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Research Article

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School change efforts often rely on formal organizational structures to support educator knowledge of new instructional practices. Rural districts face challenges accessing the resources necessary for robust structures, but informal relationships among educators are often strong. Using structuration theory as a lens, this paper examines the knowledge-building behaviors of educators in one rural school district regarding new instructional practices related to a recent initiative. A thematic analysis of interviews with a purposive sample of district educators reveals that, in the absence of robust formal supports, educator agency was critical for establishing informal knowledge-building structures that supported knowledge-sharing within district schools. These findings suggest that rural districts would benefit from attending to structures and routines that support social interaction in order to leverage educator agency during change implementation.

Capacity for change centers on the individual and collective learning of educators. Thus, embedded in schools and districts are formal organizational structures (roles, rules, routines and resources established by school and district leaders) designed to increase educator access to information and resources about new instructional practices (Brezicha et al., 2015). These often include formal leadership roles for knowledgeable individuals (Spillane et al., 2015), structured communities of inquiry (Butler et al., 2015; Stoll, 2006), and norms and understandings shared throughout the organization (Hatch et al., 2016). In addition to supportive formal structures, social relationships centered on trust foster educator learning of new practices (Bryk & Schneider, 2002; Moolenaar & Sleegers, 2010). Friendship ties are highly correlated with trust, and in the context of organizations, with innovation and change (Bryk & Schneider, 2002; Daly et al., 2010; McGrath & Krackhardt, 2003). Thus, the presence of informal friendships among educators can also enhance knowledge-sharing related to a change effort.

Rural districts tend to have fewer resources for formal initiative-specific support roles and limited opportunities for collaborative teacher meetings, yet there are likely to be strong personal ties between district educators (NASBE, 2016; Harmon & Smith, 2007). This paper reveals the central role that educator agency plays in capacity-building for organizational change in an under-resourced rural district by examining how district educators go about building their knowledge of new instructional practices in the absence of robust organizational structures supporting a new initiative. Specifically, this paper addresses the following question: How do district educators in a rural district access knowledge about new instructional practices related to a recent change initiative?

Literature Review

School Change in Rural Contexts

While the research exploring change implementation in rural contexts is sparse, evidence suggests that change efforts in these districts can be particularly challenging (NASBE, 2016). Many challenges relate directly to a rural district's capacity to provide the resources, expertise and routines that support knowledge-creation and sharing among district educators—supportive knowledge structures.

Challenges providing resources and expertise. Many rural districts are geographically distant from urban centers and clusters of towns, making it difficult to access resources and expertise, such as higher education institutions and opportunities for professional development (NASBE, 2016). In addition, uneven broadband access and capacity to leverage it can impede a rural district's ability to access virtual resources supporting a change initiative (NASBE, 2016). Rural districts also face funding challenges, coupled with a limited ability to achieve economies of scale in the procurement of resources, compounding the challenge of resource access (NASBE, 2016; Harmon & Smith, 2007). Finally, a lack of funding often leads to low salaries which hinder recruitment and retention, particularly in specialized fields (NASBE, 2016; Preston & Barnes, 2017). As a result, rural districts often lack expertise relating to change efforts (Blanton & Harmon, 2005;

Margolis, 2020). Furthermore, geographic isolation can create closed systems within the district and/or the community which are resistant to change (Harmon & Smith, 2007).

Challenges providing meeting opportunities. School leaders foster positive interactions with and among teachers to generate support and buy-in for new initiatives (Zuckerman & O'Shea, 2021). However, rural districts face unique challenges in supporting formalized meetings and interaction opportunities. For example, it is not uncommon for educators and administrators to take on multiple roles due to the small staff size (NASBE, 2016; Harmon & Smith, 2007; Preston & Barnes, 2017), thus limiting time available for team meetings and collaborative planning. Also, the administrative burdens related to having a small staff limit opportunities for school leaders to directly support teachers on issues of instructional improvement and change (NASBE, 2016, Zuckerman & O'Shea, 2021). Small staff size also results in many staff who are isolated in their professional roles—e.g., the only fourth grade teacher, music teacher, etc. (Hargreaves et al., 2015). With limited access to expertise relating to specific change initiatives and limited opportunity to engage in conversations with colleagues, the capacity of rural districts to engage educators in collective knowledge-building is hindered.

Rural schools' advantages. Despite these challenges, research points to some important advantages of rural school settings. Residents of rural communities often have strong relationships that they have maintained over a long period of time, long personal histories with the school, and a tradition of schools serving as community centers resulting in strong attachments to the school (NASBE, 2016). Students in rural districts often experience low student-to-teacher ratios, allowing for more personalized attention (NASBE, 2016; Preston & Barnes, 2017). Smaller central offices can result in greater autonomy for principals, enabling implementation decisions from a site-based perspective that attends to the specific needs of the school (Matte, 2018. Research also suggests that strong ties are often present among staff, resulting in rich social and professional networks that can support the sharing of information and resources (Hite, et al., 2007; Preston & Barnes, 2017). However, we know little about if and how rural districts leverage this social network advantage to support educator and/or organizational learning (e.g., Hite et al., 2007).

Theoretical Frameworks

Structuration Theory. Structuration theory (Giddens, 1984) proposes that the structures of a social system shape and are shaped by the actions of individuals within the system. Thus, the theory provides a lens for examining the role of individual agency in justifying, shaping and re-shaping organizational structures in institutions (Barley & Tolbert, 1997). Structures are conceptualized as the rules, resources and structuring properties that bind time and space in social systems, and agency is the ability of individuals to have some control over one's actions (Emirbayer & Mische, 1998). Through routine and repeated interactions, individuals reproduce the structural conditions of the system in which they are embedded. Thus, structuration theory describes structure and agency as a duality, each influencing the other— "rules, norms and meanings arise in interaction, and they are preserved and modified by the behavior of social actors" (Scott, 2008, p. 429). Researchers have used structuration theory to explore issues of organizational management (e.g., Bouncken et al., 2016) and organizational learning (e.g., Gao, 2007). As such, the theory is a useful lens for understanding how organizational structures (roles, rules, routines and resources) shape and are shaped by one another. Based on this duality of structure and agency, in the absence of robust organizational structures it is likely that individual agency plays an important role in supporting knowledge-building and sharing in a rural district.

Theories of structure and agency in educational policy implementation are valuable because, "they provide a way to uncover the microprocess by which social structure influences action, and how action, in turn, influences institutionalization" (Coburn, 2016, p.473). When examining the interactions between individuals and organizational structures, it is helpful to conceptualize agency as a process of social engagement bounded by time and context (Emirbayer & Mische, 1998). Educator agency has been explored to some extent in recent research examining the development of educator practice (Vaughn & Faircloth, 2011; März et al., 2016) and reform/policy implementation (Bridwell-Mitchell, 2015; Rigby, 2016). In the context of district-initiated reform, Datnow (2012) describes educator agency in three forms: (1) active support and implementation of the reform; (2) passive acceptance or engagement at a surface-level; or (3) active resistance. This article

applies concepts of agency and structure to the process of knowledge-building in schools—an essential first step in change implementation.

Theory of social networks. Educators are embedded not only within the formal organizational structures of their schools, but also within networks of informal social relationships. Both support the movement of information and ideas through the interactions between educators. Thus, the theory of social networks is a useful conceptual approach for understanding how the formal and informal relationships within a district shape educators' interactions and contribute to the building and sharing of organizational knowledge (Cross et al., 2005; Wasserman & Faust, 1994). In social network theory, interactions between two actors are conceptualized as ties (Wasserman & Faust, 1994). Ties can be thought of as either instrumental or expressive (Robins, 2015). Instrumental ties serve as a mechanism for moving goal-oriented resources (e.g., knowledge, materials). Expressive ties represent affective relationships such as friendship (Robins, 2015). Friendship is highly correlated with trust (McGrath & Krackhardt, 2003) and often used as a proxy for trust in studies of social networks in education (e.g., Moolenaar et al., 2012). Datnow (2012) argues that studying the social networks of educators can provide insights into how knowledge related to a reform flows into and across those networks and proposes that social networks can be leveraged to support school change. In this study, social network theory is used to inform understandings of how knowledge (information and advice) moves among district educators within the context of the formal organizational structures and informal social relationships in which they are embedded.

Very little research has examined the role of social networks in rural school change implementation (e.g., Hite et al., 2010). Spillane and colleagues (2015) included one rural and one urban district in their study which examined the role of formal organizational structures and individual characteristics of educators in the shaping of information and advice interactions about instruction. They found that while organizational routines and leadership roles were more influential than individual characteristics in both districts, the lack of district supports in the rural district resulted in few between-school connections. Penuel et al. (2010) examined how formal and informal aspects of two elementary

schools contributed to instructional change within each school, concluding that when patterns of formal and informal interactions are aligned, educators are better able to coordinate change. Together, these studies point to the importance of both formal and informal social structures in reform. This paper advances scholarship in this area by uncovering the role that educator agency plays in linking formal structures and informal social networks to support the flow of knowledge among educators.

Research Context

This paper draws from a larger study which employed an explanatory mixed-methods sequential design (Creswell & Plano Clark, 2018). The context was a school district made up of one elementary, one middle, and one high school in the Midwest that fit the Rural Education Achievement Program (REAP) definition of rural due to its remote location. Prior to this study the researcher had no relationship to the district or any individuals within the district, and thus was positioned as an outsider throughout the research process. However, past experience as a principal in a rural elementary school setting likely informed how the researcher approached this study and the interpretation of the data. At the time of this study, within the Harding Community School District (pseudonym) there were a total of 148 educators and administrators serving 1800 students. In 2016, three years prior to this study, the district launched a new science, technology, engineering and math (STEM) initiative. While the push for STEM was encouraged by the central office, all school and district leaders acknowledged that no explicit directives, guidance or definition of what constituted STEM instructional practices were given to school principals. The concept of "STEM" is often enmeshed with generalized ideas of improving education in workforce-related areas, resulting in a variety of interpretations of what constitutes a STEM initiative (Seigel & Giamellaro, 2020). Thus, in a situation similar to that encountered by Seigel & Giamellaro (2020), what constituted "STEM," and how STEM instructional practices were implemented differed in each school.

- *Elementary School STEM*—At the elementary school, beginning in 2017 the principal nominated one teacher per year to participate in a grant-funded "STEM Fellows" year-long training program. In April of 2019 two STEM Fellows established a

Table 1
Educator Response Rate by School

School	Total number of educators	Number of survey respondents	Response rate
Elem	66	53	80%
Middle	36	33	91%
High	46	39	85%
Total	148	125	84%

makerspace with funding from a grant that they had secured.

- *Middle School STEM*—In 2016, the middle school began a 1-to-1 Chromebooks initiative, which was piloted by the sixth grade and included hiring a part-time STEM coach. As the initiative broadened to the rest of the school the coach was employed full time, and by 2018 the focus became achieving state STEM certification, which included an external evaluation of STEM practices school wide. In 2019 the STEM coach left the district and the position was eliminated due to budget constraints.
- *High School STEM*—The High school went 1-to-1 with Chromebooks school-wide in 2018 and to help with related technology issues, they hired a part-time technology coach who also served as a business teacher. In this school STEM was equated with the sciences and workforce development.

Participants

All 148 educators in the Harding Community School District were invited to participate in this study in the Fall of 2019. In total, 125 completed an online survey and 18 participated in interviews. The survey response rate was 84% across the district. Eighty five percent (85%) of high school educators completed the survey. The middle school had the highest response rate at 91%, and at the elementary school, 80% of educators completed the survey (see Table 1). The majority of survey participants were classroom teachers (75%), but also included teacher leaders, administrators, non-classroom teachers, as well as speech and language pathologists (SLPs) and counselors. All grade levels (PreK-12) were represented in the survey results, and all participants identified as White, non-Hispanic. The majority were female (73%). Table 2 (below) details this information.

Data Collection

The survey gathered social network data regarding two instrumental ties—information and advice—and the relational tie, friendship. Participants were asked "Who do you reach out to for information and/or resources about STEM instructional practices?" and "From whom do you receive feedback, support or guidance about STEM instructional practices?" Using a Likert-type scale, participants reported frequency of interactions with district colleagues over the course of this academic year and last (yearly, monthly, weekly, daily). To capture out-of-district inputs to the knowledge network an open-response question asked participants to list any other sources of information or advice utilized to bring STEM instructional practices into their classroom.

The survey also asked participants to identify friendship relationships at each school using a survey question from McCormick et al. (2015) modified for this study. Again, a roster format was used and participants identified the nature of their relationship with each district colleague listed, using the following terms and definitions: *known* (participant has met the person); *friend* (participant shares personal anecdotes); *close friend* (participant spends time in personal activities and/or engages in candid conversations with the individual). Participants were asked to leave the row blank, or mark *not known* if they did not know the individual listed.

Survey questions also collected demographic and descriptive data, including participant gender, age, race/ethnicity, formal role in the district, whether or not they have received formal training in STEM, years of teaching experience, years of leadership experience, years of administrative experience, number of years in the school, number of years in the district and number of years living in the community. Principles of homophily, or the notion that

Table 2
Characteristics of Survey Participants

Participant Characteristic	Percent	Count
Male	27%	34
Female	73%	92
White	100%	126
Elementary	42%	53
Middle School	26%	33
High School	31%	39
Central Office	1%	1
Building or central office admin	6%	7
Instructional Coach/Teacher leader	2%	2
Non-classroom teacher	10%	13
Classroom Teacher	75%	95
Other (SLP, Counselor)	7%	9

relationships are more likely to form between individuals with similar characteristics (Wasserman & Faust, 1994) informed the selection of these variables.

In addition to completing the survey, 18 educators were purposefully selected to participate in interviews. Initial interviews with those in administrative positions—the superintendent, the assistant superintendent, the director of technology for the district, the elementary, middle and high school principals occurred in June of 2019 and informed my understanding of the initiative and district context. The second interview phase occurred between November 2019 and January 2020 and included fourteen survey participants selected based on social network measures of *flow betweenness* and *degree* centrality (Borgatti, 2005). High centrality scores are an indicator of actor importance in the flow of knowledge, while low scores indicate a less involved, or peripheral actor. Two from each school with high centrality scores and two from each school

with low scores participated in a 30-minute semi-structured interview (see Table 3). Two principals found to be central to the flow of knowledge were also interviewed. This purposive sampling ensured a diversity of perspectives in the data. Interview questions explored participants' history with the district, their knowledge-building behaviors as they related to STEM instructional practices, and educators' assessments of the value of the district structures and supports as compared with the value of friends and colleagues in building educator knowledge related to STEM instruction. Throughout all data sources, identifying information was replaced with either an identifying code, or a pseudonym.

Data Analysis

I conducted open coding of survey responses to the open-ended question that asked educators to name resources they used to build their knowledge of STEM instructional practices, and then used the

Table 3
Characteristics of Interview Participants

	District Administrator	School Administrator	Educator with High Involvement	Educator with Low Involvement	Total
Admin Building	3	-	-	-	3
Elementary School	-	1	2	2	5
Middle School	-	1	2	2	5
High School	-	1	2	2	5
Total	*3*	*3*	*6*	*6*	*18*
Male	1	2	1	3	7
Female	2	1	5	3	11

program MAXQDA to conduct a frequency count of codes. I used thematic analysis (Braun & Clarke, 2006) to examine the interview data. Through an iterative process which included multiple passes of each interview, I employed an inductive approach to coding (Yin, 2016) and examined educators' choices relating to who they turned to and how they accessed knowledge about STEM instructional practices, as well as their perceptions of how these choices were influenced by their relationships with colleagues and the roles, rules, routines and resources within their rural district context. Through member-checking I ensured the accuracy of my interpretation of the interview data and organized the codes into broader categories, using rules for data inclusion as salient categories developed. The final set of categories included: 1) online information sources; 2) interaction opportunity; 3) personal interest as motivation; 4) use of personal time. These categories supported the final integration of the quantitative and qualitative data which began with *qualitizing* the quantitative data by writing descriptions of the quantitative findings (Yin, 2006). Using MAXQDA's coding matrix browser feature I tracked the clustering and/or segmenting of codes within categories to create themes that "capture the contours of the coded data" (Braun & Clarke, 2006, p. 91). These categories all connected to the broader theme: educator agency influenced knowledge acquisition and sharing.

There were limitations to this study that must be acknowledged. First, some changes in administration during this study limited the presence of a central office perspective in the second round of interviews. In addition, my position as a district outsider may have influenced the response rate and/or nature of the responses of some educators. These circumstances may have impacted findings.

Findings

The analysis uncovered the role of educator agency in the building and sharing of reform-related knowledge among educators in this rural district with few formal support structures. First, in the absence of robust knowledge-building supports within this district, educators relied heavily on out-of-district resources, including those accessed electronically through the internet. Second, educators actively utilized school routines as well as personal time to create opportunities for knowledge-building

interactions with colleagues. Those who created these opportunities were often driven by personal interest in STEM instructional practices. These knowledge-building interactions supported knowledge acquisition and sharing, augmenting the knowledge of STEM-related instructional practices available within these schools.

Limited In-District Support Structures

While the superintendent touted STEM as an instructional priority, across the district there was no shared understanding of what constituted STEM instructional practices, nor were there district-approved curriculum or resources related to STEM. Thus, each school leader developed their own interpretation of the initiative, providing educators with support that aligned with these interpretations. The 124 survey participants who answered the open-ended survey question regarding sources of STEM-related information provided 198 instances where a resource was identified. Frequency counts revealed that teachers utilized a variety of resources ranging from out-of-district colleagues to the internet. As illustrated in Figure 1 (below), the most frequently cited resource category was the internet, which accounted for 33% of responses. *Teacher colleagues* were identified in 24% of the responses, while sources directly aligned with the formal implementation structures utilized in each school received significantly fewer mentions by comparison, including *administrators/teacher leaders* (12%), *technology coach* (3%), *meetings* (1.5%), and *administrator emails* (.5%). The fact that formal school supports were named with less frequency than informal supports (i.e., the internet and teacher colleagues) signifies that the formal supports were inadequate and/or inaccessible. Furthermore, it indicates that educators interested in building their knowledge of STEM instructional practices actively sought out additional information sources and thus points to educator agency as important to the knowledge-building and sharing that supported this initiative.

Interview data provided further insight into educator use of agency in regard to gathering information from external resources. Nine of the 15 interview participants described using online resources and/or social media sites in addition to, or instead of, district resources and supports to build their knowledge of STEM instructional practices. As noted by one elementary teacher, "I think probably
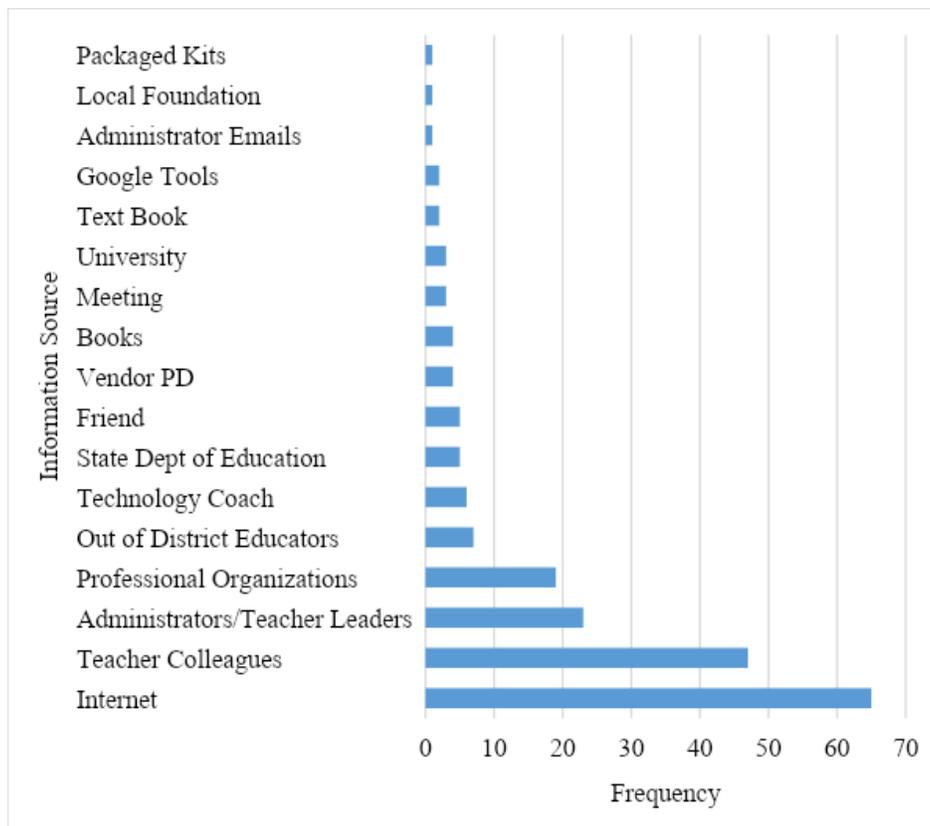
Figure 1: Frequency count of information sources named in survey responses

the very first things that I did were like ideas that I had gotten from teachers online or like STEM activities purchased off of Teachers Pay Teachers or things like that." Another teacher observed:

> Mostly if I have a question, I'll just kind of, if we're at a team meeting—hey, have you ever done this? Or hey, I'd like to do this. Um, or I just Google it and go to a social—the social studies network on Facebook is really good about—You can put out there, "Hey, I want to do this." And then everybody responds.

These educators described internet resources as easy to access and full of information. They talked about the responsiveness of colleagues on social media sites and the value of these online spaces for conversations and learning.

District colleagues were also mentioned as a source of information by interview participants at all three school sites—sometimes in conjunction with other resources. Two teachers described utilizing a combination of both in-school colleagues and social media colleagues to help them work through an idea. Two other educators interviewed explained that they

turned to colleagues who they knew could point them in the direction of useful books or websites. The following quote illustrates the primacy of educator agency versus district supports for supporting the knowledge network:

> We go out and search, we find things ourselves, I know that's why I share ... colleagues will share things. But as far as any formal curriculum or anything like that, no, we've not been provided with much in that regard.

In the absence of district guidance around STEM curriculum, teachers took it upon themselves to support one another's efforts to engage with STEM instruction. One teacher summed up this sentiment by stating, "I think your best asset as a school are the teachers you work with. So, finding teachers you trust and can learn from, that helped me." Interestingly, among the interview participants with high centrality scores, all but one talked about giving informal support to, or receiving it from, district colleagues, indicating that individual educator actions to support one another contributed to these individuals' central positions.

The limitations of existing resources within the district's knowledge network influenced educator actions. Some educators stated they felt they had utilized all of the resources available within the district and needed to look elsewhere to build their knowledge and understandings. This was particularly true of those in leadership positions. Two of the three building principals interviewed and two of the three central office staff stated that they did not turn to educators within the district for information or advice about STEM instruction, but rather sought out colleagues from outside the district. This was also true of the teacher managing the makerspace at the elementary school. One principal explained:

> I use the online journals the most, or colleagues from other schools. My hits is [sic] probably from the outside world and then bringing it into the school. I think if you network just within your school, you can't grow. So, I really feel like, you know, if there's an idea that, say, is at another school 20, 30 miles away and you have a chance to go observe that and can share with your group an idea.

Those who were seen as important sources of information for their colleagues expressed a feeling that conditions for developing their own knowledge were not present in the district. This was particularly true at the elementary school and high school, where all of those who described turning to out-of-district colleagues occupied formal or informal STEM leadership positions. Interestingly, at the middle school the interview participants who described turning to outside colleagues were those who had low centrality in the network and served in roles where they lacked grade-level or department colleagues or were physically located in areas somewhat distant from colleagues in the building. Thus, to fulfil their desire to access information in support of initiative-aligned teaching practices, most district educators activated their own agency and looked beyond the limited resources provided by their schools. While district colleagues were valuable sources for some, those who felt isolated or in leadership roles looked to colleagues outside of the district for information related to STEM practices.

Educator Agency Enables Learning

Although all three schools lacked organizational structures that supported consistent, built-in collaboration time, all interview participants talked about the importance of interactions with colleagues for building their understanding of STEM practices. The absence of team meeting time and resulting impact on opportunities to engage in information and advice interactions was mentioned by 10 of the 15 school-based interview participants, indicating that such opportunities for interactions were desired and/or valued. This was particularly true at the middle school where all of the teachers interviewed described the lack of opportunities to meet during the school day as having a negative impact on the development of their skills related to STEM instruction. When asked about opportunities to talk with other colleagues, one middle school teacher explained:

> In the middle school we used to have that team time. We don't have that anymore. So, if you catch somebody at lunch, you can [meet], and it just depends. You know, people who go home, people eat someplace else. You know, those different kinds of things. So, we really don't have, uh, a set time any more for, I think, what you're talking about. Collaboration.

Here we see that in the absence of formal meeting time, this educator relied primarily on reaching out to colleagues during moments of opportunity. All but one interview participant specifically mentioned the challenges of finding time to meet as being a barrier to implementing STEM instructional practices, and nine of the 18 individuals interviewed, including those in the central office, described trying to arrange meeting time or talk briefly with colleagues when they could, either before or after school, during lunchtime, or even in passing in the hallway.

For many educators interviewed, these interactions of opportunity often occurred outside of school space and time. For example, when asked how she found time to have conversations about STEM instruction with staff, one principal stated:

> Probably by happenstance, um, lunch time. Sometimes things will come up, mornings if I can with one individual, she's here earlier than I am, but she usually has her work done. And if she comes down and we have a chance to talk, then it might be there or even after school. But, you know, they're just kind of built in wherever we can.

This quote illustrates that in the absence of scheduled time to engage in conversations about instructional practices, this school principal and a staff member took it upon themselves to seek one another out when their schedules allowed. It was through individual efforts that these information and advice exchanges

occurred. Thus, personal interest was an important driver for knowledge interactions.

Those teaching STEM related subjects, or who had an innate interest in STEM were more likely to take action to create opportunities, especially considering that finding opportunities typically meant giving up personal time. For example, at the elementary school, creating an opportunity to learn about STEM instruction likely meant arranging to attend a makerspace training after school hours. At the middle school when the STEM coach was present, it meant giving up a planning period or after-school time to find an opportunity to meet with her. After the coaching role was eliminated, knowledge-building opportunities became even more limited. Those who were most interested in STEM instruction took it upon themselves to find the time to meet, either during the school day or on their own time. As stated by one of these individuals, "I don't know, when do you find time? You just, if it's important, you find time."

At the high school, some teachers took the time to engage with the informational articles sent out via email and/or conference opportunities. Some reached out to colleagues. It was up to each individual educator to pursue these opportunities. The following quote illustrates how one newly hired teacher came to understand expectations around STEM instruction:

> When I was initially hired and the head of the math department and the math teachers in general were making their introductions to me, quite a few of them, and not just the math teachers, but people who had been math teachers and were now teaching other subjects, mentioned to me that this particular middle school math teacher is just one of the best math teachers in the district. They suggested that I meet with her, get together with her because she teaches Algebra One at the 8th grade level and since I was going to be teaching Algebra One, have a couple conversations with her. So, we set it up at the beginning of the year to introduce myself.

Through informal conversations with department colleagues and others in the school, this teacher learned about a potentially valuable resource—an experienced and respected teacher in the district. However, it was up to the new teacher to reach out and initiate a relationship to support her instructional practice.

Personal Interest Motivated Learning

Engagement in the district's STEM knowledge network was often driven by an educator's personal interest in STEM instructional practices. In fact, many interview participants described the resources available within the district, including the elementary school's makerspace training opportunities, participation in conferences and the middle school's STEM coach as being "for those who were interested." In describing the supports she utilized in her school one teacher stated, "but I also feel like if you didn't take the initiative, then you weren't really going to be, you weren't really, uh, you didn't get the full, I guess benefit of what we're trying to do." This reliance on teacher initiative led at least one educator to feel out of the loop regarding the district's STEM work. This interview participant described feeling alienated and expressed concerns of favoritism on the part of the school leader. "A lot of times there'll be things going on, uh, kind of behind the scenes or where a certain select group know what's happening and everybody else is totally in the dark." This educator interpreted the growth of knowledge among others as an indication that those others were provided with special opportunities by the principal.

As noted earlier, many district educators accessed electronic information sources including social media sites, professional organizations and vendors to build their knowledge of STEM instructional practices. While some may have been following links provided in the informational emails sent out by school leaders, many were seeking out these sources on their own initiative. One educator described her experience seeking out knowledge of STEM practices:

> Just me randomly finding something that says, "oh, I think that this would be helpful", or I'm on Twitter and I see something and I end up in a rabbit hole. I'm like, oh, I've read five articles now. You sometimes don't know how you get there, but then you're there already.

This educator was motivated enough to seek out information online and also interested enough to follow multiple links to new sources. Most interview participants who were identified through high centrality scores within the district's STEM knowledge flow expressed a personal interest or enthusiasm for STEM instruction.

Personal Time Used for Learning

Another finding identifying the importance of educator agency in supporting knowledge-building interactions is that many such interactions occurred during personal time rather than within the confines of the school day. Ten of the 15 school-level interview participants described using personal time to engage in STEM-related conversations with friends and colleagues. As described earlier, these interactions often occurred before or after school, but other opportunities and venues for interactions were used as well, including arranging to drive together to conferences to converse in the car, or texting or calling colleagues on evenings or weekends. One teacher gave this example:

> Kelly [pseudonym] sent me a text just last, oh, it was Sunday night saying, "Hey dah, dah, dah, dah, dah." And I, you know, I texted her back. So, we feel comfortable that outside of school that that communication is important enough that it's going to happen.

As illustrated above, educators highly valued interactions with colleagues as a resource for developing their STEM instructional practices. In the absence of district-supported opportunities for these interactions, these educators utilized their agency to create conversation spaces outside the boundaries of school time and space.

In sum, the structures put in place by building principals were not the only avenues for building knowledge around STEM instructional practices utilized by these district educators. Across all three schools educators used their individual agency to create opportunities for information and advice interactions. These educator-initiated interactions included seeking out online information sources and creating opportunities to interact with other educators during personal time. Those exercising agency in this way had a personal interest in increasing their knowledge of STEM instructional practices. Through their actions, these educators continued to support and enhance the district's knowledge network in the face of limited district resources.

Discussion and Conclusion

This study uncovers the critical role that agency plays in educator access to initiative-related knowledge in this under-resourced rural district, thus contributing new understandings to organizational learning in a rural context. Like many rural districts,

this district lacked formal knowledge-building supports (Matte, 2018 and a shared understanding of what constituted STEM instructional practices (Siegel & Giamellaro, 2020). Within each school, where the formal organizational structures failed to provide adequate support for building knowledge of new instructional practices, educators supplemented by seeking out resources and reaching out to others informally and repeatedly.

Prior research identifies individuals in formal and informal leadership positions in both urban and rural contexts tend to have more ties in information and advice networks, thus signifying the importance of these roles to knowledge network structure (Spillane et al., 2015). The present findings temper this claim by calling attention to the role of educator motivation and opportunity to seek out knowledgeable colleagues and/or external resources. The presence of knowledgeable individuals is not enough to create knowledge ties, rather, educators must also choose to engage with these individuals. This choice is rooted in past experience, linked to future goals and informed by present opportunities and demands—the activation of educator agency (Emirbayer & Mische, 1998).

In addition to informing scholarship and practice related to rural school contexts, these findings also build upon prior literature on educator information networks broadly. While support structures utilized by school leaders influence the nature of the district's knowledge network to some extent (Coburn & Russell, 2008; Daly & Finnigan, 2012; Penuel et al., 2015; Spillane et al., 2017), the informal interactions of educators are of particular importance to the flow of knowledge for change implementation (Brezicha et al., 2015; Daly et al., 2010; Siciliano et al., 2017). The present study provides an explanation of the factors that contribute to the formation of knowledge ties. In the absence of robust school or district knowledge-building routines, knowledge exchanges occur when individual educators are motivated to engage with others during moments of opportunity— taking advantage of more mundane formal structures or existing relationships. In other words, these knowledge-building interactions are the consequence of educators' agency (Giddens, 1984). Of particular significance is the notion that informal routines of interaction established by educators became important knowledge-building structures. Butler et al., (2015) noted, "in the context of an initiative that distributes leadership and agency across levels, teachers working in less-than-ideal settings may still

be able to create opportunities to experience agency within the initiative structures" (p. 21). Recognizing that through exercising agency, educators establish informal knowledge-building structures has implications for both research and practice.

Implications for Practice

This study's findings suggest that by galvanizing teachers around a shared goal, school principals can leverage educators' motivation to engage in knowledge-building, and thus enhance organizational learning. While the power of educator agency can be an asset to under-resourced rural districts, it is important for leaders to recognize the pitfalls of relying exclusively on educator agency for knowledge-building of new practices. Many educators in this study faced barriers related to opportunities for interactions and motivation (i.e., understanding if and how the initiative related to their work). This limited educators' choices and opportunities to engage in knowledge-building. Furthermore, to better leverage educator agency, school leaders should carefully consider the desired depth and breadth of change—for example, are the desired new practices most relevant to a specific department or grade level grouping? With this established, leaders can more effectively communicate shared goals and resources that motivate and support knowledge-building.

Another important implication is that through careful attention to the master schedule, classroom assignments and the strategic use of non-instructional assignments (e.g., bus duty) school leaders can help facilitate valuable informal knowledge-building opportunities among their faculty. The field would be well-served to recognize that valuable learning interactions often occur in these unstructured spaces. School leaders might consider strategies for acknowledging and enhancing these informal learning mechanisms such as protecting and increasing these opportunities, incentivizing

participation, and formally recognizing the efforts and contributions of educators who utilize such unstructured time to support educator knowledge-building. Those in solitary roles or who have limited access to knowledgeable colleagues would benefit from leadership support in connecting with peers from other schools or districts.

Implications for Research

In regard to research, prior examinations of educator agency have centered on policy implementation and the role of social structure in constraining and enabling individual agency (e.g., Bray & Russell, 2016; Woulfin, 2016). The present findings extend this research by elevating educator agency as playing a significant role in this district's STEM knowledge—an organizational context where there were few formalized structures supporting knowledge-building. Further exploration of what motivates agency and how it is enacted in school contexts may be particularly valuable for supporting change implementation in rural and other under-resourced districts that lack formalized time for collaborative conversations and face challenges accessing expertise related to a school change initiative. For example, future research might explore the role of shared goals for fostering educator buy-in and participation knowledge exchanges supporting a reform. Such work would build needed knowledge relating to effective leadership strategies and the extent to which buy-in is a necessary precursor to knowledge-building behaviors. In sum, armed with new understandings of how educator agency contributes to the flow of knowledge about new instructional practices, and how educator motivation, ordinary organizational structures and informal social relationships interact to activate agency, rural administrators can more effectively leverage valuable human resources—their educators— when unrolling new initiatives that require changes in classroom teaching practices.

<div align="center">References</div>

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