lower teaching load so that you have time to try to

redesign things. Yeah, often you're on the treadmill and there's no time to slow down and recast things.

Why might it be important for non-tenure track faculty to be engaged in educational research when they already show a higher disposition toward using research-based instructional methods? Literature claims that non-tenured faculty function without sufficient autonomy as professionals, which constrains both their agency and professional identity, and reduces their credibility in the research community primarily represented by tenured colleagues (Levin & Shaker, 2011). As a result, they are more likely to perceive themselves as employees and be less committed to the institution (Levin & Shaker, 2011; Ochoa, 2011). It is possible that this lower commitment to the institution manifests as lower ownership for student outcomes as evidenced in their epistemological beliefs. Therefore, it is likely that research engagement of non-tenured faculty, a hallmark of tenured faculty, has the potential to contribute to boundary spanning relationships that unite two previously insular groups in efforts to broaden the implementation of research-based instruction. Ultimately, this approach holds promise for increasing the quality, quantity, scope of knowledge building, and diffusion of research-based instructional strategies at the institutional scale.

Conclusions & Implications

Epistemological and network analysis in one STEM department at a midwestern, research-intensive university, points to the importance of several factors for supporting non-tenured faculty. The analysis grouped faculty into two categories of lecture and active teaching-oriented members. Epistemological analysis elicited faculty respondents' perceptions regarding active learning strategies. While the majority of active learning-oriented colleagues were fully invested in and practicing this approach, lecture-oriented faculty advocated for authentic research as a nuanced path to making learning active and dependable but did not necessarily act on this belief. At the same time, the majority of active-learning colleagues were represented by non-tenured faculty who have greater teaching loads and are more resource limited than the average tenured colleague. Due to their teaching loads non-tenured faculty had no dedicated time to incorporating authentic research and are cut off from the educational research opportunities that facilitate exploration of early student experiences.

It would be fitting if institutional support were adapted to capitalize on the complementary skillsets and interests of tenured (LO) and non-tenured (ATO) faculty. This might entail providing non-tenured faculty with resources to work on curriculum and teaching strategies at a research level and recognizing the value of this expertise. At first glance this may appear to contradict the primary roles and responsibilities of the faculty ranks, blurring lines within the unit. However, many non-tenured faculty are already early adopters of cutting-edge pedagogies simply because of their stronger commitment to teaching, thus such a move might require little more than formalizing this function and minor adjustments in course loads. To the extent that institutional support provides LO and ATO faculty opportunity for intuitive reflection based on experience, these divergent epistemologies can combine to create an optimal solution for STEM teaching and student learning. While this study offers important insights, several limitations should be noted. The sample is drawn from a single STEM department at one institution, which may limit the generalizability of the findings to other settings. Additionally, social network data rely on self-reported connections, which could miss informal or unrecognized teaching interactions. The cross-sectional nature of the data captures a snapshot in time, limiting our ability to observe changes in faculty epistemologies or network positions over time. Finally, although the mixed-methods design integrates qualitative and

quantitative data, further methodological refinement could deepen understanding of the causal relationships between epistemological orientations and social network roles.

Building on these findings, future research could pursue several avenues to deepen understanding and enhance institutional support for STEM faculty. First, expanding the study across multiple STEM departments or institutions would enable examination of whether the observed patterns of epistemological beliefs, teaching practices, and network positions hold across diverse contexts. Second, longitudinal research could investigate how faculty beliefs and engagement with research-based instructional strategies evolve over time, particularly as non-tenured faculty gain experience or benefit from institutional resources. Third, intervention-based studies could assess the impact of targeted supports—such as dedicated time for curriculum development, teaching-focused resources, or mentorship programs—on fostering collaboration between lecture-oriented (LO) and active teaching-oriented (ATO) faculty. Finally, further investigation into how epistemological differences shape the diffusion of teaching innovations could inform strategies to optimize faculty networks, promoting equitable teaching practices and improved student outcomes. Together, these directions position the present study as a starting point for broader inquiries into the interplay between epistemology, social networks, and instructional change across diverse disciplinary settings.

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References

- Baldwin, R. G., & Wawrzynski, M. R. (2011). Contingent faculty as teachers: What we know; what we need to know. *American Behavioral Scientist*, 55(11), 1485-1509.

- Bonacich, P. (1987). Power and centrality: A family of measures. *American Journal of Sociology*, 92(5), 1170-1182.
- Carolan, B. V. (2013). *Social network analysis and education: Theory, methods & applications*. SAGE.
- Carvalho, T., & Diogo, S. (2018). Non-tenured teachers, higher education. *Encyclopedia of international higher education systems and institutions*, 1-5.
- Cucciarre, C. (2020). Non-Essential: Adjuncting During COVID-19. *Writing Program Administration*, 44(1), 156-162.
- De Vries, R. E., Van den Hooff, B., & De Ridder, J. A. (2006). Explaining knowledge sharing: The role of team communication styles, job satisfaction, and performance beliefs. *Communication Research*, 33(2), 115-135.
- Daniels, E. (2014). *Biology teachers' perceptions of satisfaction: The mediating effects of workplace conditions and epistemological beliefs* [Doctoral dissertation, University of Maryland]. Digital Repository at the University of Maryland. <https://drum.lib.umd.edu/items/4b75d39b-b35f-442c-a4d2-491853eee40a>
- Dovidio, J. F., Ellyson, S. L., Keating, C. F., Heltman, K., & Brown, C. E. (1988). The relationship of social power to visual displays of dominance between men and women. *Journal of Personality and Social Psychology*, 54(2), 233-234.
- Emerson, R. M. (1976). Social exchange theory. In A. Inkeles, J. Coleman, & N. Smelser (Eds.), *Annual Review of Sociology*, Vol 2 (pp. 335-362) Annual Reviews.
- Freeman, L. C. (1977). A set of measures of centrality based on betweenness. *Sociometry*, 35-41.
- Freeman, L. C., Roeder, D., & Mulholland, R. R. (1979). Centrality in social networks: II. Experimental results. *Social Networks*, 2(2), 119-141.
- Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410-8415.
- Geletkanycz, M. A., & Hambrick, D. C. (1997). The external ties of top executives: Implications for strategic choice and performance. *Administrative Science Quarterly*, 654-681.
- Glaser, B. (1992). *Basics of grounded theory analysis*. Sociology Press.
- Goodwin, E. C., Anokhin, V., Gray, M. J., Zajic, D. E., Podrabsky, J. E., & Shortlidge, E. E. (2021). Is this science? Students' experiences of failure make a research-based course feel authentic. *CBE—Life Sciences Education*, 20(1), article 10.
- Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology*, 78: 1360-1380.

- Huziak-Clark, T., Sondergeld, T., van Staaden, M., Knaggs, C., & Bullerjahn, A. (2015). Assessing the impact of a Research-Based STEM program on STEM majors' attitudes and beliefs. *School Science and Mathematics, 115*(5), 226-236.
- Jehng, J. C. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology, 18*(1), 23-35.
- Kezar, A. (2013). Examining non-tenure track faculty perceptions of how departmental policies and practices shape their performance and ability to create student learning at four-year institutions. *Research in Higher Education, 54*, 571-598.
- Kezar, A. (2014). Higher education change and social networks: A review of research. *The Journal of Higher Education, 85*(1), 91-125.
- Kienhues, D., Bromme, R., & Stahl, E. (2008). Changing epistemological beliefs: The unexpected impact of a short-term intervention. *British Journal of Educational Psychology, 78*(4), 545-565.
- Kreber, C., & Castleden, H. (2009). Reflection on teaching and epistemological structure: Reflective and critically reflective processes in 'pure/soft' and 'pure/hard' fields. *Higher Education, 57*, 509-531.
- Levin, J. S., & Shaker, G. G. (2011). The hybrid and dualistic identity of full-time non-tenure-track faculty. *American Behavioral Scientist, 55*(11), 1461-1484.
- McKay, V. C., & Rozee, P. D. (2004). Characteristics of faculty who adopt community service learning pedagogy. *Michigan Journal of Community Service Learning, 10*(2), 21-33.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. SAGE.
- Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317-328.
- Nussbaum, E. M., & Bendixen, L. D. (2003). Approaching and avoiding arguments: The role of epistemological beliefs, need for cognition, and extraverted personality traits. *Contemporary Educational Psychology, 28*(4), 573-595.
- Ochoa, A. (2011). Contingent faculty: Helping or harming students. *The Journal of the Professorsiate, 6*(1), 136-151.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.
- Prince, M., Borrego, M., Henderson, C., Cutler, S., & Froyd, J. (2013). Use of research-based instructional strategies in core chemical engineering courses. *Chemical Engineering Education, 47*(1), 27-37.

- Raubenheimer, C. D. (2004). *Cases of university faculty conceptions and practices of teaching, assessment and action research* [Doctoral dissertation, University of Louisville]. ThinkIR: The University of Louisville's Institutional Repository. "Cases of university faculty conceptions and practices of teaching, ass" by Carol Dianne Raubenheimer 1959-
- Rogers, E. M. (1995). Lessons for guidelines from the diffusion of innovations. *The Joint Commission Journal on Quality Improvement*, 21(7), 324-328.
- Schommer-Aikins, M., & Hutter, R. (2002). Epistemological beliefs and thinking about everyday controversial issues. *The Journal of Psychology*, 136(1), 5-20.
- Schwartz, J. M. (2017). Resisting the exploitation of contingent faculty labor in the neoliberal university: The challenge of building solidarity between tenured and non-tenured faculty. In S. F. Schram (Ed.), *Neoliberalizing the University: Implications for American Democracy* (pp. 92-110). Routledge.
- Thomas-Hunt, M. C., Ogden, T. Y., & Neale, M. A. (2003). Who's really sharing? Effects of social and expert status on knowledge exchange within groups. *Management Science*, 49(4), 464-477.
- Umbach, P. D. (2007). How effective are they? Exploring the impact of contingent faculty on undergraduate education. *The Review of Higher Education*, 30(2), 91-123.
- Valanides, N., & Angeli, C. (2005). Effects of instruction on changes in epistemological beliefs. *Contemporary Educational Psychology*, 30(3), 314-330.
- van Staaden, M.J., & Raubenheimer, C.D. (2015, October, 15). *Uncorking the Bottleneck: Measuring Fidelity of Research Based Instructional Strategies* [presentation]. International Society for Exploring Teaching and Learning (ISETL), Savannah, GA.
- Weinberg, F. J. (2015). Epistemological beliefs and knowledge sharing in work teams: A new model and research questions. *The Learning Organization*, 22(1), 40-57.
- Wong, K. Y., Chan, K. W., & Lai, P. Y. (2009). Revisiting the Relationships of Epistemological Beliefs and Conceptions about Teaching and Learning of Pre-Service Teachers in Hong Kong. *Asia-Pacific Education Researcher*, 18(1).