

Beginning Science Teachers' Self-Directed Learning: Improving Instructional Practice Through Social Media Use [PRE-PRINT]

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KEYWORDS

self-directed learning, professional development, beginning teachers, science teachers, instruction, social media

INTRODUCTION

IN the aftermath of the COVID-19 pandemic, disruptions to education continue to be felt. Impacts have included widespread teacher shortages (Darling-Hammond & Hylar, 2020) and burnout (Pressley, 2021). These difficulties are in addition to the reality that even before the pandemic, teachers had been leaving the classroom at an unprecedented rate (Hackman & Morath, 2018), with especially high attrition among beginning teachers (Ronfeldt & McQueen, 2017). Science, technology, engineering, and mathematics (STEM) classes are consistently difficult to staff, with higher teacher turnover rates than other subjects (Malkus et al., 2015).

Teaching is a difficult profession at any career stage, but beginning teachers' period of transition into the profession additional challenges. At a minimum, beginning teachers must navigate a transition from learning about teaching to practicing teaching. Beginning science teachers, specifically, may also still be in the process of shifting their instructional practice from teacher-centered knowledge transmission to student-centered *sensemaking* (Jaber, 2021)—that is, helping students learn by becoming “active, self-conscious, motivated, and purposeful in the world” (Fitzgerald & Palincsar, 2019, p. 228). Early career challenges may be further compounded when beginning teachers enter their school of employment with theories and methods learned in pre-service programs that are not practiced—or in some instances are actively discouraged—by experienced in-service colleagues (Feiman-Nemser & Buchmann, 1985).

Beginning teachers' early career transition has only gotten more complicated as numerous social media platforms have created new opportunities for teachers' ongoing professional learning (Trust & Prestridge, 2021). Subsequently, beginning teachers must juggle opportunity costs arising from having more outlets for self-directed learning, and they must navigate more, potentially conflicting, messages about what and how to teach. In other words, although social media may offer access to extra resources and broader expertise, these platforms introduce new complications and challenges as well.

In this context—the post-pandemic educational landscape, trends of high teacher attrition, and competing voices suggesting what and how to teach amplified by social media—teacher professional development (PD) is of utmost importance. Teacher PD can be understood as any ongoing training and support to improve the quality of teaching (Kheswa et al., 2014). Unfortunately, numerous studies, span-

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ning several decades, have reported the inadequacy and ineffectiveness of formal teacher PD programs (e.g., Darling-Hammond et al., 2009; Desimone et al., 2006; Hill, 2009; Rhodes & Beneicke, 2002; Tuli, 2017; Zein, 2016). PD has often not enacted teachers' agency; rather, teachers have found PD to feel forced because they are rarely able to choose topics and options for themselves (Auletto, 2021). Similarly, many teachers have found PD to be unhelpful because it did not align with their individual needs (Darling-Hammond et al., 2009). Furthermore, PD has often not allowed teachers to pursue their curiosity; participants are often divided as to whether the learning activities are engaging or boring (Phillips, 2008). Finally, PD has often not supported teachers' self-regulation (i.e., being aware of and making decisions to control thoughts, emotions, and behaviors while working toward desired goals), leaving teachers dependent on outside experts to sustain changes and innovations (Butler et al., 2004). As a result of these limitations, many teachers have not viewed PD as beneficial, have expressed frustration with the process, and have decided not to change their classroom practice (McChesney & Aldridge, 2021).

For science teachers specifically, background contextual factors (Avalos, 2011) further exacerbate PD challenges. For instance, pervasive and persistent barriers prohibit many individuals' entry into science, technology, engineering, and mathematics (STEM) learning and work. Barriers include *systemic forces* of exclusion like funding disparities and historic, exclusionary institutional policies (McGee, 2020). There are also *individual forces* of exclusion, such as teachers' low expectations of some students, lack of mentoring, lack of appropriate accommodations, and isolated—not collaborative—efforts to support students (Klimaitis & Mullen, 2021; Sukhai & Mohler, 2016). Taken together, these issues have created barriers to STEM education for K-12 students along lines of race, gender, and disability. STEM teachers can potentially be the catalyst to help students overcome these barriers, but they need better training (e.g., PD that enacts their agency, aligns with their needs, allows them to pursue their curiosity, and supports their self-regulation) to fulfill this role.

STEM teachers must navigate unprecedented opportunities and challenges as technology advances at an ever-accelerating pace. Ideally, PD would prepare and update STEM teachers' readiness in these areas, but technology often moves faster than PD planning. Even while STEM teachers are still learning how to proceed with new technologies, they must model best practices and ethical considerations for students. For example, recent advances in artificial intelligence (AI) have led to a proliferation of new applications and tools, ranging from facial recognition tools in the classroom (Selwyn et al., 2023) to large language models (e.g., ChatGPT) that can assist with writing code or automatically produce full essays (Williamson et al., 2023). Both facial recognition tools and large language models are producing unprecedented amounts of data about private individuals. Although these AI applications have been purported to potentially revolutionize many aspects of daily life and education (e.g., facial recognition: banking, online purchasing, proctoring of online

exams; large language models: writing of K-12 lesson plans, assistance with programming), they simultaneously raise important concerns related to how the applications' data are processed and stored. It is incumbent on developers to ensure AI applications and tools are not biased against certain groups of people (e.g., facial recognition not recognizing darker skin tones) and are not used for malicious purposes (e.g., financial hacks using deepfakes). However, there are plentiful examples of developers not fulfilling this responsibility. In this context, STEM teachers assume the burden of choosing which applications are safe to use in terms of data security and social responsibility—necessitating an emergent set of *digital literacy* skills to “perform tasks and solve problems in digital environments” (Reddy et al., 2020).

FRAMEWORK

IN response to PD limitations, STEM barriers, and technological challenges, teachers often initiate and guide their own PD through *self-directed learning* (SDL). SDL has been long established as a form of adult learning wherein teachers take ownership over what and how they learn (Knowles, 1975). First, educators identify challenges, learning gaps, and desired outcomes (Beach, 2017) related to addressing immediate problems (Louws et al., 2017). They then pursue readily applicable information (Blaschke, 2012). Past research has shown that teachers are proactive learners with a high level of ownership and autonomy over their learning goals, purposes, and processes to solve problems (Louws et al., 2017; Macià & García, 2016). Teachers seek advice and resources needed for teaching or through personal relationships in both formal and informal settings (Mercieca & Kelly, 2018; Staudt Willet, 2023). Recently, digital technologies have become integral to SDL (Merriam & Baumgartner, 2020), particularly by facilitating greater autonomy (Macià & Garcia, 2016) and increased ability to have detailed discourse around specific topics raised by teachers themselves (Carpenter & Staudt Willet, 2021). The Internet has opened new avenues for SDL, allowing educators to access expertise beyond the confines of local geography (Beach, 2017) and do so “just-in-time” and as needed (Greenhalgh & Koehler, 2017). These findings highlight the usefulness of SDL in cases of professional isolation, such as being the only STEM teacher in a school building (Yadav et al., 2016).

To supplement formal teacher education and PD options, teachers have pursued different approaches to SDL, spanning a range from in-school peer and mentor relationships to resources from social media (Avalos, 2011; Keay et al., 2019; Staudt Willet, 2023). SDL can also serve as a protective measure against teacher burnout and attrition as the systems of support and community it offers can offset obstacles to teacher retention (Saleem et al., 2023).

Existing resources abound for STEM teachers to engage as self-directed learners with agency, whether they are addressing students' barriers to STEM education, contending with the challenges of rapid technological innovations, or resisting burnout and leaving the profession. For instance, scholarship on *culturally sustaining practices* (CSP) has illuminated methods for alleviating barriers in STEM through

centering the experiences and perspectives of learners, and making teaching and learning relevant to, responsive to, and sustaining of the cultural practices of learners across categories of difference (Paris, 2012). CSP, as an umbrella concept, draws from frameworks including community cultural wealth (Yosso, 2005), culturally relevant pedagogy (Ladson-Billings, 1995), culturally responsive teaching (Gay, 2002), culturally responsive pedagogy (Sleeter, 2011), and culturally sustaining pedagogy (Paris, 2012). Although CSP-related frameworks have typically focused on K-12 students' experiences and outcomes, as a broad framework, CSP has additional uses. CSP can be used to encapsulate STEM teachers' experiences and needs in the midst of ongoing professional learning. For instance, in recent work (Smith & Staudt Willet, 2023), I applied CSP to develop a new model of culturally sustaining instructional design. This model synthesized two different sets of assumptions and perspectives: the knowledge, skills, and best practices drawn from instructional design and the values or norms that may differ by learners' cultures (Biesta & Miedemac, 2002). CSP emphasizes the importance of building relationships, validating individuals' identities, and providing opportunities for students to see themselves represented in the STEM curriculum.

Although STEM teachers do self-supplement formal PD with SDL, they do not necessarily know how to do SDL efficiently or in a culturally sustaining manner. Teachers are left to figure things out on their own; there is rarely, if ever, training on how to do SDL well. Instead, STEM teachers are left to figure things out on their own. This results in teachers' engaging in SDL inefficiently (e.g., unfocused scrolling through social media feeds for materials), without boundaries (e.g., looking at social media at all hours of the day), and with social-comparison pressure—such as operating out of a sense of what a “good” teacher would do, fueled in part by seeing posts from other teachers on social media (Pittard, 2017; Staudt Willet, 2023). Other research has confirmed this tendency for social media platforms to foster competition rather than collaboration amongst teachers (Carpenter et al., 2020). In addition, relying on SDL as the mechanism for PD requires teachers to contribute additional—often invisible or uncredited—efforts outside normal work programs, locations, and hours (Fox & Bird, 2017).

From this background, I approach the current study with a conceptual framework of *context-aware self-teaching* (CAST) to synthesize best practices of SDL while implementing values and norms drawn from teachers' specific home context (e.g., communities, cultures) following CSP principles. The CAST framework emphasizes the strengths that teachers can draw from their own cultures, past experiences, and situations to self-direct their professional learning. Six CAST principles include a performance objective and a starting context, along with four principles for fostering SDL skills drawn from Francom (2010): practice opportunities, content area, difficulty level, and external guide.

- **Performance Objective:** SDL is intentional and purposeful. Drawing from research on agency, CAST starts by directing attention to self-directed learners' purpose—where they are trying to get to.
- **Starting Context:** Learners draw from the community cultural wealth (Higbee et al., 2012; Yosso, 2005) from the contexts in which and with which they learn. That is, although learning is self-directed, no one learns alone or without history and situation. Learners can draw from cultures and communities in which they are currently embedded, or they can remember to draw from cultures and communities from their past experiences and background.
- **Practice Opportunities:** Self-directed learners need opportunities to try new skills and receive feedback. Learners will become increasingly independent and engage in self-guided practice more as they develop familiarity with content and the skills needed to perform at the current level.
- **Content Area:** SDL skills are related to and acquired alongside subject matter knowledge. The self-directed learner has freedom to deepen skills and knowledge in a current content area or move to new content. The pacing of these movements is determined by the learner.
- **Difficulty Level:** The difficulty or complexity of the learning tasks should match the learner's readiness to tackle challenges while not overwhelming them. The level can increase as the self-directed learner advances. This principle draws from Vygotsky's (1978) zone of proximal development. The self-directed learner has freedom to stay at the same level while developing comfortability with content or move to more difficult and complex challenges.
- **External Guide:** The beginning stages of SDL involves teacher- or instructor-directed learning. The need for an external guide decreases as the learner's capacity for self-direction increases. External guides can include teachers, instructors, mentors, coaches, and peers. As the self-directed learner moves into new content areas or increasingly difficult levels of learning, they may need to return to an external guide for assistance.

Through these principles, the CAST framework empowers STEM teachers to address pervasive PD issues (e.g., not enacting teachers' agency, not aligning with teachers' individual needs, not allowing teachers to pursue their curiosity; not supporting teachers' self-regulation) not because CAST is a panacea, but because the framework directs focus toward the experiences and cultural capital inherent to learners, their context, and their home communities. The CAST framework also sets a path for ongoing, self-guided exploration by reassuring STEM teachers that their backgrounds, experiences, and home cultures and communities—as well as those of their students—can contribute important perspectives and understanding to STEM subjects.

PURPOSE AND RESEARCH QUESTIONS

In this study, I explore how beginning science teachers seek self-directed learning—especially as this may occur

through social media—and how this process impacts their instructional practice. An earlier study (Staudt Willet, 2023) was an initial, related exploration, but that previous work left many pertinent questions unanswered. For instance, that earlier study focused on beginning teachers' induction challenges and how they expanded their support systems using social media, but data collection, analysis, and discussion did not specifically address changes in instructional practice. This has been a trend in the literature. Greenhow et al.'s (2020) systematic literature review identified 58 studies focused on teacher learning with social media. Of these, only four considered the effects that informal professional learning through social media may have on teachers' practices, and these four relied solely on self-reported data. Numerous additional studies have similarly commented on the need for more research exploring the impact of teachers' social media use on instructional practice and student learning (e.g., Carpenter & Krutka, 2014; Lantz-Andersson et al., 2018; Macià & Garcia, 2016; Trust et al., 2016). Therefore, although a growing body of research describes teachers' use of social media for professional learning, there is a noteworthy gap in the literature related to its effects on instructional practice. To address this gap in the literature, this study seeks to answer two research questions (RQs):

- **RQ1.** Through what social media sources, if any, do beginning teachers seek self-directed learning during their transition into the profession?
- **RQ2.** What effect does beginning teachers' self-directed learning through social media have on their instructional practice?

METHOD

THIS qualitative exploration follows a *multiple-case study* design, which offers both in-depth descriptions within each case as well as comparisons between cases (Yin, 2018). The goal in choosing this research design is to develop rich, detailed, nuanced understanding of where beginning teachers seek self-directed professional learning and the effect this has on their instructional practice. These cases are not meant to produce generalizable results, but instead provide a foundation for future work that describes broader trends.

Participants

I invited five beginning teachers to participate in the study. These teachers were in their first or second year of employment. All taught science in the U.S. state of Florida—two in middle school and three in high school. They all self-identified as active users of social media.

I recruited these participants from alumni of the *FSU-Teach program*, a science and mathematics pre-service teacher education program at Florida State University based on the design of the UTeach program at the University of Texas at Austin. FSU-Teach program faculty extended personal invitations to specific teachers on my behalf. The recruitment message outlined the purpose of the study and disclosed a participation incentive of a \$250 Amazon gift card

and include a brief questionnaire asking for their name, contact information, location, start date as a teacher, subject, grade level, and use of specific social media platforms (e.g., Facebook, Twitter, Instagram, Pinterest, TeachersPayTeachers, TikTok, Reddit) for professional learning.

Data Collection

I collected data through eight weeks of diary entries and a series of five interviews with each participant from March to May 2022. I started data collection with a one-on-one, semi-structured interview, lasting 45–60 minutes, with each participant. This initial interview was an opportunity for me to seek an authentic understanding of the teacher's background, their teaching context, and their experiences as a new teacher. During this interview, I also introduced the *diary study* (Aldrup et al., 2017; Lavy & Eshet, 2018) portion of data collection, a type of intensive longitudinal method. I asked each teacher to record brief reflections once per week, for a total of eight weeks. I set up a weekly reminder email to each participant, including these prompts for reflection: (a) In the past week, what has prompted you to look for ideas and resources to support your teaching? (b) In the past week, where (e.g., in-school relationships, social media) have you looked for ideas and resources to support your teaching? (c) What effects has your search had on your instructional practice, if any? (d) What is your level of satisfaction with the whole process?

After every two weeks of recording diary entries (in weeks 3, 5, and 7 of the study), I conducted follow-up interviews with each participant. On a Zoom video call, I asked the participants to explain and elaborate on their diary responses from the previous two weeks. In these interviews, I also had the teacher demonstrate and describe—following a *think aloud* protocol—a lesson plan they had taught in the past week. Specifically, I asked them to pick a lesson plan inspired by or sourced from social media. In the interview, I asked them about how they located and adapted the plan, their goals for that part of their instruction, and their evaluation of how the lesson went and the usefulness of social media in the process.

Following this process of eight weeks of diary entries and three think-aloud interviews, I conducted a final interview, where I presented several themes gleaned from the entire data collection process up until that point. I asked the participants for their own interpretations of what I noticed in the data. As was the case with the initial interview, my goal in the final interview was to seek authentic understanding of the teacher's self-directed professional learning and its impact on their instructional practice.

Data Analysis

For each of the five participants, I used Zoom's auto-transcribing function to create text files for the five interviews. I also compiled all diary entries into one text file, resulting six files per participant, or 30 total. I then put these files into Dedoose (<https://dedoose.com/>), qualitative analysis software that allowed me to code, refine, track, and compare themes across data sources.

After an initial review of the data, I created codes following the context-aware self-teaching (CAST) framework: performance objective, starting context, practice opportunities, content area, difficulty level, and external guide. In addition, I created the codes *social media source* and *effect on instructional practice* to connect to the research questions.

I recruited and trained a doctoral student to follow Saldaña's (2016) procedures for qualitative analysis of interview transcripts and diary entries in a first round of coding. The student I met regularly to discuss the coding process and agree upon emergent codes, such as skill development and difficulty with classroom management. I then conducted a second round of coding to synthesize the initial codes and analytic memos into emergent categories of prompts for SDL, limits to SDL, and instructional impacts of social media.

RESULTS

At the time of writing, data analysis is incomplete and ongoing. I present results here for the first two (of five) participants. All names are pseudonyms.

Ginny, a first-year 8th-grade science teacher in a public school, used the social media tools TeachersPayTeachers.com, TikTok, and YouTube for professional learning. She primarily used these tools to gather ideas for her science classroom and keep up with current events in education. In terms of SDL, she was relied primarily on mentor teachers in her school, especially on her hallway.

Sarah, a first-year high school science teacher (biology and forensics science) in a private Catholic school, used the social media tools Facebook and Instagram for professional learning. However, typically she would start a search for resources through Google rather than a social media platform. In addition, using social media for professional learning was a secondary option for her, as she primarily wanted to stick with her own teaching philosophy and create her own resources. Even when she found and retrieved resources on social media, she was careful to revise and update them to fit the students in the context of her private Catholic school. Her SDL was largely independent, as her teaching philosophy and preference for teacher-centered, direct instruction conflicted with many of her colleagues. When she did look for an external guide, she looked to her co-teacher much more than any mentors. Even with her co-teacher, though, she differed in terms of how extensively they should adapt a slide deck sourced from social media—she pushed for extensive revisions while her co-teacher was content to use the slide deck without making any changes.

For both Ginny and Sarah, the social aspect of SDL was extremely important—however, they met this social need within their schools much more than through the internet. Although they both used social media in ways connected to SDL, social media was a secondary outlet for SDL. When it came to navigating complex challenges of teaching, their in-school colleagues (e.g., mentors, peer teachers) were essential for SDL as their external guides. Similarly, their starting context for SDL was important, as they both looked back on what they learned through the teacher preparation program as the foundation for ongoing learning. In contrast, social me-

dia tools were used for simply finding resources and ideas for instruction as well as staying updated on what is happening with teachers in other states.

With these within-case and cross-case analyses in mind, I answer the two research questions in the following sections.

RQ1. Through what social media sources, if any, do beginning teachers seek self-directed learning during their transition into the profession?

Participants described self-directing their learning through a variety of social media tools, including TeachersPayTeachers.com, TikTok, YouTube, Facebook, and Instagram. However, their SDL spanned both online and local connections, with in-school colleagues being primary and social media sources secondary. Still, participants did identify some reasons why SDL through social media was useful, including getting the broad perspectives of teachers in other states, which was particularly valuable when local PD was unhelpful, the school was not supportive, and students' parents were conflictual. Furthermore, social media tools did offer a wide variety of resources to choose from and the ability to efficiently find ideas and resources in the midst of their very full school schedules.

In addition to the SDL opportunities available through social media, participants talked extensively about the limits of using social media for SDL. First, participants described trying to maintain social boundaries around their social media. They often just wanted to use social media in lighthearted ways, not wanting to get their attention pulled into the interpersonal drama so common on social media. They expressed frustration at needing to navigate through a sea of venting posts to find posts related to teaching content. They also held concerns about school colleagues seeing their social media activity and forming conclusions about their professional abilities.

Second, time was a concern. Although locating instructional resources on social media could be done efficiently, teachers would need to find time within their busy schedules to pause their other responsibilities to get on social media. Then, even if they could find resources that seemed helpful, they would also need to take additional time to adapt those resources to their own teaching context.

Third, participants voiced concerns about the quality and relevancy of instructional resources found through social media. They said they often found an absence of resources when searching on specific science topics on social media. One issue is that many science resources were for younger students, perhaps due to elementary school teachers being more active on social media, and/or because social media algorithms pointed to resources for younger grade levels more often. In addition, when participants did locate relevant resources, they were still worried about the quality of those resources. It was impossible to determine the credibility of the teachers (if they even were teachers) who posted resources. Furthermore, many resources were superficial applications, and it was unclear which principles undergirded their design.

RQ2. What effect does beginning teachers' self-directed learning through social media have on beginning teachers' instructional practice?

More often, participants described noninstructional impacts of SDL through social media, such as stress relief, opportunities to stay informed with what was happening with teachers in other places, and prompts for self-reflection. Participants' descriptions of effects on instructional practice itself were limited. They recounted being inspired by and getting resources from other teachers through social media, and they talked frequently about resources they found on social media. They appreciated being able to save resources from social media so that they could access them later, when needed. However, participants' social media use for SDL seemed limited in scope, particularly when compared to their extensive and varied SDL activity within their schools.

DISCUSSION

DESPITE the expansive possibilities of SDL through social media reported in the literature, findings in this study raise questions regarding the degree to which teachers know how, are interested in, or have capacity to pursue these opportunities. Participants relied on their starting context of knowledge from a teacher preparation program, and they favored their in-school colleagues as their external guides. When they did choose SDL through social media, it was mostly to find supplemental resources than to develop their content knowledge or practice new pedagogical skills. This result is surprising because participants in this study self-identified as active social media users and were willing to participate in a research project spanning more than two months. Yet across 13 chances (eight weeks of diary entries and five interviews) to describe robust enactment of SDL through social media, participants' activity was limited to getting a few ideas for classroom management, warm-ups, lesson resources that needed to be modified. They did not seek out mentors, actively participate in online communities of teachers, seek feedback on their own lesson plans or materials, or test out new ideas or instructional approaches. Teachers in other studies have reported doing all these forms of SDL, but perhaps capitalizing on these possibilities is not as common as the victory narratives of educational technology research might imply (Selwyn, 2011). Here, participants' posture toward SDL seemed to be more of a solitary, information-retrieval approach than a community-oriented one. This suggests a view of social media tools as a loose network of external guides and extensive library of resources—although these may be hard to locate through the noise of irrelevant and low-quality materials. The result is that some affordances of social media were maximized while others were neglected altogether.

Implications

There are several important implications of these findings for beginning teachers, mentors, teacher educators, and education leaders.

First, SDL is an essential skill for teachers, from beginning teachers who are having to rapidly adjust to a new profession to experienced teachers who are having to rapidly ad-

just to changes in policy, curriculum, and technology. Regardless of position on the career spectrum, formal, top-down professional development cannot keep up. Teachers must figure some things out on their own. The CAST framework suggests one approach as a structured set of principles that teachers can adopt, starting with a performance objective in mind, taking into account their starting context, looking for practice opportunities, deepening knowledge in their content area, managing and finding the appropriate difficulty level, and seeking out trusted external guides as necessary.

Second, viewing SDL as part of a professional development ecosystem is the most appropriate perspective. Much of the relevant literature has focused on self-reports of social media at a single point in time, reporting from those willing volunteer participants the possibilities of professional learning through social media. However, lost in this narrow focus is that teachers rarely, if ever, only pursue SDL through social media. Even the first research question in the present study likely falls into this trap—taking too confined a view. Findings from this study make clear that teachers likely do not see SDL this way. They are interested in reaching those performance objectives and naturally, and constantly, make intuitive decisions about who to seek out as an external guide. They choose their co-teacher, their mentor teacher, a friend down the hall, and sometimes social media. Any of these individual choices are part of the larger ecosystem. In providing training for or nurturing SDL, this more holistic view will be important.

Finally, echoing the calls of past research (e.g., Staudt Willet, 2023), SDL is a voluntary effort that largely occurs around the slim margins of teachers' busy work lives (and home lives). Teachers should not discredit any feelings they have about maintaining boundaries around social media use—this is healthy and will likely help with burnout. When teachers do choose to include social media as an outlet for SDL, these pursuits should be acknowledged and supported as much as possible. Teachers' seeking out SDL is a way of giving back to their schools and districts—they are participating in professional development that is on-topic and just-in-time (Greenhalgh & Koehler, 2017). They are self-guiding themselves to get exactly what professional development they need. Mentors and education leaders can reinforce this good work through praise, counting SDL toward required licensure hours, and otherwise incentivizing.

Limitations and Future Research

First, analysis of the data is incomplete and ongoing. Data from the other three participants must be analyzed before the interpretation and discussion of the findings can be considered. Anecdotally, drawing from the experience of conducting these interviews, I suspect the conclusions will not change drastically. However, this is all, officially, still preliminary.

Second, although the data collection process was limited in unfortunate ways. First, the time of data collection, Spring 2022, was too close to the COVID-19 pandemic to allow for access to classrooms, so I relied on the self-reported think aloud with a lesson plan rather than being able to observe teachers' instruction directly. Future research should include

classroom observations as part of the case study design. In addition, data collection in this study spanned March to May, meaning that many of the weeks were disrupted by standardized testing and preparing for the end of the school year. Future research should aim to capture a broader range of time or a time with more regular instruction.

Third, this qualitative case study design was intended to provide insight into detailed practices and experiences. This depth came at the cost of breadth; future research should attempt more widespread research, such as a survey study, to describe trends and frequencies of the codes and categories observed in the present study. Relatedly, design- or intervention-based research could validate the CAST framework rather than just describe it.

CONCLUSION

TEACHING is a complex and ever-changing profession. Through a multiple case study of beginning science teachers' diary entries, interviews, and lesson plans, this study adds to the knowledge base of teachers' SDL. This inquiry focused on the effects of social media on instructional practice, but findings offer new insights into SDL as a trainable skill, SDL as part of a professional development ecosystem, and SDL as effort that should be acknowledged and rewarded. With these considerations, teachers can potentially participate in SDL in more sophisticated ways to tackle more sophisticated problems, such as making STEM classrooms more inclusive and supporting students' adoption of science-learning practices like sensemaking.

REFERENCES

- Aldrup, K., Klusmann, U., & Lüdtke, O. (2017). Does basic need satisfaction mediate the link between stress exposure and well-being?: A diary study among beginning teachers. *Learning and Instruction, 50*(50), 21–30. <https://doi.org/10.1016/j.learninstruc.2016.11.005>
- Auletto, A. (2021). Making sense of early-career teacher support, satisfaction, and commitment. *Teaching and Teacher Education, 102*, 103321. <https://doi.org/10.1016/j.tate.2021.103321>
- Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Teaching and Teacher Education, 27*(1), 10–20. <https://doi.org/10.1016/j.tate.2010.08.007>
- Beach, P. (2017). Self-directed online learning: A theoretical model for understanding elementary teachers' online learning experiences. *Teaching and Teacher Education, 61*, 60–72. <https://doi.org/10.1016/j.tate.2016.10.007>
- Biesta, G. J., & Miedema, S. (2002). Instruction or pedagogy? The need for a transformative conception of education. *Teaching and Teacher Education, 18*(2), 173–181. [https://doi.org/10.1016/S0742-051X\(01\)00062-2](https://doi.org/10.1016/S0742-051X(01)00062-2)
- Blaschke, L. M. (2012). Heutagogy and lifelong learning: A review of heutagogical practice and self-determined learning. *The International Review of Research in Open and Distributed Learning, 13*(1), 56–71. <https://doi.org/10.19173/irrodl.v13i1.1076>
- Butler, D. L., Lauscher, H. N., Jarvis-Selinger, S., & Beckingham, B. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education, 20*(5), 435–455. <https://doi.org/10.1016/j.tate.2004.04.003>
- Carpenter, J. P., & Krutka, D. G. (2014). How and why educators use Twitter: A survey of the field. *Journal of Research on Technology in Education, 46*, 414–434. <https://doi.org/10.1080/15391523.2014.925701>
- Carpenter, J. P., Morrison, S. A., Craft, M., & Lee, M. (2020). How and why are educators using Instagram?. *Teaching and Teacher Education, 96*, 103149. <https://doi.org/10.1016/j.tate.2020.103149>
- Carpenter, J. P., & Staudt Willet, K. B. (2021). The teachers' lounge and the debate hall: Anonymous self-directed learning in two teaching-related subreddits. *Teaching and Teacher Education, 104*, 103371. <https://doi.org/10.1016/j.tate.2021.103371>
- Darling-Hammond, L., Chung Wei, R., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad* [technical report]. National Staff Development Council. <https://eric.ed.gov/?id=ED536383>
- Desimone, L. M., Smith, T. M., & Ueno, K. (2006). Are teachers who need sustained, content-focused professional development getting it? An administrator's dilemma. *Educational Administration Quarterly, 42*(2), 179–215. <https://doi.org/10.1177/0013161X04273848>
- Feiman-Nemser, S., & Buchmann, M. (1985). Pitfalls of experience in teacher preparation. *Teachers College Record, 87*, 53–65. <https://www.tcrecord.org/content.asp?contentid=677>
- Fitzgerald, M. S., & Palincsar, A. S. (2019). Teaching practices that support student sensemaking across grades and disciplines: A conceptual review. *Review of Research in Education, 43*(1), 227–248. <https://doi.org/10.3102/0091732X18821115>
- Fox, A. & Bird, T. (2017). The challenge to professionals of using social media: Teachers in England negotiating personal-professional identities. *Education and Information Technologies, 22*(2), 647–675. <https://doi.org/10.1007/s10639-015-9442-0>
- Francom, G. M. (2010). Teach me how to learn: Principles for fostering students' self-directed learning skills. *International Journal of Self-Directed Learning, 7*(1), 29–44. <https://www.oltraining.com/SDLwebsite/IJSDL/IJSDL7.1-2010.pdf>
- Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of Teacher Education, 53*(2), 106–116.
- Greenhalgh, S. P., & Koehler, M. J. (2017). 28 days later: Twitter hashtags as “just in time” teacher professional development. *TechTrends, 61*, 273–281. <https://doi.org/10.1007/s11528-016-0142-4>
- Greenhow, C., Galvin, S., Brandon, D., & Askari, E. (2020). A decade of research on K-12 teaching and teacher learning with social media: Insights on the state-of-the-field. *Teachers College Record, 122*(6).

- <https://www.tcrecord.org/Content.asp?ContentId=23303>
- Hackman, M., & Morath, E. (2018, December 28). Teachers quit jobs at highest rate on record: Small raises, budget frustration and opportunities elsewhere persuade teachers and other public-education workers to move on. *Wall Street Journal*. <https://www.wsj.com/articles/teachers-quit-jobs-at-highest-rate-on-record-11545993052>
- Higbee, J. L., Goff, E., & Schultz, J. L. (2012). Promoting retention through the implementation of integrated multicultural instructional design. *Journal of College Student Retention: Research, Theory & Practice*, 14(3), 291–310. <https://doi.org/10.2190/CS.14.3.a>
- Hill, H. C. (2009). Fixing teacher professional development. *Phi Delta Kappan*, 90(7), 470–476. <https://doi.org/10.1177/00317217090900070>
- Jaber, L. Z. (2021). “He got a glimpse of the joys of understanding”: The role of epistemic empathy in teacher learning. *Journal of the Learning Sciences*, 30(3), 433–465. <https://doi.org/10.1080/10508406.2021.1936534>
- Klimaitis, C. C., & Mullen, C. A. (2021). Including K-12 students with disabilities in STEM education and planning for inclusion. *Educational Planning*, 28(2), 27–43. <https://isep.info/educational-planning-journal/>
- Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers*. Pearson Learning.
- Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32, 465–491. <https://doi.org/10.3102/00028312032003465>
- Lantz-Andersson, A., Lundin, M., & Selwyn, N. (2018). Twenty years of online teacher communities: A systematic review of formally-organized and informally-developed professional learning groups. *Teaching and Teacher Education*, 75, 302–315. <https://doi.org/10.1016/j.tate.2018.07.008>
- Lavy, S., & Eshet, R. (2018). Spiral effects of teachers' emotions and emotion regulation strategies: Evidence from a daily diary study. *Teaching and Teacher Education*, 73, 151–161. <https://doi.org/10.1016/j.tate.2018.04.001>
- 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. <https://doi.org/10.1016/j.tate.2017.04.004>
- Macià, M., & Garcia, I. (2016). Informal online communities and networks as a source of teacher professional development: A review. *Teaching and Teacher Education*, 55, 291–307. <https://doi.org/10.1016/j.tate.2016.01.021>
- Malkus, N., Hoyer, K., Sparks, D., & Ralph, J. (2015). *Teaching vacancies and difficult-to-staff teaching positions in public schools*. Department of Education Institute of Education Sciences, National Center for Education Statistics.
- McChesney, K., & Aldridge, J. M. (2021). What gets in the way? A new conceptual model for the trajectory from teacher professional development to impact. *Professional Development in Education*, 47(5), 834–852. <https://doi.org/10.1080/19415257.2019.1667412>
- McGee, E. O. (2020). *Black, brown, bruised: How racialized STEM education stifles innovation*. Harvard Education Press.
- Mercieca, B., & Kelly, N. (2018). Early career teacher peer support through private groups in social media. *Asia-Pacific Journal of Teacher Education*, 46(1), 61–77. <https://doi.org/10.1080/1359866X.2017.1312282>
- Merriam, S. B., & Baumgartner, L. M. (2020). *Learning in adulthood: A comprehensive guide* (4th ed.). Jossey-Bass.
- Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher*, 41(3), 93–97. <https://doi.org/10.3102/0013189X12441244>
- Phillips, P. (2008). Professional development as a critical component of continuing teacher quality. *Australian Journal of Teacher Education*, 33(1), 37–45. <http://doi.org/10.14221/ajte.2008v33n1.3>
- Pittard, E. A. (2017). Gettin' a little crafty: Teachers Pay Teachers, Pinterest and neoliberalism in new materialist feminist research. *Gender and Education*, 29(1), 28–47. <https://doi.org/10.1080/09540253.2016.1197380>
- Pressley, T. (2021). Factors contributing to teacher burnout during COVID-19. *Educational Researcher*, 50(5), 325–327. <https://doi.org/10.3102/0013189X211004138>
- Reddy, P., Sharma, B., & Chaudhary, K. (2020). Digital literacy: A review of literature. *International Journal of Technoethics*, 11(2), 65–94. <https://doi.org/10.4018/IJT.20200701.oa1>
- Rhodes, C. & Beneicke, S. (2002). Coaching, mentoring and peer-networking: challenges for the management of teacher professional development in schools. *Journal of In-service Education*, 28(2), 297–310. <https://doi.org/10.1080/13674580200200184>
- Ronfeldt, M., & McQueen, K. (2017). Does new teacher induction really improve retention? *Journal of Teacher Education*, 68(4), 394–410. <https://doi.org/10.1177/0022487117702583>
- Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). SAGE.
- Saleem, U., Inam, A., & Siddiqi, A. A. (2023). The effect of self-directed learning skills on teacher turnover intention in post-COVID era: A teacher-perceived paradigm. *UCP Journal of Business Perspectives*, 1(1), 58–83. <http://ojs.ucp.edu.pk/index.php/jbp/article/view/130>
- Selwyn, N. (2011). In praise of pessimism—the need for negativity in educational technology. *British Journal of Educational Technology*, 42(5), 713–718.
- Selwyn, N., Campbell, L., & Andrejevic, M. (2023). Autoroll: scripting the emergence of classroom facial recognition technology. *Learning, Media and Technology* 48(1), 166–179. <https://doi.org/10.1080/17439884.2022.2039938>
- Sleeter, C. E. (2011). An agenda to strengthen culturally responsive pedagogy. *English Teaching: Practice and Critique*, 10(2), 7–23.

- Smith, C., & Staudt Willet, K. B. (2023). A model for culturally sustaining instructional design. *Journal of Applied Instructional Design*.
- Staudt Willet, K. B. (2023). Early career teachers' expansion of professional learning networks with social media. *Professional Development in Education*. <https://doi.org/10.1080/19415257.2023.2178481>
- Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & Education*, 102, 15–34. <https://doi.org/10.1016/j.compedu.2016.06.007>
- Trust, T., & Prestridge, S. (2021). The interplay of five elements of influence on educators' PLN actions. *Teaching and Teacher Education*, 97, 103195. <https://doi.org/10.1016/j.tate.2020.103195>
- Tuli, F. (2017). Teachers professional development in schools: Reflection on the move to create a culture of continuous improvement. *Journal of Teacher Education and Educators*, 6(3), 275–296. <https://eric.ed.gov/?id=EJ1207277>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Williamson, B., Macgilchrist, F., & Potter, J. (2023). Re-examining AI, automation and datafication in education. *Learning, Media and Technology*, 48(1), 1–5. <https://doi.org/10.1080/17439884.2023.2167830>
- Yadav, A., Gretter, S., Hambrusch, S., & Sands, P. (2016). Expanding computer science education in schools: Understanding teacher experiences and challenges. *Computer Science Education*, 26(4), 235–254. <https://doi.org/10.1080/08993408.2016.1257418>
- Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE.
- Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, 8(1), 69–91. <https://doi.org/10.1080/1361332052000341006>
- Zein, S. (2016). Factors affecting the professional development of elementary English teachers. *Professional Development in Education*, 42(3), 423–440. <https://doi.org/10.1080/19415257.2015.1005243>