Continuity and change in educators' professional learning networks

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Abstract

While prior research suggests that many educators turn to social media to grow and enhance professional learning networks (PLNs) that extend beyond their schools, little is known about how PLNs shift over time. In this exploratory study, we investigated the nature of continuity and change in the PLNs of 192 K-12 and university educators from 17 countries. Participants responded to our request to comment on PLN descriptions they provided in a previous 2014 survey, and then identify continuity and change during the intervening years. Respondents overwhelmingly expressed that their PLNs had changed over the four years between the two surveys. The causes of PLN changes appeared to be diverse, dynamic, and interrelated. Various proximal and distal factors contributed to changes in professional activities. We frame the study through social ecological systems theory, discuss the significance of these findings, and consider implications for K-12 and higher education professional learning. Educators and those who lead and support their professional learning should reflect upon and attend to PLN change to ensure more educative results for teachers and students.

Keywords Social media · Professional development · Adult learning

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Introduction

Although educators' local colleagues can provide various forms of support, teachers and professors in varied positions can also benefit from professional connections with individuals who work beyond their buildings (Huberman 1995). During the last decade, educators have increasingly utilized digital technologies to expand their professional learning networks (PLNs) in order to learn from and with peers from outside their local schools, districts, and organizations (Colwell and Hutchison 2018; Porath 2018; Tour 2017). By reducing communication barriers, participatory technologies such as social media can contribute to PLN development by affording access to a wider pool of colleagues, including those with similar affinities (Gee 2004).

PLNs are uniquely cultivated systems of support for ongoing professional learning (Kearney 2019; Trust et al. 2016). Although the personalized nature of PLNs means that they are disparate in nature, they generally include the people, spaces, and tools that support various kinds of learning and professional growth (Krutka et al. 2017). Educators' PLNs often consist of *people* who share information (e.g., teaching strategies, resources, ideas), provide feedback, advice, and emotional support, and encourage changes in teaching practices. PLNs also consist of *spaces* (in-person and digital) where educators go to meet new people, discover new information, and engage in conversations or collaborative learning with others. Information seeking and curation *tools*, such as search engines, databases, books, curriculum materials, and social bookmarking platforms, also play an important role in educators' ongoing learning and professional growth, and are therefore, also part of their PLNs.

While the PLN concept is commonly associated with digital technologies, participants in our prior research (Trust et al. 2016) often did not draw strict distinctions between online and offline professional activities in describing their PLNs. Many educators conceived of their PLNs as including face-to-face, blended, and digital elements. For example, participants described PLN colleagues from both their schools and virtual contacts, such as fellow Twitter chat participants. Similarly, PLNs can span both physical and online spaces that facilitate networking and social learning (e.g., Gleddie et al. 2017). Educators may derive professional support from both a virtual space such as an educator Facebook group (Kelly and Antonio 2016) and a face-to-face setting such as a conference or Edcamp (Carpenter and Linton 2016). Along with other researchers, we have suggested that the anytime, anywhere availability of technology-enhanced PLNs and their capacity to respond to educators' diverse interests and needs offer possibilities for supporting educators' holistic growth (e.g., Tour 2017; Trust et al. 2016).

Prior studies have relied heavily upon participants' perspectives on their PLNs at a single moment in time (e.g., Gleddie et al. 2017; Prestridge 2019; Trust et al. 2016). Researchers have not hitherto identified or detailed the degree to which educators' PLN activities are consistent or ephemeral. Because educators' professional needs and contexts change some over time (Huberman 1989; Richter et al. 2011), their PLNs logically may also evolve in response to and in order to reflect

these shifts. If educators' PLNs shift to include new or different people, spaces, or tools, how much or what they learn could change too. However, the literature lacks descriptions of patterns in PLN continuity and change. For example, little is known regarding the sustainability of educator engagement with self-directed professional learning activities. Moreover, PLN research thus far has focused on the perspectives of educators who have more actively engaged with their PLNs and not teachers who have shifted, reduced, or abandoned some of the people, spaces, or tools in their PLNs for various professional or personal reasons. Additionally, the factors that contribute to PLN transformation, stability, growth, diversification, and narrowing are unresearched. To address these gaps in the literature, we designed an exploratory mixed-method study that addressed the following research questions:

RQ1: In what ways do educators perceive their professional learning networks have changed and stayed the same over the previous four years?
RQ2: In instances of change, what do educators perceive as causing shifts in their professional learning networks?

Before explaining the research methods used to address these questions, we first describe the theoretical framework used in the study and then synthesize the relevant literature. After the research methods section, we present our findings, which we then discuss in light of the theoretical framework. We also consider the limitations and implications of our findings.

Theoretical framework

We framed our understanding of continuity and change in educators' PLNs through Bronfenbrenner's social ecological systems theory. Social ecological systems theorists suggest that factors and changes in settings, people, and relationships can influence change at the individual level. Bronfenbrenner (1979) posited that humans are influenced by "a set of nested structures, each inside the next, like a set of Russian dolls" (p. 22), and this notion of a nested set of contexts impacting human behaviors has been previously applied to schools (e.g., Felner et al. 2007), teachers learning about technology (Beemt and Diepstraten 2016), research-informed ecosystems in education (Pollock et al. 2019), and in particular, educators' professionalism and professional activities (e.g., Carpenter et al. 2020; Keay et al. 2019). Educators' professional actions are, after all, "embedded in local contexts, visible in relational interactions, ethical and political in nature, and involving multiple layers of knowledge, judgment, and influences from the broader societal context" (Dalli et al. 2012, p. 8). In other words, there is a complicated interplay between educators, schools, professional communities, and the larger social contexts surrounding them. As a result, PLN experiences cannot be fully understood without consideration of the multiple influences on individuals' behaviors (Prenger et al. 2020).

Social ecological models have been used to examine and understand various aspects of human development and activity from gender inequities in computer

sciences to the experiences of female coaches (e.g. Dalli et al. 2012; LaVoi and Dutove 2012; Michell et al. 2018). Social ecological models can accommodate various proximal and distal factors that impact educators' professional learning. Furthermore, using social ecological models when considering influences on continuity and change in PLNs is consistent with Bronfenbrenner's (1986) assertion that social ecological systems develop and change over time for a multitude of reasons.

In the social ecological model utilized in this paper (Fig. 1), the educator is at the center of a series of concentric circles. Educators' individual characteristics and affinities can shape and cause changes in their PLN experiences (e.g., Noonan 2019), and *individual* considerations are therefore central to our model. For example, an educator could develop a new professional interest and thus begin seeking out new people, spaces, or tools associated with that interest (e.g., Richter et al. 2011).

Second, educators' PLNs can be affected by their interactions with other individuals and dynamics at their school; we refer to such influences as *microsystem* factors. For instance, a change in department chairs might cause a teacher to shift her professional learning focus, or if an individual moved jobs to teach at a new school, the culture there could contribute to the teacher adjusting the people, spaces, or tools they prioritize (e.g., Vescio et al 2008).

Third, the *mesosystem* describes the larger professional communities relevant to each educator, such as professional associations for their subject areas, unions, and online communities of practice (e.g., Wesely 2013). For instance, if the professional association for a certain content area begins to use a particular social
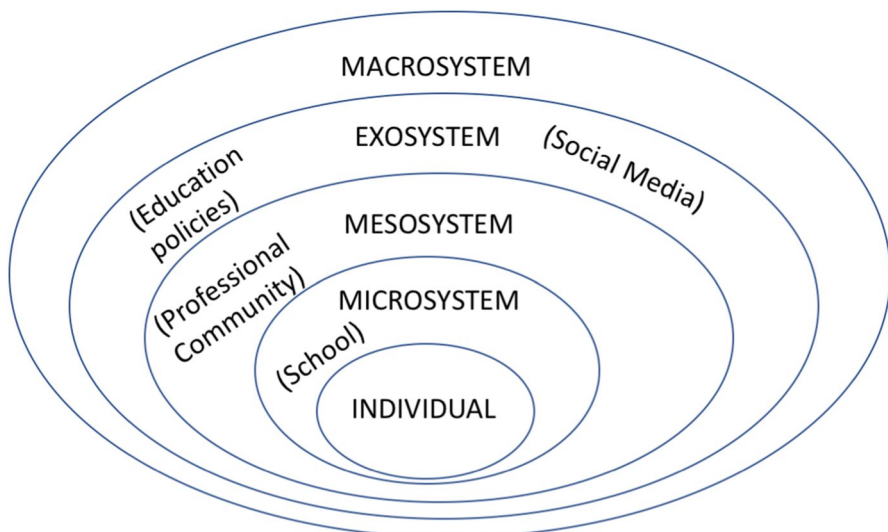

Fig. 1 A social ecological model of influences on continuity and change in educator professional learning networks

media platform, some educators might gravitate towards or expand their engagement with that technology as well.

At the fourth level of the model, the *exosystem*, environmental elements impact PLNs even though educators might not interact as directly with them. Policy regimes that emphasize school accountability via standardized test scores have, for example, been linked to a narrowing of school curricula and teachers' deprofessionalization (e.g., Hursh 2007; Giles and Hargreaves 2006). Such policy effects might encourage or discourage teacher engagement in some professional activities.

Lastly, the *macrosystem* involves forces such as entrenched social structures and cultural norms that can impact educators' professional activities (Choi and Tang 2009; Veletsianos et al. 2019). For example, cultures can have particular understandings of and approaches to the teaching profession (e.g., Stigler and Hiebert 1999). In sum, this model accommodates the complexity of educators' work and is consistent with the reality that they operate in various contexts. We acknowledge the interconnected influences among the different levels.

Technologies can influence and facilitate interactions among the different levels of the model (Pollock et al. 2019). For example, a teacher might be able to communicate more with school colleagues (*microsystem*) thanks to a new technology and those interactions could shape the development of their PLN. Additionally, how technology companies design their platforms, the communication environments and services they create, and the impacts these decisions have on the ways communication is afforded and constrained are factors that exist at the exosystem level. For instance, platform designs, including the character limits, algorithms and notifications, and forms of communication (e.g., text, gifs, videos, images, "likes"), can influence the nature of educators' PLNs. Also, changes in platforms such as Twitter increasing its character count to 280 characters, Facebook sharing data with third parties in new ways, or Ning moving to a paid model could result in an individual using platforms more, less, or differently. We therefore see technology design and changes as elements that can impact educators' PLNs at multiple levels.

Literature review

Educator's professional learning preferences and needs are disparate and can shift across their careers (e.g., Choi and Tang 2009), which suggests that PLNs likely change over time too. For example, researchers have reported that teachers seemed to prefer different learning opportunities at different points in their careers (Louws et al. 2017; Richter et al. 2011). However, attempts to define patterns of change in educators' professional learning activities across their careers have produced multiple possible trajectories for teacher development (e.g., Huberman 1989) rather than a single common path. In Choy and colleagues' (2006) sample of educators, teachers with more than 20 years of experience exhibited marginally lower professional development (PD) participation rates than did early and mid-career teachers, but a study based on a different sample reported that "older teachers do not invest less time in professional development than their younger peers, but … prefer different

media or learning opportunities" (Richter et al. 2011, p. 124). Given such mixed results, there is still much to be understood regarding the causes and nature of change in educators' professional learning activities over time.

Furthermore, although the forms and goals of educator professional learning activities are diverse (Kennedy 2005), researchers have tended to focus on formal PD activities with established structures or curricula led by instructors or facilitators (Borko, 2004; Evans 2019). While such PD activities are important, educators' growth does not occur solely in the context, or as a result, of such professional learning activities (Kyndt et al. 2016); instead, professional learning has long included a "patchwork of opportunities-formal and informal, mandatory and voluntary, serendipitous and planned–stitched together" (Wilson and Berne 1999, p. 174). Professional learning activities are considered especially productive when teachers help determine the agenda, focus, and nature of the activities, and many scholars have argued that teachers should determine, or at least influence, the shape and course of their own development (e.g., Ball 1996; Little 1993). In recent years, educators have utilized various digital technologies to support such personalization and autonomy in their professional learning (Prestridge 2019).

Scholars of educator learning via social media have often focused their inquiries on participation through a particular platform, such as Facebook (e.g., Lantz-Andersson et al. 2017) or Twitter (Carpenter and Krutka 2015). However, research on a single professional learning modality may fail to capture more holistic understandings of educator growth, since in many cases, learning occurs across various physical and digital contexts (Gleddie et al. 2017; Prestridge 2019; Tour 2017). Therefore, examining the multifaceted systems of people, spaces, and tools that comprise PLNs can potentially yield a deeper understanding of the complexity of professional learning and generate new insights for supporting educators' growth. In our study of K-12 teachers' PLNs ($N = 732$), we concluded that the diverse, flexible, and multifaceted nature of PLNs supported personalized professional activities and growth across cognitive, social, affective, and identity domains (Trust et al. 2016). The overwhelming majority of participants in the study reported that as a result of their PLN engagements, they made changes to their teaching and in most cases they believed those changes affected student learning.

Prior findings paint an inconsistent picture of the evolution of technology-enhanced professional networks. Researchers in some studies have suggested that users' Twitter networks narrowed over time as less useful connections and relationships were discarded (e.g., Stepanyan et al. 2010). For example, Smith Risser's (2013) case study of a novice math teacher found that over a 9-month time period the teacher's network shrank as she "began to direct her questions to particular members of her network whose previous advice had been helpful" (p. 30). In contrast, other studies have found that over time the networks of novice teachers' can increase in size (Fox et al. 2011). For instance, Baker-Doyle (2012) described instances of first-year teachers' professional networks expanding over the course of the academic year. Meanwhile Rehm and Notten's (2016) research similarly reported growth in the size of educators' professional Twitter networks over time. In the context of higher education, Veletsianos et al. (2018) found that many academics take extended breaks from their professional uses of Twitter. There may also be an ebb and flow

for K-12 educators in terms of which people, spaces, and tools they access or utilize in their PLNs (Harvey and Carpenter 2020).

For some educators, the size of their networks may not necessarily change even while their PLNs otherwise evolve in nature. For example, some professional ties might weaken and other ties could strengthen as time passes, thus changing the network structures and resources teachers are able to access (Seibert et al. 2001). A new curricular reform, the revision of subject matter standards, or an updated school policy could all cause educators to re-prioritize particular people, spaces, or tools (e.g., Fischer et al. 2019). Additionally, online dynamics can change in ways that cause individuals to disengage or seek out new places to connect with others. For instance, while educator online spaces appear to be less toxic than many other places online, harassment, negativity, and other forms of implicit or explicit bigotry can occur in these platforms and drive away individuals (Krutka et al. 2019; Nagle 2018). The ways in which educators interact in online spaces can also shift over time. Biddolph and Curwood (2016) found that, for some educators, online role changes–such as moving from lurking to leading–were more salient than the size of their networks. In sum, while the limited existing literature on continuity and change in educators' professional learning in a digital era offers insights on some aspects of the phenomenon, there is still much to be learned. We aim to help address this gap in the literature in the hope that our work might contribute to understanding of the multifaceted elements that shape educator PLN growth over time.

Methods

While researchers have found that educators' PLNs can influence changes in teaching and potentially impact student learning, it is also critical to look at whether PLNs change over time, as shifts in the people, spaces, and tools in PLNs may lead to changes in related outcomes. Additionally, examining changes in PLNs can yield new insights regarding educators' dynamic relationships with PLNs. Therefore, for this exploratory study, we sought to move beyond a single snapshot of educators' PLN engagement to discern the shifts that occurred over a four-year period. Our goal for the study was not to generalize the findings to a broader population; instead we aimed to identify common themes within the dataset that might help scholars develop a holistic understanding of PLNs and help educators shift the way they reflect upon and engage with their PLNs.

Instrument

To address our research questions, we created a new online survey to follow up on the findings from our earlier PLN survey (Trust et al. 2016). The design of this new survey was guided by extant literature on professional learning, our own previous research on PLNs (Krutka et al. 2016, 2017; Trust et al. 2016, 2017, 2018), and criteria for electronic survey design quality (Dillman et al. 2009). Our research team first discussed, drafted, and refined the survey, before soliciting expert feedback

from scholars (Olson 2010). We made adjustments to the survey based on four experts' responses. The final version of the survey included two items that allowed us to pair participants' 2018 response with their 2014 response, one item where we asked about their job in 2018, and six items related to continuity and change in their PLNs. Three of these six items were close-ended in nature, while the other three were open-ended (Appendix A). We enhanced reliability and validity through data triangulation of closed and open-ended items on related topics (Shenton 2004).

The survey was an emergent and theoretically congruent extension of our previous study as our first two sections directly asked participants to address gaps in our prior data set (Charmaz 2014) and the third section asked participants to respond to items derived from recent PLN literature. In the first section of the survey, participants were asked to review their responses to our 2014 survey, in which they were asked to describe their PLNs, and indicate whether their PLN changed since 2014. In the second section of the survey, participants were asked to explain the most important changes to their PLN (open-ended), identify which elements of their PLN had changed (check all that apply), and provide a specific example of how one element of their PLN had shifted. The third section of the survey focused on the factors that influenced the PLN changes. We selected the options for the check-all-that-apply questions based on the PLN literature, including our own previous work. For example, when asked "which elements of your PLN have changed" participants could choose from people, organizations, spaces, and tools, which are common themes in PLN studies (Kearney 2019; Krutka et al. 2016, 2017; Trust et al. 2016).

Data collection

Respondents to our 2014 survey (University of Massachusetts Amherst IRB #2014–2234) had the option to leave their email address if they were willing to participate in follow-up research. Of these original 1412 respondents, 629 left email addresses (44.5%). By 2018, 137 of the email addresses had changed or been deleted, and thus only 492 emails were valid at the time of data collection. We sent emails to each of these original respondents and included their individual responses to the 2014 survey. In these emails, we requested that potential participants respond to a new survey after first reviewing their earlier responses. We also sent two reminder emails to individuals who did not respond to the initial request. In the end, 192 individuals consented to participate (39.0% response rate) in this follow up study.

Participants

Among the 2018 survey respondents, more than half (54.7%) identified as K-12 teachers. K-12 administrators and instructional support (20.3%) and higher education faculty and staff (17.2%) were also well represented in the sample. Fifteen individuals (7.8%) fell into an "other" category and included, for example, a program officer for an education-related grant agency. More than half (58.3%, $n = 112$) of the

Table 1 Participants' locations

Country	$n =$	%
United States	144	75.0
Canada	17	8.85
Australia	5	2.60
New Zealand	4	2.08
U.K	4	2.08
Brazil	3	1.56
India	3	1.56

$n = 1$ for the following countries: Argentina, Ireland, Israel, Serbia, Singapore, South Korea, Switzerland, Thailand, United Arab Emirates, and Zambia

sample identified their sex as female, while the remaining 41.7% ($n = 80$) identified as male. At the time of the data collection in 2018, the participants' mean years of experience working in education was 20.57 (SD = 8.63). Participants resided in 17 countries (Table 1). Because the survey did not require participants to respond to every prompt, the number of responses for individual prompts varied slightly.

Data analysis

We engaged in thematic analysis of responses to the open-ended items (Braun and Clarke 2006). For qualitative data, our research team engaged in iterative cycles of individual coding and group discussion to reconcile differences of interpretation, refine the code structure, and consider emerging themes (Saldaña 2016). To increase credibility and trustworthiness, we employed investigator triangulation by having two or more researchers involved in the analyses of all qualitative data (Elliott et al. 1999).

When we initially analyzed the data from the three open-ended prompts, the authors together coded a subset of responses to individual survey items. This resulted in an initial tentative code structure with seventeen codes. Next, the three authors individually coded thirty responses with this initial structure. However, we realized a number of participants' responses to individual open-ended items were referring to their responses to previous open-ended items. To accommodate this, we elected to combine responses to the three open-ended items into one larger qualitative response for each participant, albeit with responses from the three items differentiated by different color text.

Having reorganized the data, we again individually re-coded the first thirty responses in this new combined format using the initial coding structure. We then further discussed the code structure, resulting in revisions to two codes and adding two new codes. We divided the remaining data so there was a first and second coder for each response. After we coded all of the responses and the first and second coders had reconciled discrepancies in coding, we further discussed the

coding structure. This led to two codes being absorbed into other codes, yielding our finalized coding structure of seventeen codes (Appendix B). Due to the interpretive nature of this type of qualitative coding, we relied upon intensive group discussion and consensus to reach agreement upon codes, rather than on an interrater reliability statistic (Saldaña 2016). After coding, and further discussion regarding our emergent findings, we interpreted these results through the lens of Bronfenbrenner's social ecological model.

We also conducted quantitative analyses to further examine patterns in both the quantitative and qualitative data, the latter of which were assigned numerical codes. We analyzed the data using descriptive statistics to report frequency counts and percentages for quantitative survey items. We utilized SPSS Version 25 to run chi-square cross tabulations tests of independence on all items. This allowed us to see significant relationships between the codes as well patterns and trends among those statistical relationships. We checked that assumptions for chi-square tests were met.

Findings

RQ1: In what ways do educators perceive their professional learning networks have changed and stayed the same over the previous four years?

We asked participants to reflect upon continuity and change in their PLNs over a four year period. While the vast majority ($n = 174$, 90.6%) indicated that their PLNs had changed over time, a small number ($n = 18$, 9.4%) expressed that their PLNs, at least in part, remained unchanged. For example, an ICT coordinator from India wrote, "Not much has changed for me. I continue to swear by my Twitter PLN which has widened since 2014. I still connect regularly with it to get ideas for my class." However, the same individual shared in response to a different prompt, "I've also started using Facebook and blogs much more than I used to in 2014…I have become an active professional blogger where I keep sharing my classroom practices." While this educator initially reported continuity in her PLN activities, later in the survey she indicated that she actually had shifted some spaces, and the role she played in them. Overall, participants who stated in response to the early survey question that

Table 2 Participants' reported changes in different elements of their PLNs

Type of change	% of 192 (%)	$n =$
Change in people who are part of my PLN	78.6	151
Change in particular online and/or offline professional spaces where I engage with others (e.g., social media sites, online communities, conferences)	66.2	127
Change in organizations that are part of my PLN	59.4	114
Change in tools to access, curate, or share information (e.g., social bookmarking tools, eNewsletters, RSS readers)	40.1	77
	Total:	469

their PLNs were unchanged were actually more likely to indicate in later qualitative responses that the tools (e.g., blogs, eNewsletters, Feedly) they utilized had shifted, X^2 (1, $N=192$)$=4.173$, $p=0.041$.

When prompted to identify types of PLN changes from a list of options, participants reported that, on average, 2.44 PLN elements changed. They most frequently noted changes in the people who were part of their PLNs, followed by changes in spaces, and then professional organizations (see Table 2).

We also asked participants to explain the most important changes to their PLNs and provide a specific example of change. All participants ($n=192$) responded to the prompt regarding the most important changes and 180 (93.5%) provided a specific example. Upon review of these 372 open-ended responses, we identified some common types of changes that matched quantitative results (i.e., people, spaces, tools), as well as additional themes (i.e., engagement, network size, topic focus) that spanned various levels of the social ecological model.

People changes

The type of change respondents most frequently discussed was a change in people ($n=103$; 53.6%). Participants described multiple ways the people in their networks shifted, from adding new work colleagues at the microsystem level of their schools, to building stronger relationships with people in their networks, to connecting with specific scholars or educators at the mesosystem level via social media. Forty-six respondents (24.0%) specifically mentioned intentionally seeking out people they wanted to add to their networks. This intentional search for people often occurred beyond their school buildings, at the mesosystem level. For instance, a high school teacher shared, "My PLN in 2014 looked and sounded like me. Since then I have made a conscious effort to use Twitter to follow people who are experts in fields that I need to know more about—particularly social justice." By seeking out specific people, this individual changed their PLN such that they were able to broaden their "knowledge of inequity and disparity in many areas."

Space changes

Another common PLN change type we coded was a shift in engagement within a particular space ($n=91$; 47.4%). Some participants reported increasing their participation level, while others decreased it. Individuals described changes in their interactions within a space or the roles they enacted, as one educator commented, "I went from being a 'consumer' of better science practices and PD to being a facilitator in future workshops." Participants also altered the spaces in their networks ($n=87$; 45.3%). Individuals reported both joining new spaces and leaving spaces where they previously participated. For instance, one teacher described how she changed social media sites: "Twitter chats were very big to my growth 4 years ago … but they became redundant, and I realized I was spending more time "chatting" than doing … I found a specific Facebook group where you could go at any time to follow the conversation and share materials." Although shifts in spaces often pertained to spaces associated with the mesosystem, a few participants also reported

moving from digital spaces to face-to-face settings. For instance, one assistant principal shared, "I now use Twitter far less than before. When I do engage by PLN, it is with people who are present in-person and local."

Another theme was a change in the size of participants' networks ($n=61$; 31.8%). As educators alter the people, spaces, and levels of engagement with their network, this can also accompany a change in network size. Some participants reported increasing or decreasing their network size in terms of numbers of people. Educators also identified changes in the number of spaces in their PLNs. For example, one teacher shared, "Since 2014, I have expanded my PLN by joining new communities." Overall, more responses referenced PLN growth over time ($n=56$; 29.2%), rather than narrowing ($n=5$; 2.6%).

Tool changes

Approximately one-third of participants ($n=63$; 32.8%) identified changes in the tools they utilized as part of their PLNs. Participants described multiple types of changes, from using new tools, to discontinuing use of specific tools that were no longer relevant, to changing engagement levels with tools (e.g., blogging more or less). Participants who reported changes in the tools they utilized also were likely to identify changes in the spaces that were part of their PLNs, X^2 (1, $N=192$) $=3.97$, $p=0.046$, and their level of engagement in particular PLN spaces, X^2 (1, $N=192$) $=9.74$, $p=0.002$.

Two additional themes pertained to topic focus ($n=48$; 25.0%) and professional organizations ($n=30$; 15.6%). As participants' interests, goals, or jobs changed, they often modified the topics central to their PLNs. Respondents who mentioned a change in the topics they focused on in their PLNs were more likely to also refer to a transformation in their interests, X^2 (1, $N=192$) $=25.17$, $p<0.001$, and job switches, X^2 (1, $N=192$) $=13.27$, $p<0.001$, as influencing their PLN. One educator described how a shift in teaching responsibilities influenced her PLN topic focus: "When I took the survey I was teaching science, but now I am teaching a STEM elective course in the CTE department, so my PLN now revolves around this course and people who can support me in teaching it." Interestingly, while 114 participants indicated changes in organizations in the quantitative data, only 30 individuals described instances of these changes in their open-ended responses, indicating they may not have considered this type of change as important as other shifts in their PLNs.

Although we did not explicitly ask participants for examples of what outcomes resulted from the changes to their PLNs, a few participants did address how changes to their PLNs affected their learning or teaching. For example, an educator who intentionally used social media to follow more people concerned with "critical pedagogy and critical race theory" felt "buoyed" by her PLN and as a result sought to "address racial inequity in the classroom." This respondent reported a shift in her teaching practice as an outcome of changing her PLN. A few other respondents indicated outcomes resulting from PLN changes, such as discovering new teaching strategies, ideas, and tools, accessing diverse perspectives, increasing their pool of educators to learn with, and shifting classroom practices and routines. Similarly, a few

respondents identified shifts in student learning outcomes due to their PLN changes. These individuals' responses focused on changes in students' academic knowledge, skills, or use of digital tools. For instance, one participant asserted that changes to her PLN had helped her become "better able to prepare myself and my students for the future."

We address our second research question on the causes of PLN changes in the following section. However because participants often described changes and their causes in an interconnected fashion, the section that follows provides further examples of the nature of PLN changes.

RQ2: In instances of change, what do educators perceive as causing shifts in their professional learning networks?

Participants attributed the changes in their PLNs to various factors. When asked to select from a list of predetermined options (Table 3), they most frequently indicated that changes in the learning opportunities available to them were a major contributor to modifications to their PLNs ($n=78$; 41.7%). More than one-third of educators also noted changes in professional roles, responsibilities, goals, and interests as major contributors to PLN changes. Conversely, changes in participants' personal lives (20.5%) and technology uses (24.5%) were less frequently considered major factors contributing to PLN change.

When we asked participants to identify the most important factors contributing to changes in their PLNs in an open-ended prompt, the results differed some from the quantitative item: new or different learning opportunities were rarely mentioned ($n=15$; 7.8%). Instead, the most commonly cited influences on PLN changes were job-related factors ($n=117$; 60.9%), followed by people or organizations ($n=57$; 29.7%), technologies ($n=38$; 19.8%), and interests or goals ($n=36$; 18.8%). This suggests that while participants' viewed new learning opportunities as playing a role in shaping their PLNs, they did not consider them the most influential element of change.

Influence of jobs on PLNs

Participants offered various examples of how shifts in their jobs led to changes in their PLNs ($n=117$; 60.9%). For instance, a new assistant professor wrote, "The only major change is adding people and organizations related to my new position at the university. Learning sciences is a new field for me, and my PLN reflects my entry into that field." In this case, changes at the microsystem level in terms of a new job led this individual to connect with different people and organizations at the mesosystem level. Respondents reported that their new positions or roles influenced the spaces in which they engaged in their PLNs. Some of the participants also noted that the increased demands of their new positions or roles influenced their PLN interactions. For instance, one educator commented that new job responsibilities resulted in less time for active engagement in digital spaces: "When I responded in 2014, I was posting to a blog at least twice a month. I was also contributing to Twitter chats on a

Table 3 Responses to "Indicate factors contributing to changes in your PLN"

Question	Did not contribute to changes (%)	n =	Minor contributor to changes (%)	n =	Major contributor to changes (%)	n =
Change in learning opportunities available to me	26.2	49	32.1	60	41.7	78
Change in my professional role	37.4	70	25.1	47	37.4	70
Change in my professional responsibilities	34.6	64	28.7	53	36.8	68
Change in my professional goals	25.5	47	40.2	74	34.2	63
Change in my professional interests	20.9	38	45.1	82	34.1	62
Change in technologies	43.5	80	32.1	59	24.5	45
Changes in personal life	49.7	92	29.7	55	20.5	38

weekly basis. With my current job responsibilities, I feel like I have less time to contribute." Due to new professional obligations at the microsystem level, this educator moved away from multidirectional knowledge exchanges at the mesosystem level to unidirectional knowledge acquisition.

Other job-related factors influencing people's PLN changes included district or school initiatives (e.g., "Twitter was pushed by our district as a way to expand our PLN"), lack of administrative support, changes in school personnel, shifts in grade level or subject, retirement, and awards/fellowships. A couple of participants noted that increasing confidence in their practice shaped their PLN engagement, as one educator shared, "I've become more confident in the areas I teach and don't spend a lot of time on Twitter."

Influence of people and organizations on PLNs

Participants ($n=57$; 29.7%) reported that people in their local (microsystem) and online (mesosystem) networks often influenced various changes in their PLNs over time. The influence of people and jobs was particularly interconnected in shaping PLN changes, and involved interplay between the microsystem and mesosystem levels. For example, one educator wrote, "Interacting with colleagues from administration in my district, as well as leaders in the ministry of education has impacted my interests and dialogue around teaching," and another participant shared, "My principal changed and my new one doesn't push me as much and encourage me to keep the PLN going strong." A few participants indicated that their new roles opened up access to local colleagues who were more influential in their learning and that they therefore no longer needed as much engagement with their online networks.

Some participants indicated that the actions of people in their online networks caused changes in their PLNs, most commonly regarding the spaces where they participated. A few educators reported shifting to new spaces along with colleagues in their network. As an illustration, one respondent shared, "many high school psychology teachers who used to communicate and share via Twitter, clustered around the #psychat hashtag, have left the platform for a closed, private group on Facebook." Other educators changed spaces because of what they deemed to be negative comments:

> Our online community on Twitter was ruined because many people were being publicly attacked by a few others for not having enough research to support their comments and ideas. So I'm not on Twitter nearly as much and have shifted to Facebook groups primarily because they can be better regulated …
> The decimation of a community on Twitter due to harsh online bullying from a few specific professionals who ignored feedback from the rest of the group.

Consistent with such examples, our quantitative analysis suggested that respondents who identified people as causing changes to their PLNs also frequently mentioned changes in PLN spaces X^2 $(1, N=192)=6.84, p=0.009$.

A few participants noted that they sought out specific people or groups of people to add to their PLNs upon reflection and evaluation of the people in their networks.

One educator reported that, "I've been seeking greater breadth and diversity in the members of the PLN I've cultivated. This was a conscious decision as I was taking a look at whose voices I listen to." Participants who referred to such intentional changes in the people they included in their PLNs also were more likely to mention shifts in their professional interests as causing PLN change, both for a quantitative item, X^2 (3, $N=188$)$=12.99$, $p=0.005$, and qualitative code, X^2 (1, $N=192$)$=8.3$, $p=0.004$. Another teacher relayed how reflecting upon the people in her network resulted in a shift from mesosystem-level online to microsystem-level face-to-face engagement:

> I lost faith in the online Twitter chats as I got to know some of the moderators. Words can sound really good in 280 characters, but when I realized how they practice and how much different than what they "preach" I left the Twitter chat world and dove more into personal exchange PD alongside like-minded educators.

A small number of participants described how joining or increasing engagement with professional organizations resulted in PLN changes. One educator wrote, "I have also been accepted to the board of a local tech organization called Cahuilla CUE… I am an event coordinator. I do not attend tweet-ups now…instead Cahuilla CUE has coffee meetings, brewCUE and a major conference held in my town, Palm Spring." Such shifts in organizational membership resulted in changes to the participants' network size and type of interaction at the mesosystem level. Moreover, changes in participation in organizations also tended to link with different levels of engagement in spaces, X^2 (1, $N=192$)$=4.32$, $p=0.038$, and shifts in interests, X^2 (1, $N=192$)$=5.44$, $p=0.02$. While we cannot address causation, it is possible that involvement with new professional organizations could result in involvement in associated online groups and spaces and the discovery or prioritization of new interests.

Technology

The changing technology landscape, and ways in which people use digital technologies, appeared to play an influential role in shaping some participants' PLNs ($n=38$; 19.8%). One educator described how changes in the types of available digital technologies and the ways people engaged with them influenced his network:

> The tools and means have changed. New tools have come onto the scene and others have retired. Social bookmarking has fallen by the wayside, but regular, ongoing conversations through Slack (instead of Skype chat) have become central to my PLN efforts. Again, it boils down to the technology and the dynamics of the social tool. I can't remember the last time I blogged, for example, and while I have a professional FB page, I don't get a lot of interaction from that. Instead, tools like Twitter are still at the core of a public PLN, but private groups in Slack, and even SnapChat have become more effective and sustainable.

Educators identified a number of different social technologies, such as Slack, Snapchat, Instagram, Flipgrid, Zoom, Voxer, collaborative annotation tools (e.g., Hypothes.is), and Google Apps, that had become more popular since 2014. These technologies offered distinctive ways of interacting with other educators. For instance, a special education teacher shared that when her PLN was first starting out, "we only had Twitter and teacher blogs in order to connect with other educators. Now I can go on Zoom and chat with educators and the actual author of the book we're reading and discuss best practices for our classrooms." With the exosystem level featuring more technologies, educators had additional ways in which they could interact with their PLNs.

Participants also detailed why they stopped using certain digital technologies. In some cases, participants reported that particular technologies were no longer useful or were defunct. In other cases, individuals identified concerns and issues with social technologies that caused them to find new spaces and tools for learning. Respondents reported dismay with the echo chambers in certain online spaces or the ways in which social media corporations tracked and misused user data. For instance, one person wrote, "Twitter feels repetitive and Facebook is tracking data I don't want it to have." Two individuals shared how toxic political conversations on social media led them to seek out other learning spaces. Exosystem-level decisions by technology companies regarding data privacy and how to regulate or moderate user activities thus affected educators' PLNs. These examples also highlight how changes in technologies, and the ways in which people engage with them, can impact PLNs. In some instances, technology changes appeared to be associated with job related changes. For example, several respondents referred to moving to jobs at schools that used different learning management systems or productivity tools. However, on the whole, respondents who mentioned changes in technology as a factor in PLN change were actually less likely to also attribute change in their PLN to changes in jobs, X^2 $(1, N=188)=11.88$, $p=0.001$, professional roles, X^2 $(3, N=188)=15.82$, $p=0.001$, and professional responsibilities, X^2 $(3, N=188)=9.36$, $p=0.025$.

Shifting interests and professional goals

PLNs shift and grow with educators' changing interests, needs, and goals; 36 (18.8%) participants mentioned such changes. For instance, one participant commented, "My PLN is in continual evolution, an iterative process of continually refining it to meet my current needs." A K-12 teacher, described how her PLN influenced her interests, which in turn shaped her PLN:

> The more I learn from my PLN the more my interests grow and shift. If my interests weren't shifting I would be concerned I wasn't actually gaining much from my time spent online. The more I read and connect, the more I gain understanding in a wide range of areas, and the more my curiosity grows.

When PLNs are enhanced by digital connections they can lead to serendipitous learning opportunities that result in the discovery of new ideas or topics, which participants did not originally set out to explore. Furthermore, flexible curiosity-driven

learning means that participants' PLNs and their individual-level interests are inextricably linked.

Participants indicated that their interests tended to change with shifts in roles, jobs, or professional aspirations. When respondents referred to shifts in their interests as causing changes in their PLNs, they also tended to mention changes in their professional roles, X^2 (9, $N = 188$) = 56.63, p < 0.001, responsibilities X^2 (9, $N = 188$) = 58.87, $p < 0.001$, and goals X^2 (9, $N = 188$) = 141.93, $p < 0.001$, as also influencing their PLNs. Changes in professional aspirations also influenced interests. An educator shared how her PLN was shaped by her career goals: "I want to move up in my career to a leadership role so I have found using leadership groups on social media to be a big help to me." Changes in educators' interests and goals seemed to impact their PLNs in various ways, from network size, to new spaces and people, to different topics. For example, one respondent wrote, "My interests have shifted away from seeking advice from practitioners to following education policy experts and professors, ultimately engaging in systemic change conversations with people." The evolution of this educator's individual-level interests therefore affected who she sought out to learn from and with at the mesosystem level. Shifts in jobs and responsibilities can lead to changes in interests or vice versa and these examples highlight the interconnected nature of the elements that cause PLN changes.

Other influential factors

Beyond the factors listed above, participants identified multiple elements that evoked changes in their PLNs. The most common components we coded were lack of time ($n = 34$; 17.7%) and personal lives ($n = 21$; 10.9%). Participants also listed the following elements as influential to their PLNs: enrolling in graduate school, changing attitudes, and shifting political and social contexts. For example, one educator shared that she "shifted to interests in social justice and US politics as a result of the 2016 election. [She became] more interested in political actions of teacher organizations (i.e., Oklahoma teachers' walkout)."

Some participants entered new jobs, increased their workload, or coped with changes in their personal lives (individual level), and thus had less time to engage with their PLNs. For instance, a teacher and technology coordinator wrote, "I used to be able to use my 30-min commute (each way) to access my PLN just to 'check-in.' I now have to drive myself, so I cannot do that." In reflecting on their social media engagement, some participants determined their time could be better utilized. Participants who noted that time pressures led to PLN changes were more likely to refer to shifts in which spaces were part of the PLN, X^2 (1, $N = 192$) = 4.22, $p = 0.04$, and changing levels of engagement in particular spaces, X^2 (1, $N = 192$) = 8.91, $p = 0.003$. Such participants may have been searching for spaces that were more compatible with the new time pressures they were feeling, and/or could have been engaging less in some spaces simply because of less available time to do so.

Another influential factor shaping participants' professional learning was changes in personal lives. Examples of these changes at the individual level included marriages, health issues, care for family members, new family members, and house purchases. For instance, an educator noted that changes in his son's sleep patterns

limited his ability to engage with others through social media: "My son has gotten older and isn't taking naps or going to bed by the time my favorite Twitter chats start." Another participant related that, "Family illness has had a huge impact. We are discovering a 'new normal' and I have disconnected myself from most of my online connections due to limited time and changing priorities." Respondents who mentioned changes in PLN space engagement tended to also mention personal life factors as influencing PLN change, on both quantitative, X^2 (3, $N=188)=8.56$, $p=0.036$, and qualitative items, X^2 (1, $N=192)=16.4$, $p<0.001$.

Discussion

Our participants disclosed both the status and reasons for continuity and change across their professional learning networks during the 2014–2018 time period. Our analysis of the data suggests that a complex interplay of factors including educators' interests and goals, schools, professional communities, technologies, and larger contexts helped explain educators' PLN shifts over time. Altogether, most educators shifted their PLNs to meet their changing professional needs within their contexts; in contrast, predetermined and standardized PD often struggles to accommodate educators' diverse and evolving needs. We now detail factors influencing PLN change individuals expressed for each level of our social ecological model.

At the individual level, educators' expressed that their personal characteristics and concerns influenced their PLNs in both our closed- ($n=62$, 34.1%) and open-ended ($n=36$, 18.8%) queries. Their interests were disparate and interrelated with various other systems that included changes in their personal lives, jobs, or even serendipitous interests that grew out of social media interactions. This finding aligns with Huberman's (1995) assertion that reliance exclusively on school-based professional learning can be problematic given that in many schools educators have been "brought together more by the vagaries of career paths and the central office than by affiliation or purpose" (p. 195). Social media spaces offer educators opportunities to connect with peers with similar affinities even when colleagues in their building have different concerns. Researchers have reported that many educators find benefit in connecting freely with those pursuing similar aims whether in open networks, closed groups, or face-to-face spaces (e.g., Hur and Brush 2009; Wesely 2013).

At the microsystem level, our participants' identified multiple factors that immediately influenced their PLNs. From people in participants' personal lives to close social media contacts to the changes associated with a shift in jobs or job responsibilities, educators identified numerous proximal influences that resulted in PLN changes. In some cases, personal or professional changes resulted in less time dedicated to informal learning and, in other instances, job changes led to joining new online communities to investigate new topics. Most educators identified shifts in people in their PLNs, whether work colleagues or online connections, and a quarter of respondents pointed out that they intentionally sought out certain colleagues or kinds of colleagues who might help them grow. This

suggests that some educators may be quite intentional about reflecting upon the composition of their PLNs and strategically making changes to whom it includes.

At the level of the mesosystem, our participants' described various ways in which groups such as professional organizations and online communities affected their PLNs. Many educators communicated that changes in organizations, and growth in the size of their online and face-to-face networks affected their PLNs. However, only a small number of participants suggested that joining organizations influenced their networks in particularly significant ways. Formal professional organizations might provide some valuable PD and other benefits, but they may also differ in character and methods from the online networks many respondents referenced. It could also be the case that traditional education organizations are still learning to adapt to the possibilities for networking and community that are afforded by online environments (Brickner 2016).

At the exosystem level, educators expressed ways in which the social contexts of their institutions or online spaces affected their PLNs. In terms of institutional changes, mandates such as requiring that all teachers in the school use Twitter, and initiatives such as shifting to technology-rich classroom environments, shaped how and with whom educators connected for professional learning. New technologies came onto the scene, while other technologies faded due to poor design or lack of popularity or upkeep. Furthermore, the design of social technologies, such as Facebook and Twitter, directly influenced participants' networks and interactions with others. Consistent with concerns previously expressed by Nagle (2018), some participants cited the growth of toxic environments in online spaces and data tracking by social media companies as negative factors that drove them away from online interactions. While social media technologies augment some professional possibilities, the participants generally did not discuss the ways these media create environments in which particular cultures arise, and subsequently shape and limit engagements (Mason 2019). However, social media platforms might also counteract career plateaus or disengagement from collaboration (e.g., Richter et al. 2011), encourage serendipitous learning that could inspire new lines of professional inquiry (e.g., Kop 2012), and support educators who feel geographically or intellectually isolated (e.g., Carpenter and Krutka 2015).

Finally, while educators did not tend to address how cultural norms and social structures on the macrosystem level impacted their PLNs, such factors may well have been interconnected with others. For example, it is likely that common features of educational institutions, like cultures of standardization, and social-cultural norms within an online community (e.g., reciprocity, positivity, authentic posts; Trust 2017), shape the types of learning opportunities and goals which educators pursue. Furthermore, some aspects of informal professional learning can be implicit and unconscious (Eraut 2004; Evans 2019), and it may be that educators are sometimes less keenly aware of how macrosystem factors influence their PLNs.

Change in participants' PLNs sometimes appeared to result from interconnected influences at various levels within Bronfenbrenner's (1979) set of nested structures. We identified numerous factors that tended to be linked in ways that further studies might tease out. For example, a shift in topic focus (e.g., change from science to STEM) tended to also be concurrent with shifts in technologies, interests, jobs,

people, and tools, as well as digital, face-to-face, and blended spaces. Throughout the findings section we identified such links between variables to note that respondents' described their PLNs as fluid, organic, and interconnected. The complex nature of PLN change may be part of why one-size-fits-all and one-off PD so often fails to have the hoped for impacts.

On the whole, the shifts, consistencies, and variation in our participants' PLNs over four years aligned with our previous finding that educators utilize PLNs to meet their diverse needs (Trust et al. 2016). As Wilson and Berne (1999) argued, educators' professional learning is likely to include a patchwork of diverse activities, and social media has afforded more, different, and unique opportunities for informal learning around issues of interest. In considering the systems influencing educator PLNs, it seemed they were often impacted by factors from multiple systems or levels. For example, one teacher shared that she was teaching at a new school with new colleagues and PD opportunities, but her PLN also changed because she had engaged with new online groups and job responsibilities. While we coded each aspect of this educator's shifts separately, there is little question these elements were interconnected. This study offers insights into the multidimensional systems of people, spaces, and tools that make up educators' PLNs. It might yield fresh understandings of how educators can cultivate PLNs, and also how colleagues, administrators, and policymakers can encourage professional learning beyond the standard formal PD fare.

Limitations

This study was limited by its reliance upon a convenience sample and self-report data. The survey collected limited quantitative data, and as a result we can provide only relatively basic statistical analyses. The participants may not reflect trends in the overall population of educators. For example, negative online interactions may cause some educators to avoid online spaces, but such experiences may have been underrepresented in our data because our participants were recruited from online spaces. Furthermore, educators have not always proven to be reliable narrators of changes in their own practices (e.g., Cohen 1990). However, we attempted to counteract this by refreshing the participants' memories of the past by sharing with them their 2014 descriptions of their PLNs.

Implications for practice, policy, and research

Acknowledging these limitations, we believe this study offers helpful implications for educator practice, policy, and future research. Our findings highlight that educators can cultivate and personalize their PLNs over time in a variety of ways to support their evolving interests, needs, and aims, and that outside factors are also likely to impact their PLNs. Through reflection, educators should continuously evaluate how their PLNs might mature, and target ways to improve and deepen their PLN experiences (Krutka et al. 2017). Furthermore, while some aspects of PLNs may remain consistent or stable, it appears educators should be intentional about and

reflect upon the evolution of their PLNs. Given one large-scale study that suggested experienced teachers' growth can plateau and that they can even experience gradual declines in their pedagogical skills (Van de Grift et al. 2011), educators should leverage the potential of evolving PLNs to expose themselves to people, spaces, and tools that might combat such stagnation. A potential benefit of digitally-augmented networks is the exposure they can bring to novel and even un-searched-for learning opportunities (Kop 2012). Educators must also consider how sustainable their PLN activities are, as initial enthusiasm associated with interacting with new colleagues can quickly turn to burnout if teachers overextend themselves (Carpenter and Harvey 2019).

Despite the changing landscape of educator professional learning, many school districts and certification regimes accept limited types of activities for continuing education credit or licensure requirements. However, if only formal PD is ever encouraged and recognized, school districts can potentially miss out on opportunities to leverage the collective knowledge and resources educators build through more informal and self-directed learning (Jones & Dexter, 2014). Policy makers might consider creating definitions of professional learning that accommodate the variety of participant-driven, voluntary professional activities that shift and evolve with educators' changing interests and goals, Although the formal PD that many schools emphasize can positively impact teacher and student learning, and will remain part of the professional learning landscape, it is clear that educators do not learn and network purely through such PD formats. Many educators do not want to learn solely about the topics their state, district, or school prioritize (Ferriter and Provenzano 2013). Furthermore, the complexity of teaching means that educators rarely learn in the linear fashion presumed by many PD activities. Educators begin new professional learning experiences from different starting points (Keay et al. 2019) and seek to implement what they learn in unique contexts. If education systems are truly committed to educator development, then they should seek to understand and support the full scope of professional activities and learning in which those educators engage. While teachers' PLN activities may sometimes be less explicitly linked to institutional goals or strategic plans, it is likely that some PLN activities can be harnessed for the benefit of schools or districts. For example, institutions might consider supporting educators in creating digital backchannels in social media spaces by using a school or district Twitter hashtag or forming groups to encourage sharing within the immediate school environments (e.g., Carpenter and Morrison 2018). Or, administrators may encourage educators to reflect on and intentionally consider what people, spaces, and tools can help them grow as professionals, particularly in instances of job or role changes. Pre-service teachers (PSTs) and early career educators may also benefit from understanding the diversity of learning opportunities and support from which inservice educators in our sample benefitted and considering how their professional learning and networking may shift over the course of their careers.

The technology-enhanced professional learning of educators is an area ripe for further study. While copious prior research has focused on episodic or sporadic PD events or formalized programs, there is a shortage of investigation of educators' learning in the wild (Evans 2019). Regarding matters of PLN continuity and change, researchers could expand on recent work by Xing and Gao (2018) which sought

to define what factors keep educators returning to certain online spaces over time. Similarly, future research could further delve into specific types of PLN changes we have identified, and if certain kinds of change appear to contribute to particular outcomes in terms of educators' learning or their teaching. To augment and triangulate educators' self-reports, content analysis of social media postings over an extended period of time could contribute to understanding of changes in educators' online behaviors. Beyond issues of continuity and change, there are other important gaps in the knowledge base regarding educators' PLNs. Investigation of how educators negotiate commercial aspects of the technology platforms that are parts of their PLN would benefit the field (Kelly and Antonio 2016).

Conclusion

In this paper, we have shared findings that fill a gap in the literature by exploring the continuity and change that occurs in PLNs over an extended period of time. Professional learning is a complex process, and there is a need to "develop a more robust and in-depth understanding of how this complex process evolves over time" (Keay et al. 2019, p. 125). Simplistic notions of educator learning that presume a straightforward transfer of empirical knowledge and seamless translation of that knowledge into practice fail to explain and respond to how professional growth transpires and ignore the multiple types and levels of systems that influence educators' actions. Prior research suggests educators bring diverse motivations and objectives to professional learning (e.g., Hur and Brush 2009; Kennedy 2016; Selwyn and Gorard 2004), and our findings indicate the extent to which these diverse purposes translate into variations in changes in educators' PLNs. While previous studies have captured useful snapshots of educators' perspectives on their PLNs, this research offers the benefit of providing insights based on teachers' reflections regarding their PLNs at two points in time. Digital technologies have been credited with changing the educator learning and growth landscape by allowing for more self-directed and personalized professional activities. The PLN concept has emerged as a means to describe this technology-enhanced approach to professional learning. This research demonstrates how PLNs are dynamic in nature and how educators' professional activities are influenced by a complex multitude of proximal and distal factors that can both contribute to and impede change.

Compliance with ethical standards

Conflict of interest The author(s) declare that they have no competing interests.

Appendix A: Survey Items

Please review your original survey response in which you described your PLN (attached to the e-mail that included the link to this survey). Has your PLN changed since filling out our survey in

2014? O Yes   O No

Please explain the most important changes to your PLN since 2014.

_____

_____

_____

Which elements of your PLN have changed? (Check all that apply)

☐   Change in people who are part of my PLN

☐   Change in organizations that are part of my PLN

☐   Change in particular online and/or offline professional spaces where I engage with others (e.g., social media sites, online communities, conferences)

☐   Change in tools to access, curate, or share information (e.g., social bookmarking tools, eNewsletters, RSS readers)

Please provide a specific example of how one element of your PLN has changed.

_____

_____

_____

Indicate factors contributing to changes in your PLN.

	Did not contribute to changes	Minor contributor to changes	Major contributor to changes
Change in my professional role	O	O	O
Change in my professional responsibilities	O	O	O
Change in my professional goals	O	O	O
Change in my professional interests	O	O	O
Change in learning opportunities available to me	O	O	O
Change in technologies	O	O	O
Changes in personal life	O	O	O
Other	O	O	O

Please explain the most influential factor(s) contributing to changes in your PLN since 2014.

_____

_____

_____

Appendix B: Codebook

Category	Code	Definition
Type of change	People (general)	Adding or subtracting particular people as well as changes in depth of relationships with existing people
	People (intentional)	Seeking out particular people or kinds of people to add to their PLN
	Spaces	Joining new spaces or leaving spaces
	Shift in engagement in a space	Increasing or decreasing engagement within a particular space
	Network size	Growing or shrinking of the overall number of people in the PLN
	Tools	Using new tools, discontinuing use of tools, changing how tools are used
	Topic Focus	Adding, removing, or changing degree of attention to particular topics as focus of learning and development
	Professional organizations	Joining, leaving, or changing engagement levels with particular professional organizations
	Face-to-face	Adding more face-to-face components to their PLN
	Interactions	Interacting with people in new ways
Cause of PLN change	Interests	New or different professional interests influence change
	Job	New or different job roles, responsibilities, and/or sites influence change
	People	New or different people and/or people's behavior influence change
	Technology	New technologies or changes to existing technologies influence change
	Time	A shortage of time or time pressures influence change
	Personal lives	Changes in participants' personal lives influence PLN change
	Continuity	In the midst of describing causes of change, also described causes or elements of continuity

References

Baker-Doyle, K. J. (2012). First-year teachers' support networks: Intentional professional networks and diverse professional allies. *The New Educator, 8*(1), 65–85.

Ball, D. L. (1996). Teacher learning and the mathematics reform: What we think we know and what we need to learn. *Phi Delta Kappan, 77*(7), 500–508.

Biddolph, C., & Curwood, J. S. (2016). #PD: Examining the intersection of twitter and professional learning. In M. Knobel & J. Kalman (Eds.), *New literacies and teacher learning* (pp. 195–218). New York, : Peter Lang.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Brickner, R. K. (2016). Tweeting care: Educators' dissent through social media in the US and Canada. *Labour/Le Travail, 77*(1), 11–36.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge: MA:Harvard University Press.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22*(6), 723.

Carpenter, J. P., & Harvey, S. (2019). "There's no referee on social media": Challenges in educator professional social media use. *Teaching and Teacher Education*, *86*, 102904.

Carpenter, J. P., & Krutka, D. G. (2015). Engagement through microblogging: educator professional development via Twitter. *Professional Development in Education*, *41*(4), 707–728.

Carpenter, J. P., & Linton, J. N. (2016). Edcamp unconferences: Educators' perspectives on an untraditional professional learning experience. *Teaching and Teacher Education*, *57*, 97–108.

Carpenter, J. P., & Morrison, S. A. (2018). Enhancing teacher education…with Twitter? *Phi Delta Kappan*, *100*(1), 25–28.

Carpenter, J., Tani, T., Morrison, S., & Keane, J. (2020). Exploring the landscape of educator professional activity on Twitter: An analysis of 16 education-related Twitter hashtags. Professional Development in Education. Advance online publication. https://doi.org/10.1080/19415257.2020.1752287.

Charmaz, K. (2014). *Constructing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

Choi, P. L., & Tang, S. Y. F. (2009). Teacher commitment trends: Cases of Hong Kong teachers from 1997 to 2007. *Teaching and Teacher Education, 25*(5), 767–777.

Choy, S. P., Chen, X., Bugarin, R., & Broughman, S. P. (2006). *Teacher professional development in 1999–2000: What teachers, principals and district staff report (NCES 2006–305)*. Washington: National Center for Education Statistics.

Cohen, D. K. (1990). A revolution in one classroom: The case of Mrs Oublier. *Educational Evaluation and Policy Analysis, 12*(3), 311–329.

Colwell, J., & Hutchison, A. C. (2018). Considering a twitter-based professional learning network in literacy education. *Literacy Research and Instruction, 57*(1), 5–25.

Dalli, C., Miller, L., & Urban, M. (2012). Early childhood grows up: Towards a critical ecology of the profession. In L. Miller, C. Dalli, & M. Urban (Eds.), *Early childhood grows up* (pp. 3–19). Dordrecht, Netherlands: Springer.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed-mode surveys: The tailored design method*. Hoboken, NJ: Wiley.

Elliott, R., Fischer, C. T., & Rennie, D. L. (1999). Evolving guidelines for publication of qualitative research studies in psychology and related fields. *British Journal of Clinical Psychology, 38*(3), 215–229.

Eraut, M. (2004). Informal learning in the workplace. *Studies in Continuing Education, 26*(2), 247–273.

Evans, L. (2019). Implicit and informal professional development: What it 'looks like', how it occurs, and why we need to research it. *Professional Development in Education, 45*(1), 3–16.

Felner, R. D., Seitsinger, A. M., Brand, S., Burns, A. M. Y., & Bolton, N. (2007). Creating small learning communities: Lessons from the project on high-performing learning communities about "what works" in creating productive, developmentally enhancing, learning contexts. *Educational Psychologist, 42*(4), 209–221.

Ferriter, W. M., & Provenzano, N. (2013). Today's lesson: Self-directed learning… for teachers. *Phi Delta Kappan, 95*(3), 16–21.

Fischer, C., Fishman, B., & Schoenebeck, S. Y. (2019). New contexts for professional learning: Analyzing high school science teachers' engagement on Twitter. *AERA Open, 5*(4), 1–20.

Fox, A., Wilson, E., & Deaney, R. (2011). Beginning teachers' workplace experiences: Perceptions of and use of support. *Vocations and Learning, 4*(1), 1–24.

Gee, J. P. (2004). *Situated language and learning: A critique of traditional schooling*. New York: Routledge.

Giles, C., & Hargreaves, A. (2006). The sustainability of innovative schools as learning organizations and professional learning communities during standardized reform. *Educational Administration Quarterly, 42*(1), 124–156.

Gleddie, D., Feith, J., Howe, P., Larsson, H., Cale, L., & Casey, A. (2017). Joey: Social media as a tool for professional development. In A. Casey, V. Goodyear, & K. Armour (Eds.), *Digital technologies and learning in physical education: Pedagogical cases* (pp. 121–136). New York, NY: Routledge.

Harvey, S., & Carpenter, J. P. (2020). Genesis and change in physical educators' use of social media for professional development and learning. *Journal of Teaching in Physical Education*, *39*(4), 445–453.

Huberman, M. (1989). The professional life cycle of teachers. *Teachers College Record, 91*(1), 31–57.

Huberman, M. (1995). Networks that alter teaching: Conceptualizations, exchanges and experiments. *Teachers and Teaching, 1*(2), 193–211.

Hur, J. W., & Brush, T. A. (2009). Teacher participation in online communities: Why do teachers want to participate in self-generated online communities of K-12 teachers? *Journal of Research on Technology in Education, 41*(3), 279–303.

Hursh, D. (2007). Assessing No Child Left Behind and the rise of neoliberal education policies. *American Educational Research Journal, 44*(3), 493–518.

Kearney, M., Maher, D., & Pham, L. (2020). Investigating pre-service teachers' informally-developed online professional learning networks. *Australasian Journal of Educational Technology, 36*(1), 21–36.

Keay, J. K., Carse, N., & Jess, M. (2019). Understanding teachers as complex professional learners. *Professional Development in Education, 45*(1), 125–137.

Kelly, N., & Antonio, A. (2016). Teacher peer support in social network sites. *Teaching and Teacher Education, 56,* 138–149.

Kennedy, A. (2005). Models of continuing professional development: A framework for analysis. *Journal of In-service Education, 31*(2), 235–250.

Kennedy, M. M. (2016). How does professional development improve teaching? *Review of Educational Research, 86*(4), 945–980.

Kop, R. (2012). The unexpected connection: Serendipity and human mediation in networked learning. *Journal of Educational Technology & Society, 15*(2), 2–11.

Krutka, D. G., Carpenter, J. P., & Trust, T. (2016). Elements of engagement: A model of teacher interactions via professional learning networks. *Journal of Digital Learning in Teacher Education*, *32*(4), 150–158.

Krutka, D. G., Carpenter, J. P., & Trust, T. (2017). Enriching professional learning networks: A framework for identification, reflection, and intention. *TechTrends*, *61*(3), 246–252.

Krutka, D. G., Manca, S., Galvin, S., Greenhow, C., Koehler, M., & Askari, E. (2019). Teaching "against" social media: Confronting problems of profit in the curriculum. *Teachers College Record*, *121*, 14.

Kyndt, E., Gijbels, D., Grosemans, I., & Donche, V. (2016). Teachers' everyday professional development: Mapping informal learning activities, antecedents, and learning outcomes. *Review of Educational Research, 86*(4), 1111–1150.

Lantz-Andersson, A., Peterson, L., Hillman, T., Lundin, M., & Rensfeldt, A. B. (2017). Sharing repertoires in a teacher professional facebook group. *Learning, Culture and Social Interaction, 15,* 44–55.

LaVoi, N. M., & Dutove, J. K. (2012). Barriers and supports for female coaches: An ecological model. *Sports Coaching Review, 1*(1), 17–37.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*(2), 129–151.

Louws, M. L., Meirink, J. A., van Veen, K., & van Driel, J. H. (2017). Teachers' self-directed learning and teaching experience: What, how, and why teachers want to learn. *Teaching and Teacher Education, 66,* 171–183.

Mason, L. E. (2019). Media literacy and pragmatism. In G. Cappello, M. Ranieri, & B. Thevenin (Eds.), *The international encyclopedia of media literacy* (pp. 1–5). San Francisco, CA: Wiley.

Michell, D., Szabo, C., Falkner, K., & Szorenyi, A. (2018). Towards a socio-ecological framework to address gender inequity in computer science. *Computers & Education, 126,* 324–333.

Nagle, J. (2018). Twitter, cyber-violence, and the need for a critical social media literacy in teacher education: A review of the literature. *Teaching and Teacher Education, 76,* 86–94.

Noonan, J. (2019). An affinity for learning: Teacher identity and powerful professional development. *Journal of Teacher Education, 70*(5), 526–537.

Olson, K. (2010). An examination of questionnaire evaluation by expert reviewers. *Field Methods, 22*(4), 295–318.

Pollock, K., Campbell, C., McWhorter, D., Bairos, K., & van Roosmalen, E. (2019). Developing a system for knowledge mobilisation: The case of the knowledge network for applied education research (KNAER) as a middle tier. In D. Godfrey & C. Brown (Eds.), *An ecosystem for research-engaged schools: Reforming education through research* (pp. 22–40). UK: Taylor & Francis.

Porath, S. L. (2018). A powerful influence: An online book club for educators. *Journal of Digital Learning in Teacher Education, 34*(2), 115–128.

Prenger, R., Poortman, C. L., & Handelzalts, A. (2020). Professional learning networks: From teacher learning to school improvement? *Journal of Educational Change Advance online publication*. https://doi.org/10.1007/s10833-020-09383-2

Prestridge, S. (2019). Categorising teachers' use of social media for their professional learning: A self-generating professional learning paradigm. *Computers & Education, 129,* 143–158.

Rehm, M., & Notten, A. (2016). Twitter as an informal learning space for teachers!? The role of social capital in twitter conversations among teachers. *Teaching and Teacher Education, 60,* 215–223.

Richter, D., Kunter, M., Klusmann, U., Lüdtke, O., & Baumert, J. (2011). Professional development across the teaching career: Teachers' uptake of formal and informal learning opportunities. *Teaching and Teacher Education, 27*(1), 116–126.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Thousand Oaks, CA: Sage.

Seibert, S. E., Kraimer, M. L., & Liden, R. C. (2001). A social capital theory of career success. *Academy of Management Journal, 44*(2), 219–237.

Selwyn, N., & Gorard, S. (2004). Exploring the role of ICT in facilitating adult informal learning. *Education, Communication & Information, 4,* 293–310.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63–75.

Smith Risser, H. (2013). Virtual induction: A novice teacher's use of Twitter to form an informal mentoring network. *Teaching and Teacher Education, 35,* 25–33.

Stepanyan, K., Borau, K., Ullrich, C. (2010). A social network analysis perspective on student interaction within the Twitter microblogging environment. In *2010 10th IEEE International Conference on Advanced Learning Technologies* (pp. 70–72). Sousse, Tunisia: IEEE.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Tour, E. (2017). Teachers' self-initiated professional learning through personal learning networks. *Technology, Pedagogy and Education, 26*(2), 179–192.

Trust, T. (2017). Using cultural historical activity theory to examine how teachers seek and share knowledge in a peer-to-peer professional development network. *Australasian Journal of Educational Technology, 33*(1).

Trust, T., Carpenter, J. P., & Krutka, D. G. (2017). Moving beyond silos: Professional learning networks in higher education. *The Internet and Higher Education*, *35*, 1–11.

Trust, T., Carpenter, J. P., & Krutka, D. G. (2018). Leading by learning: Exploring the professional learning networks of instructional leaders. *Educational Media International*, *55*(2), 137–152.

Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & Education*, *102*, 15–34.

Van de Grift, W. J. C. M., Van der Wal, M., & Torenbeek, M. (2011). Ontwikkeling in de pedagogischdidactischevaardigheid van leraren in het basisonderwijs [Development of teachers' teaching skills in primary education]. *PedagogischeStudien, 88,* 416–432.

van den Beemt, A., & Diepstraten, I. (2016). Teacher perspectives on ICT: A learning ecology approach. *Computers & Education, 92,* 161–170.

Veletsianos, G., Kimmons, R., Belikov, O., Johnson, N. (2018). Scholars' temporal participation on, temporary disengagement from, and return to Twitter. *First Monday*, *23*(11). Retrieved from https://firstmonday.org/ojs/index.php/fm/article/view/8346

Veletsianos, G., Johnson, N., & Belikov, O. (2019). Academics' social media use over time is associated with individual, relational, cultural and political factors. *British Journal of Educational Technology, 50*(4), 1713–1728.

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education, 24*(1), 80–91.

Wesely, P. M. (2013). Investigating the community of practice of world language educators on Twitter. *Journal of Teacher Education, 64*(4), 305–318.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24*(1), 173–209.

Xing, W., & Gao, F. (2018). Exploring the relationship between online discourse and commitment in Twitter professional learning communities. *Computers & Education, 126,* 388–398.