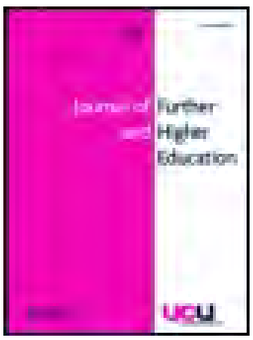

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Exploring college faculty development in 21st-century skill instruction: an analysis of teaching-focused personal networks

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ABSTRACT

While educators and policymakers increasingly link the '21st-century' skills of communication, teamwork, problem-solving, and self-directed learning to graduate success in important high-technology industries, few studies look at how technological college faculty – who are expected to help instil these important skills in students – learn to better teach such skills. Faculty development research shows that feedback- and reflection-oriented social learning improves instruction, but has not typically investigated the full scope of beneficial teaching-focused interactions, formal and informal, in which faculty engage. Using a social network perspective, which focuses on the empirical contours of relationships across settings, this mixed methods study explores (1) the people with whom technological faculty discuss teaching, referred to as 'teaching-focused personal networks;' (2) the comparative contours of these networks by faculty development involvement, teaching experience, institution type, and discipline; and (3) how, if at all, faculty believe these networks influence their communication, teamwork, problem-solving, and self-directed learning instruction. Survey data (n = 192) indicate that most respondents discuss teaching with a core personal network of about four contacts, commonly institutional colleagues, around once a month. Data also show that network size, diversity, and strength – measures connected to actionable, relationship-based information and support, or 'social capital' – are broadly similar among faculty of varying subgroups, with one exception: respondents reporting involvement in in-depth faculty development programming have larger and stronger networks. Qualitative results show that most faculty reporting teaching-focused personal networks perceived them to benefit their teaching of communication, teamwork, problem-solving, or self-directed learning through support, reflection, feedback, and sharing new ideas.

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Faculty development; 21st-century skills; social networks; teaching-focused relationships

Introduction

While college instruction in technological disciplines has traditionally focused on technical skills, in recent years – and in response to rapid changes in the world of work (e.g. Levy and Murnane 2004) – educators, employers, and policymakers internationally have increasingly emphasised the benefits of *21st-century skills* (National Research Council 2012; Williams 2005) to attainment in important high-technology industries (e.g. Bailey and Stefaniak 1999; Bourn and Neal 2008; Darling and Dannels 2003; Hecker 2005). Sometimes referred to as 'soft' (Andrews and Higson 2008) or 'noncognitive' skills (Heckman and Rubinstein 2001), interpersonal and self-regulatory competencies like communication, teamwork, problem-solving, and self-directed learning have come to be

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associated not only with high quality workforce development around the world, but also with successful college to work transitions (e.g. Benbow and Hora 2018). Despite the presumed importance of 21st-century skills to graduate success, however, we know little about *how* college faculty learn to better teach these skills, especially in disciplines traditionally centred on technical skills and knowledge. This paper investigates faculty development in this regard through a novel lens: teaching-focused personal networks.

In a highly decentralised American college environment where faculty in technological disciplines have little formal nor mandatory 'in-depth' teacher training – defined here as purposeful, hands-on, teaching-focused professional development activities lasting two or more days (Henderson, Beach, and Finkelstein 2011; Stolzenberg et al. 2019) – the concept of social learning offers an advantageous perspective. Springing from studies in precollege contexts, research shows that teacher relationships are important to professional development (e.g. Little 1982). In higher education, studies focusing on organised, collaborative learning activities help scholars better understand how faculty can learn from social interactions bringing faculty together to discuss instruction (e.g. McDonald and Cater-Steel 2016). Similarly, work looking at private, informal interactions has provided clues into how teaching-focused discussions can provide the reflection, feedback, and support faculty need to refine practice (e.g. Knight, Tait, and Yorke 2006). Still, little research focuses on how faculty social learning *across* formal and informal settings – encompassing the range of daily faculty experiences from organised professional development activities to hallway discussions – associates with instruction, let alone 21st-century skills instruction. We contend that a more detailed understanding of the broad scope of faculty teaching-focused relationships can help illuminate, and improve, this unique and significant aspect of faculty development, a continuing goal of scholars and practitioners internationally. This expanded perspective also is particularly useful in the American context, where formal faculty development is less often utilised compared to systems in British Commonwealth and northern European countries (e.g. Fink 2013).

Social network analysis, a research perspective studying relationships or 'social ties' to understand their influence on action (Wasserman and Faust 1994), provides a strong empirical and theoretical foundation for this kind of study. Using analyses of who educators talk to about teaching as well as the characteristics of these relationships, years of network research indicates that certain patterns among teaching-focused networks can lead to improved self-efficacy, job satisfaction, and student performance (e.g. Moolenaar 2012). While scholars have investigated networks within faculty development activities (e.g. Baker-Doyle and Yoon 2011), few have investigated and documented teaching-focused discussions among college faculty wherever these discussions might take place (Pataraia et al. 2015; Roxå and Mårtensson 2009; Van Waes et al. 2015, 2016), whether inside or outside formal programming, to better understand the full breadth of faculty social learning opportunities. Further, to our knowledge no studies have used social network analysis to explore how such interactions may relate to 21st-century skill instruction. Considering the myriad links between faculty social learning and improved practice, and the importance of 21st-century skills to future technological graduates (e.g. NRC 2012), the lack of research in this area presents a unique opportunity.

With these gaps in mind, this mixed-methods social network study explores teaching-focused social ties, groups of which we refer to as 'teaching-focused personal networks,' among faculty (n = 192) in two-year and four-year colleges in the US states of Wisconsin and New York.[1] We focus specifically on faculty respondents in technological disciplines, defined as those teaching students to enter important 'high-technology industries' with an elevated proportion of occupations demanding scientific, engineering, and technology knowledge (Hecker 2005; National Science Foundation 2014), in which 21st-century skills are seen as increasingly valuable (e.g., Bourn and Neal 2008; National Science Board 2018). We investigate three research questions:

RQ1: Do college faculty in technological disciplines discuss methods for teaching students important skills and, if so, with whom and how often?

RQ2: How do these teaching-focused personal networks compare among faculty subgroups regarding significant characteristics – specifically faculty development involvement, teaching experience, institution type, and discipline – linked to professional practice?

RQ3: Do college faculty perceive teaching-focused personal networks to be beneficial to their instruction of the 21st-century skills of communication, teamwork, problem-solving, and self-directed learning and, if so, how?

We begin here by outlining the wider context of this study and the specific 21st-century skills on which we focus. Next we describe faculty social learning, social networks in higher education, then the theory of 'social capital' (Lin 2001) that frames our study.

21st-century skills in high-technology industries

With globalisation and the rapid pace of scientific development changing international workforce dynamics, analysts have long recognised that academic and workplace success is not based on technical acumen alone (Dearing 1997; US Department of Labor 1991). Indeed, *intra-* and *interpersonal* skills, defined as the capacity to self-regulate and express and interpret messages to and from others (National Research Council 2012, 32–34), have been linked to a host of positive personal and professional outcomes (e.g. Heckman and Rubinstein 2001). Levy and Murnane (2004), for instance, underlined the growing importance of essential *human* workforce skills including 'expert thinking,' defined as the ability to use knowledge to identify and solve new kinds of problems, and 'complex communication,' defined as the skill to exchange complicated information with diverse colleagues. Despite considerable critique, in recent years these and other '21st-century' skills – named for their importance in the 21st-century's knowledge economy (e.g. Williams 2005) – have served as a foundation both for wide-ranging curricular and policy reforms in higher education as well as an international narrative focused on instilling so-called 'employability' skills in students (Benbow and Hora 2018; Andrews and Higson 2008).

While several competencies have garnered attention, research on the 21st-century skills faculty and employers see as most valuable – particularly in the kinds of technological occupations viewed as a cornerstone of prosperity in the new economy (NSB 2018) – underlines four competencies we focus on herein. *Communication*, both oral and written, has been shown to be crucial for work in engineering and IT (e.g. Darling and Dannels 2003), where professionals need to relay important information through reports and interpersonal meetings and presentations. *Teamwork*, or the ability to work well with others, similarly improves workplace efficiency, facilitates creativity, and allows specialists to pool intellectual resources (e.g., Bailey and Stefaniak 1999). Additionally, technological work demands *problem-solving* skills involving the ability to imaginatively and accurately analyse, and find solutions to, ill-defined workplace problems (Jonassen, Strobel, and Lee 2006). Finally, *self-directed learning* skills, or the motivation to take responsibility for one's own learning, are crucial to just-in-time training interventions and the constant skill and knowledge improvements needed in contemporary technological occupations (Muench 2006). Indeed, these skills are now important enough that engineering and technology regulation boards around the world require development in all four areas for accreditation (e.g. Accreditation Board for Engineering and Technology 2018; Engineering Council 2014).

Faculty social learning and development

But how do faculty cultivate these skills, particularly in disciplines where technical skills and content knowledge have traditionally been central to teaching and learning? Regardless of discipline, research indicates that student-centred instructional methods allowing interactive, hands-on engagement are most beneficial to the transfer of knowledge (Henderson, Beach, and Finkelstein 2011). Bridging the research-to-practice divide and improving undergraduate instruction, however, requires sustained pedagogical development in these methods that fosters trust, a long-term view of

teaching progression, and, most importantly, peer-based social learning (Postareff, Lindblom-Ylänne, and Nevgi 2008; Sunal et al. 2001). Formal faculty development offerings vary widely across institutions and teaching positions in the US, but teaching-related faculty development is typically neither mandatory nor widely utilised among US faculty compared to those internationally (Fink 2013), often because of tightening budgets and various departmental, institutional, and disciplinary disincentives to spending too much time on teaching (e.g. Brownell and Tanner 2012). Faculty in technological disciplines, in particular, are often hesitant to take part in the kinds of focused, in-depth programmes shown to be most effective (Brownell and Tanner 2012; Henderson, Beach, and Finkelstein 2011).

Still, the benefits of faculty social learning to professional practice have been well established, especially interactions in which instructors are able to discuss teaching in an open and supportive environment (Knight, Tait, and Yorke 2006; Postareff, Lindblom-Ylänne, and Nevgi 2008). Research indicates that interactive group consultations, including 'communities of practice' (McDonald and Cater-Steel 2016), foster faculty development in part through engaged *reflection* in which discussion partners purposefully consider past experiences so they can continually learn (e.g. Schön 1983). As has been shown among science and technology faculty, the discussions encouraged by these kinds of interactions help instructors think critically about their teaching, enhance their understanding of their subject matter, and iteratively improve methods that can boost student engagement (Sunal et al. 2001). Whether collaborative development efforts involve expert facilitators, which is most typical of US activities, or come in the form of self-directed group initiatives, feedback and reflection have been shown to be key to instructional change (Henderson, Beach, and Finkelstein 2011; Postareff, Lindblom-Ylänne, and Nevgi 2008).

While most research focuses on formal social learning interventions, informal faculty interactions have also been shown to facilitate valuable teaching-focused feedback and reflection. Pifer, Baker, and Lunsford (2015), focusing on informal faculty interactions at the department level, demonstrated that local support and collaboration provided an important venue for continuing teaching development. Rienties and Kinchin (2014), similarly, showed that the informal teaching-focused relationships faculty participants developed outside an intensive teaching programme provided significant support and learning. Still, few other studies simultaneously investigate such informal exchanges and formal activities to better understand the true scope of faculty social learning, especially in regards to teaching 21st-century skills. Next we discuss a methodological perspective that allows for precisely this kind of investigation.

Social network analysis and teaching-focused personal networks

Social network analysis is based on three postulates: (1) actors and the actions they take depend on one another; (2) social ties between individuals, compilations of which are called 'social networks,' act as a conduit for resources; and (3) the social networks in which individuals are nested both constrain and support their actions (Wasserman and Faust 1994, 4). Operating from these premises, 'personal' network studies focus on distinct networks of contacts around individuals that span geographic or organisational boundaries. Personal network studies typically rely on precise data gathered from respondents regarding how many people they speak to about certain topics (*network size*), the heterogeneity of their contacts (*diversity*), and how often they speak with contacts (*tie strength*). This perspective, which informs this study, allows researchers to gather fixed data on interactions across a variety of formal and informal contexts, wherever they occur and as respondents feel they are influential (e.g. Crossley et al. 2015).

The network perspective has pushed the study of precollege teacher social learning forward in a number of ways. Findings indicate that social ties among teachers shape how much valuable information, knowledge, and advice is available to them (e.g. Moolenaar 2012) which ultimately can lead to higher student achievement (e.g. Pil and Leana 2009). Only a handful of studies have investigated the influence of teaching-focused networks on faculty development, but existing work still provides an informative perspective on teaching-focused interactions. One of the earliest

network studies focusing on informal discussions, Roxå and Mårtensson (2009), used data on social ties to illuminate the many ways faculty – typically engaging with a few significant others through reflective exchanges in 'backstage' locales like hallways or break rooms – obtain valuable advice and support that can lead to instructional growth. More recent work has confirmed these findings. Pataraia et al. (2015) found that a prevalence of diverse relationships reinforced instructional learning and classroom practice. Van Waes et al. (2015), 2016), exploring the structure, quality, and instructional value of teaching-focused ties, found that personal network formation is often associated with better teaching, with 'experienced experts' often having stronger and more diverse social ties.

Still, more basic, descriptive studies documenting the empirical contours of teaching-focused personal networks among larger numbers of faculty – across formal *and* informal faculty development boundaries – can add to the existing knowledge base. So too can analyses centred on the influence of faculty networks on 21st-century skills instruction among those who teach in important technological disciplines. With these needs in mind, we next describe how we conceptually ground the precision and flexibility social network analysis brings to these issues.

Social capital and network theory: measuring beneficial personal networks

Our formulisation of faculty teaching-focused personal networks is based on the theory of *social capital*, defined as beneficial, actionable resources invested in, and accessed, through social ties (Lin 2001). Lin's (2001) articulation of the concept, which has been used widely in education research since its introduction, envisions social capital as embedded in personal social networks and flowing through social ties. Lin (2001) maintained that social capital can come in many forms, whether through financial assistance, a tip on a job opening, or, most importantly for our purposes, another person's insight regarding the effectiveness of a particular teaching method. Such resources are not 'owned' in the traditional sense, though. Instead, they are accessed by individuals who, after cultivating (or 'investing' in) relationships, eventually use them to accrue benefits ('capital') to gain personal or professional advantage.

While social capital allows individuals to gain knowledge or develop practices that can be beneficial, it is unequally distributed from individual to individual (Bourdieu 1986). Indeed, according to Lin (2001), the flow of beneficial knowledge or support between friends, family members, or colleagues – which we focus on here in regard to 21st-century skill instruction – depends on a causal process. This process begins with an individual's social position and broader norms, which allow one to invest in, and develop, potentially useful ties (see Benbow and Lee 2019). If valuable, these ties allow one to access and mobilise social resources that can lead to 'returns' on the social investment one put into developing those relationships in the first place. A model of this social capital development process is displayed in Figure 1.

But what relationship characteristics can make social ties valuable or not? Because Lin (2001) thoroughly integrates his theory of social capital with empirical network research (pp. 76–77), we can

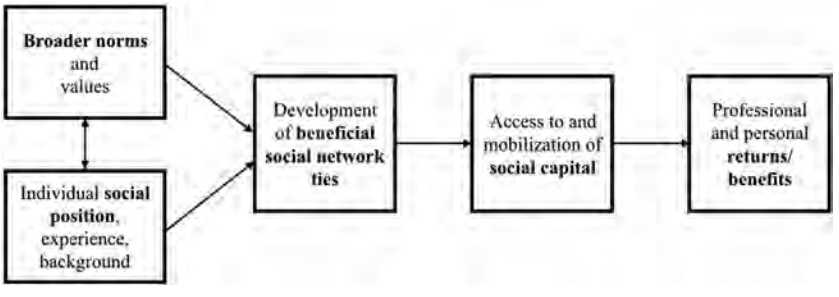

Figure 1. Modelling the personal network development of social capital (Lin 2001, 246).

operationalise these concepts using specific, observable personal network measures shown both in the social network literature (e.g. Coburn and Russell 2008) and the nascent network-oriented faculty development literature (Pataraia et al. 2015; Roxå and Mårtensson 2009; Van Waes et al. 2015) to allow access to beneficial information, support, and advice. Here we utilise three simple, oft-used measures the literature has outlined as important to professional development.

Network size

Network size, or the number of contacts in an individual's personal network, positively associates with greater levels of knowledge-sharing in the workplace as well as increased instructional expertise among faculty (Van Waes et al. 2015). Lin (2001) has pointed to network size, specifically, as a strong marker of advantage or disadvantage because greater numbers of personal network ties often translate into increased access to original information and resources from more contexts.

Network diversity

Network *diversity*, the second indicator, refers to whether individuals discuss teaching practices with people similar to themselves. Previous research suggests that faculty benefit from teaching-focused contacts who can help them see issues from different perspectives (Pataraia et al. 2015). After his review of empirical network research, Lin (2001), similarly, concludes that contact diversity increases the richness and variability of information and advice one receives through social ties, allowing one to gain resources from more social locations (p. 58).

Tie strength

Studies also show that higher network *tie strength*, represented here by how often one speaks with members of her social network, relates to the more efficient exchange of complex, nonroutine information in educational contexts (Coburn and Russell 2008) as well as trust and better collaboration among faculty (Pataraia et al. 2015). Conversely, stronger ties have also been shown to represent greater network overlaps among respondents and their contacts, which can limit access to new information (Granovetter 1973).

Methods

We answer our research questions using a convergent mixed methods survey approach (Creswell 2014) in which quantitative and qualitative data were collected through an online questionnaire. Specifically, data and text come from technological faculty teaching in two specific, prominent 'high-technology' industries: advanced manufacturing and information technology (Hecker 2005; NSF 2014). We chose to collect faculty data in Wisconsin and New York states based on research team members' proximity to these locations as well as the availability of adequate numbers of advanced manufacturing and information technology college programs and businesses in both states.

This particular study was overseen by the three authors, all of whom had up-to-date human subject training and certification. All research procedures, which were designed to ethically ensure data quality and participant informed consent and confidentiality, were vetted and approved through our university's local institutional human subjects review board before the study commenced.

Sampling

We utilised a purposeful, nonprobability sampling approach to recruit respondents and collect data. To focus on faculty teaching students to enter the advanced manufacturing and information technology industries, we began by identifying populous advanced manufacturing and information technology occupations using 'metropolitan statistical area' data showing occupation employment numbers in Wisconsin and New York towns and cities (US Bureau of Labor Statistics 2016). Looking

through these lists, we used US Census Bureau (2016) and NSF (2014) data to check whether each occupation was clustered within advanced manufacturing or information technology industries. If occupations were clustered in one of the industries, we used occupation profiles (Occupational Information Network 2016) to examine whether the skills and educational credentials needed to perform these jobs were within high-technology parameters (needing scientific, engineering, and technology-related knowledge) and demanded associate- ('two-year') or bachelor-level ('four-year') college degrees (Hecker 2005). Through cross referencing, we identified several populous technological occupations in each of the focal industries, including industrial machinery mechanics and electrical and mechanical engineers in advanced manufacturing, and computer user support specialists, programmers, and computer systems analysts in information technology.

After identifying these occupations, we reverse searched O*Net (2016) to obtain lists of college programs in each state educating students to enter the focal occupations, then gathered the addresses of all teachers of record – including all tenure- and non-tenure track instructors and part-time lecturers – in these programs from public websites. Following evidence-based survey recruitment techniques meant to reduce refusals but ensure data quality (Dykema et al. 2013; Edwards et al. 2009), researchers mailed letters with 2 USD incentives and personalised survey URLs to these 763 faculty members across Wisconsin and New York in November 2016. A total of 192 educators from 17 higher educational institutions completed the survey (response rate = 25.16%). Though this response rate limits our ability to generalise beyond the sample, it nevertheless allows for a rich exploration of faculty networks and 21st-century skill instruction. Descriptive statistics are displayed in Table 1.

Instrument

Online surveys included a subsection gathering measures for the size, diversity, and strength of each respondent's teaching-focused personal network, fundamental network indicators associated with the accrual of beneficial social capital (Lin 2001). Items adhered to conventional personal network data collection techniques allowing respondents to outline their own social ties – whether they take place in formal or informal settings, within or outside their institutions, or with colleagues, friends, or

Table 1. Descriptive statistics for the faculty survey sample.

Measure	N	%	SD
Gender			
Female	29	16	0.42
Male	147	83	
Transgender	2	1	
Race			
White Faculty	142	80	0.40
Faculty of Color	36	20	
Teaching Experience			
≤ 10 years	62	32	0.47
> 10 years	121	63	
Faculty Development			
No In-Depth Activities	64	33	0.65
≥ One In-Depth Activity	120	63	
Discipline			
Advanced Manufacturing	69	36	0.48
Information Technology	123	64	
State			
Wisconsin	129	67	0.47
New York	63	33	
Institution Type			
Two-year	32	17	0.37
Four-year	160	83	

family – based on their own perceptions of the content and influence of these relationships (Crossley et al. 2015).

As our investigation was only one part of a larger study, it was necessary to limit items to only the questions that were absolutely necessary to construct size, diversity, and tie strength measures for each faculty member's teaching-focused personal network. We began with a two-part question adapted from Burt's (1984) 'important discussions' prompt meant to elicit people with whom faculty discussed instruction. Respondents first answered, with a yes or no, this question: 'From time to time, educators discuss with others what methods or techniques they can use to better teach their students important skills. Looking back over the last year, is there anyone with whom you have discussed this matter?' Those answering 'yes' were directed to this question: 'Please type in the first names or initials of up to six people with whom you have discussed methods or techniques you can use to better teach your students important skills over the last year.' With a range of 0–6, the number of discussion partners listed here represents our *network size* measure (Freeman, Roeder, and Mulholland 1979). This item limited respondents to six contacts both in following Roxå and Mårtensson's (2009) contention that faculty teaching-focused personal networks are typically limited to just 'a few significant others' (p. 214) and to reduce respondent burden, a common problem in social network studies (e.g. Burt 1984).

Next, respondents who listed discussion contacts were asked to describe each contact's organisational affiliation, a common indicator of a contact's similarity or dissimilarity to the respondent (e.g. Baker-Doyle and Yoon 2011) that we use to measure *network diversity*. A dropdown list for each listed contact allowed respondents to choose whether the contact was affiliated with their own institution or an outside organisation based on North American Industry Classification System codes (US Census Bureau 2016). Next, respondents were asked to report how frequently they communicated with each listed contact over the previous year on a four-point scale with 1 = less than once a month, 2 = at least once a month, 3 = at least once a week, and 4 = almost every day, a common measure for *tie strength* (Burt 1984). The last item of the section asked for an open-ended text response to this question: 'How, if at all, do you think your relationships with these people have influenced your methods or techniques for teaching your students communication, teamwork, problem-solving, or self-directed learning skills?'

We also gathered data on several factors associated with college faculty social learning in the literature including faculty development involvement (Henderson, Beach, and Finkelstein 2011), teaching experience (Benbow and Lee 2019), institution type (e.g. Wright et al. 2004), and faculty discipline (Becher 1994). Information on *faculty development* participation was collected through a survey item asking respondents to estimate the number of times they had participated in 'talks or presentations about teaching,' 'brief workshops or conferences on teaching lasting less than one day,' 'in-depth workshops or conferences on teaching lasting more than one day,' and 'formal courses on teaching lasting for an entire semester or quarter' during the last five years. *Teaching experience* measures come from an item asking how many years respondents had been teaching in college, while faculty *institution type* and *discipline* data were gathered from publicly available information.

Analysis

RQ1: Do college faculty in technological disciplines discuss methods for teaching students important skills and, if so, with whom and how often?

RQ2: How do teaching-focused personal networks compare among important faculty subgroups?

To answer RQ1 and RQ2 we compiled statistics describing and comparing network size, diversity, and strength indicators among all faculty as well as dichotomous faculty subgroups demarcated by

involvement in faculty development, teaching experience, institution type, and discipline. We then utilised T-tests to compare personal network measures within subgroups to explore whether salient distinctions from the literature associate with access to teaching-focused social capital.

The first personal network measure, an indicator of network existence called 'Yes to Contacts,' is a dummy measure indicating whether respondents reported discussing teaching important skills. The next two rows show *network size* measures, the first using the mean number of contacts listed across all respondents and the second representing contacts only among those reporting personal networks. We created *network diversity* indicators by reporting the mean percentage of listed contacts in each faculty subgroup from (1) outside respondents' colleges and (2) outside education altogether. For *tie strength*, we measure how often respondents reported speaking to teaching-focused discussion contacts, averaging frequency scores in each subgroup. The variable for formal *faculty development* involvement included those who reported participating in at least one 'in-depth' faculty development activity shown to be more effective in the literature (Henderson, Beach, and Finkelstein 2011) – including workshops/conferences lasting more than one day or formal courses lasting a quarter or semester – and those who did not report participating in an in-depth program. The *teaching experience* variable included those who had taught for 10 years or less and those who had taught over 10 years, based on literature that shows 10 years' full-time engagement to be a strong marker separating beginners and experts in professional fields (Ericsson 2006). *Institution type* data was separated into whether faculty taught in an associate's granting ('two-year') or bachelor's granting institution ('four-year'), and our *discipline* measure was based on whether faculty were teaching in programs sending students into advanced manufacturing- or information technology-related occupations (O*Net 2016).

RQ3: Do college faculty perceive teaching-focused personal networks to be beneficial to their instruction in communication, teamwork, problem-solving, and self-directed learning and, if so, how?

To speak to RQ3, we collected all text responses to the survey's open-ended question and counted how many respondents clearly indicated that their social ties positively influenced their teaching of the four 21st-century skills. Those not answering the question and those answering that discussions did not influence their teaching were grouped together. To answer the second part of RQ3, we analysed responses using inductive thematic coding. We first applied open coding procedures to all responses, assigning short one- or two-word descriptors to text fragments. Next, we went back through all responses and attendant descriptors and applied the constant comparative method, redefining and combining open codes into broader categories based on similarity and renaming emergent categories to include newly combined text (Saldaña 2015). Using the list of larger groups produced by this process, we applied second cycle methods based on repetition among respondents, researcher reflective memoing, the association of emergent categories with our research questions and social capital framework, and 'code mapping' to further organise and give structure to thematically common groups (Saldaña 2015). These methods ultimately allowed us to distil data into five themes speaking to how faculty viewed their teaching-focused personal network discussions – and the social capital to which these discussions allowed access – influencing communication, teamwork, problem-solving, and self-directed learning instruction.

Limitations

Findings should be interpreted with a few limitations in mind. First, while lower cost web-based social network data collection methods have yielded important scholarly insights (see Perry, Pescosolido, and Borgatti 2018, 49–51), experts agree that interviews provide higher quality personal network data. Second, because we needed to limit social network survey items to reduce respondent burden, we could not collect more advanced network measures or qualitative data in our analysis. Similarly, though we collected data on open-ended faculty perceptions regarding the influence of teaching-focused personal networks on instruction, these data do not allow us to specify whether reported conversations

took place inside or outside formal faculty development activities nor to accurately calculate what portion of discussions were focused specifically on our four 21st-century skills or other teaching-related factors. Finally, the low survey response rate and self-selected nature of our sample limit the external validity of our findings.

Findings

RQ1: Do college faculty in technological disciplines discuss methods for teaching students important skills and, if so, with whom and how often?

Ninety percent of survey respondents reported having at least one contact with whom they discussed teaching important skills. The mean network size for all survey respondents, a measure associated with social capital accrual in previous research (e.g. Van Waes et al. 2015), was 3.74 contacts. The mean network size for those reporting discussion contacts was 4.15. Findings are displayed in Table 2.

Though a plurality of discussion contacts were from within faculty members' colleges, 42% of discussion contacts were affiliated with outside educational organisations (i.e. other colleges or schools) and 12% were affiliated with organisations outside education altogether.

RQ2: How do teaching-focused personal networks compare among important faculty subgroups?

Descriptive statistics comparing dichotomous faculty subgroups for beneficial network characteristics are also displayed in Table 2, here according to faculty development, teaching experience, institution type, and discipline.

Respondents participating in at least one 'in-depth' formal faculty development activity show significant variation along several measures associated with access to teaching-focused social capital. First, a higher proportion of in-depth faculty development participants reported engaging in teaching-focused discussions than those not participating (96% compared to 83%). Second, faculty development participants also had larger (4.46 to 3.56 contacts) and stronger networks (2.00 to 1.66) than non-participants, all significant differences (.01).

Though the other subgroupings show little significant variation across social capital measures, the first row does show that a higher proportion of faculty with 10 years or less teaching experience report engaging in teaching-focused discussions (95%) than those with 10 years or more experience (87%), a significant difference (0.1). Additionally, 84% of advanced manufacturing faculty compared to 93% of information technology faculty report engaging in teaching-focused discussions, also a significant difference (0.05).

RQ3: Do college faculty perceive teaching-focused personal networks to be beneficial to their instruction in communication, teamwork, problem-solving, and self-directed learning and, if so, how?

Of the 171 faculty who reported teaching-focused discussions, 142 faculty members (83%) clearly indicated that networks positively influenced their 21st-century skill instruction (Table 2). Inductive analysis of these open text entries elicited the five thematic categories displayed in Table 3.

Common cause

Respondents reported that teaching-oriented discussions not only allowed them to connect with others who valued instruction, but also created a more supportive environment that was conducive to trying new things when teaching 21st-century skills. This 'mutual support,' as one respondent called it, provided the motivation to continually improve. 'We both profit immensely from

Table 2. Statistical results for faculty teaching-focused personal network measures linked to social capital accrual.

		Faculty Development		Teaching Experience		Institution Type		Discipline	
Measure	All Faculty	No In-Depth Activities	≥One In-Depth Activity	≤10 Years Experience	>10 Years Experience	Two-year Institution	Four-year Institution	Advanced Manufacturing	Information Technology
Network Size									
Yes to contacts	0.90	0.83	0.96	0.95	0.87	0.91	0.90	0.84	0.93
	(0.02)	(0.05)	(0.02)***	(0.03)*	(0.03)	(0.05)	(0.02)	(0.04)	(0.02)**
Number of contacts (all)	3.74	2.93	4.27	3.85	3.73	4.13	3.66	3.71	3.75
	(0.15)	(0.26)	(0.17)***	(0.23)	(0.20)	(0.36)	(0.16)	(0.25)	(0.18)
Number of contacts (yes)	4.15	3.56	4.46	4.05	4.30	4.55	4.07	4.42	4.02
	(0.13)	(0.23)	(0.15)***	(0.22)	(0.17)	(0.30)	(0.14)	(0.19)	(0.17)
Diversity									
Share of contacts outside organisation	0.42	0.27	0.49	0.36	0.46	0.31	0.44	0.35	0.46
	(0.06)	(0.08)	(0.09)	(0.10)	(0.09)	(0.12)	(0.07)	(0.09)	(0.09)
Share of contacts outside education	0.12	0.10	0.12	0.09	0.13	0.17	0.11	0.16	0.10
	(0.03)	(0.05)	(0.04)	(0.04)	(0.04)	(0.09)	(0.03)	(0.05)	(0.03)
Tie Strength									
Frequency of communication with contacts about teaching	1.89	1.66	2.00	1.90	1.87	1.90	1.89	1.81	1.93
	(0.05)	(0.09)	(0.06)***	(0.10)	(0.06)	(0.11)	(0.06)	(0.09)	(0.07)
Network Influence									
Discussions positively influence 21st-century skill instruction	0.83	0.83	0.83	0.81	0.84	0.90	0.82	0.81	0.84
	(0.03)	(0.05)	(0.04)	(0.05)	(0.04)	(0.06)	(0.03)	(0.05)	(0.03)
N	192	64	120	62	121	32	160	69	123

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 3. Themes reflecting teaching-focused personal network influence on 21st-century skill instruction.

Theme*	Definition	Example Quotation
Common cause	Providing and receiving social support by sharing experiences	'Discussing pedagogy with my peers has been essential … being able to discuss common issues and problems builds a supportive environment.' (Four-year, information technology, faculty associate)
Expanding toolkits	Sharing new and/or effective teaching methods (i.e. activities, projects, assessments)	'By providing me with their experiences of how strategies that they used in their environment either worked or stumbled … I was able to analyse and then modify their approach to help introduce new topics.' (Two-year, advanced manufacturing, instructor)
Feedback and forth	Providing and receiving feedback on teaching ideas	'I get ideas both of how to improve/change what I am doing and also what to try. Bouncing ideas off people can really help.' (Four-year, advanced manufacturing, professor)
Reflection through expression	Reflecting on and articulating teaching methods, philosophy, and reasoning	'Talking to others is a good way to help me to become more reflective. I also remember the lyrics below to try to get myself to be more in the moment and pay attention to my interactions … "How the hell can a person/Go to work in the morning/Come home in the evening/And have nothing to say?"'(Four-year, information technology, associate professor)
Viewpoints	Hearing multiple perspectives on teaching techniques	'They have provided me with additional perspectives so that I can ensure I am considering all angles when it comes to teaching and evaluation methods.' (Four-year, information technology, assistant professor)

*We present themes in alphabetical order.

brainstorming together and sharing best practices as we continue to grow as educators,' another four-year information technology instructor wrote.

Expanding toolkits

Teaching-focused conversations also introduced faculty to a variety of concrete techniques for teaching 21st-century skills. Reported methods covered everything from syllabus design to walking students through particular scientific concepts. Many respondents told us they directly incorporated techniques they discussed with others, though sometimes with alterations. '[My] approaches to teaching communication have been improved by working with one specific person on my list,' a four-year advanced manufacturing professor wrote.

Feedback and forth

Many faculty reported discussion partners serving as important outlets or 'sounding boards' with whom they could talk through new ideas for teaching 21st-century skills. Interactions were typically described as a good way to 'test' new approaches. One four-year information technology instructor told us he 'used these people to bounce ideas off of,' while a two-year information technology faculty member said, 'I like to bounce ideas off of [discussion partners].' This kind of feedback often pushed faculty to incorporate what they thought were innovative techniques for teaching 21st-century skills.

Reflection through expression

Another common theme among faculty was that teaching-focused conversations could help them examine their own thinking, assumptions, and reasoning in regards to teaching 21st-century skills. The act of verbalising beliefs for supportive colleagues, described as a kind of articulated introspection, often helped faculty clarify, and redirect, their instructional approaches. One four-year information technology professor described this as 'better articulating my own reasons for doing things, [coming up with] new ideas … alternatives.'

Viewpoints

Others said that access to discussion partners' diverse experiences was particularly beneficial. 'Because these people have different approaches,' one four-year advanced manufacturing assistant professor explained, 'they have challenged my assumptions about how my actions in the classrooms do (or don't) work.' Faculty sometimes expressed this idea positionally, describing conversation partners whose varied occupational or content emphases provided unique 'angles' on 21st-century skill instruction. A number of novice faculty members, in particular, pointed to senior colleagues' teaching experiences as an especially beneficial resource.

Discussion

As 21st-century skills continue to be heralded for their role in the success of college graduates in high-technology industries (e.g. National Science Board 2018), this study links faculty social learning and professional development – through teaching-focused personal networks in which faculty can accrue beneficial social capital (Lin 2001) – to communication, teamwork, problem-solving, and self-directed learning instruction. While results should be read with caution, this exploratory work supports prior research pointing to the effectiveness of comprehensive, reflection- and feedback-oriented faculty development interventions that allow faculty to engage with others about teaching (Henderson, Beach, and Finkelstein 2011). It also supports studies showing that many faculty who engage in teaching-focused discussions perceive them as beneficial to their instruction, whether they take place under the auspices of organised programming or not (Rienties and Kinchin 2014; Van Waes et al. 2015, 2016). Finally, this study breaks new ground by showing that technological faculty who take part in such discussions often believe they improve 21st-century skill instruction in particular, adding to a growing body of work focused on how faculty can learn to better teach such skills across the curriculum (Andrews and Higson 2008; Moore and Morton 2017; Scott et al. 2019).

Faculty development and larger, stronger networks

The quantitative study results herein are noteworthy in several ways. Descriptive statistics show that respondents typically talk about teaching methods with a core group of about four people, a plurality of whom are from their own colleges, suggesting nominal access to the kind of new information – and social capital – associated with more diverse ties (Pataraia et al. 2015). While findings suggest consistent faculty access to the kind of complex, nonroutine information associated with strong networks (Coburn and Russell 2008), they also indicate respondents' relative inaccessibility to new knowledge coming through weaker ties that could connect faculty to social capital associated with novel sources (Granovetter 1973).

Though this network uniformity mostly holds regardless of teaching experience, institution type, or discipline, *faculty development* experience proves to be an important demarcation point. The significant association between participation in in-depth faculty development and increased network size and strength – contours closely associated with beneficial social capital – aligns with previous studies showing not only that collaborative reflection is important to successful teaching-related professional development (Knight, Tait, and Yorke 2006; Pifer, Baker, and Lunsford 2015), but also that longer development interventions are usually more effective than events of a day or less (e.g. Sunal et al. 2001).

Though our data do not allow us to determine whether discussions took place inside or outside formal programs, research in this area sheds further light on possible underlying dynamics. First, while faculty involved in formal programming commonly build networks with fellow participants, studies suggest they also engage in informal teaching discussions outside programs that often complement and strengthen their instructional development experiences (e.g. Rienties and Kinchin

2014). Many of the respondents in this study reporting in-depth faculty development participation may therefore be in a good position to continue to build stronger networks with people they talk to regularly. Less positively, we also know that faculty who self-select into teaching-related programming often have an uncommon devotion to and interest in pedagogical change (e.g. Postareff, Lindblom-Ylänne, and Nevgi 2008), especially in the US where faculty development is not typically mandated (e.g. Fink 2013). Here, a subset of highly motivated technological faculty may be engaging in teaching-focused conversation wherever it is available while those less interested engage much less often. In light of findings, further empirical work should not only measure faculty teaching-focused social ties in other experiential, institutional, and disciplinary contexts, but also aim to determine how teaching-focused relationships are created and sustained.

Linking faculty teaching-focused networks to 21st-century skill instruction

Our qualitative analysis grounds our statistical analysis by describing some of the content of, and perceived benefits from, teaching-focused discussions, important aspects of personal networks sometimes overlooked in quantitative studies. Here, findings show a perception among most respondents that discussions benefit 21st-century skill instruction, supporting research showing that faculty members often believe teaching-focused personal networks improve their professional practice (Pataraia et al. 2015; Roxå and Mårtensson 2009).

Respondent descriptions of how teaching-focused networks are beneficial also track previous studies. Pataraia et al. (2015), for instance, showed that discussions often took the form of colleagues informally sharing experiences, posing questions, and obtaining feedback on particular methods (p. 348). Such discussions allowed respondents to learn new strategies they could implement in the classroom – following our *Expanding toolkits* theme – and also to accrue affective, ideational, and reflective benefits (pp. 350–351), tracking our *Common cause* and *Reflection through expression* themes. Faculty in Van Waes et al. (2016), similarly, spoke to the kinds of benefits they received through teaching-focused interactions, including 'reframing value' (rethinking instructional principles based on discussions), mapping closely to the *Reflection through expression* theme here, and 'applied value' (making actual changes in teaching practice based on discussions), which speaks to the instrumental resources faculty in our study describe utilising through *Expanding toolkits*. Considering that this analysis explores a more delineated set of faculty social ties (i.e. technological faculty discussing skill instruction), such similarities point to the intriguing possibility that the mechanisms by which social ties contribute to teaching-oriented faculty development could be consistent among varying institutional and disciplinary areas. This preliminary finding offers rich possibilities for future study.

Ground-level social capital and network theory

But how might such benefits be constrained or afforded by particular faculty personal network characteristics? We conceptualise this phenomenon as a process by which faculty gain access to, and mobilise, beneficial social capital that flows through social ties (Lin 2001), similar to a number of studies investigating precollege and college instructional networks (e.g. Benbow and Lee 2019; Baker-Doyle and Yoon 2011; Pil and Leana 2009; Rienties and Kinchin 2014). In this study, while the clarity of the Lin (2001) model allows us to precisely describe and compare personal network size, diversity, and tie strength measures that have been linked to social capital accrual, the full potential of the concept in regards to faculty development and social learning is more vividly illustrated in our qualitative results. Here, faculty statements point to *how* certain kinds of network structures lead to social 'returns' in their everyday lives.

Tie strength, for example, representing how close conversation partners are to one another, has been linked to various benefits and challenges in the network literature (Coburn and Russell 2008; Granovetter 1973). In this study, however, the concept takes on further ecological meaning, as faculty suggest closer teaching-focused relationships facilitate several processes that helped them

develop their 21st-century skill instruction, from deeper reciprocity and understanding that help faculty support one another and give authentic feedback (*Common cause, Feedback and forth*) to mutual trust that allows for honest reflection (*Reflection through expression*). Increased network size and diversity, in particular, both of which have been linked to an influx of new information and perspective (Lin 2001), also play an important role in this study. Through responses coded here as *Viewpoints*, respondents speak directly to the access conversation partners in different positions and with different perspectives give to potentially innovative ideas (see Lin 2001, pp. 65–69).

Conclusion

This exploration adds to a growing body of theoretically-grounded research outlining the contours of teaching-focused networks among college faculty as well as the potential instructional benefits of formal and informal feedback- and reflection-oriented faculty development. Higher education leaders hoping to foster teaching reform should be cognisant of these kinds of social learning opportunities, especially as regards the potential to move instruction in 21st-century skills forward in disciplines and industries where these skills are becoming ever more important to the lives and work of graduates. As this research moves forward, reformers and policymakers may very well find success in committing resources not only to the expansion of opportunities for inter-departmental and even inter-organisational professional development, but also to programs training faculty to more purposefully develop personal networks that will help them accrue teaching-focused social capital and improve their practice (e.g. Baker-Doyle and Yoon 2011). Ultimately, using faculty members' own sociocultural contexts and collegiality to foster more effective teaching-focused development, we believe, is a meaningful step in the right direction.

Note

1. In the U.S., 'associate-level' college degrees entail two years of study after high school and typically focus on practical career competencies. Graduates usually gain entry-level jobs in industry or transfer into 'bachelor-level' degree programs, which entail four years of general education as well as focused disciplinary study.

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