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Self-Study as a Method for Engaging STEM Faculty in Transformative Change to Improve Teaching

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Reform efforts in the teaching of undergraduate science, technology, engineering, and mathematics (STEM) have included introducing faculty to specific teaching strategies and engaging them in collaborative initiatives. This study examined the experiences of STEM faculty learning interactive teaching strategies while also learning and applying self-study methodology in a year-long faculty self-study learning community. We used self-study methodology as an innovative design to support STEM faculty's research about their teaching. Drawing on multiple sources of data, the researchers found that although participants reported that learning self-study methodology was unique and complex, they embraced the problematic and sophisticated nature of self-study to examine their teaching while recognizing the close link between teaching and research. As they reflected on their professional identities as teachers, they gained a better understanding of their role in their students' learning. Supporting faculty's small changes in teaching can lead to larger changes over time. Self-study methodology can reinforce the change process. The self-study learning community design may be useful as a catalyst for developing an advanced teaching trajectory for STEM faculty and useful for faculty from various disciplines. Implications for impacting individual and institutional capacity in higher education are discussed.

Reform efforts in the teaching of undergraduate science, technology, engineering, and mathematics (STEM) have been extensive with an urgency to transform faculty instruction within these critical needs content areas (Austin, 2011; Fairweather, 2008; Fry, 2014; Jamieson & Lohmann, 2009; President's Council of Advisors on Science and Technology [PCAST], 2012; Sunal et al., 2001). STEM faculty often teach scores of undergraduates in courses foundational to students' academic success and career paths, yet they may have little training in teaching and/or opportunities to collaborate with peers as they assess their pedagogical strategies. Learning to teach, regardless of years of teaching, is a complex and "sophisticated business" (Loughran, 2014, p. 5). Many STEM faculty teach in lecture halls using a teacher-centered, rather than learner-centered, mode of delivery (Freeman et al., 2014).

Various initiatives designed specifically for improving STEM faculty teaching have been explored. Those initiatives have included introducing STEM faculty to alternative formats of instructional dissemination (Deslauriers, Schelew, & Wieman, 2011; Hayward, Kogan, & Laursen, 2016; Henderson, Finkelstein, & Beach, 2010; Wieman, 2017), observation (Smith, Jones, Gilbert, & Wieman, 2013), and inquiry (National Research Council, 2012). Initiatives for improving faculty teaching have involved familiarizing faculty with innovative teaching strategies and reflective practices (e.g., Balmer & Richards, 2012; Gunersel & Etiene, 2014; Lyons, 2010; Lavis et al., 2016). Researchers have studied pedagogical strategies and programs for improving interactive teaching practices (Cox & Harris, 2010; Light, Calkins, Luna, & Drane, 2008). As Dawson, Burnett, and Donohue (2006) assert, while universities have promoted and invested in learning communities to enhance the student learning experience, there has been less investment in supporting faculty in communities to enhance their teaching experience.

There is an emerging body of literature focused on the importance of faculty collaboration to enhance teaching and on outlets for faculty to discuss their teaching (Gast, Schildkamp, & van der Veen, 2017; McKenna, Yalvac, & Light, 2009; Percy & Beaumont, 2008; Walsh, & Kahn, 2009. Collaboration has taken place in various forums including faculty study groups (Wildman et al., 2000) and faculty learning communities to support faculty's scholarship of teaching and learning and with a focus on community building (Cox, 2003, 2004; Ward & Selvester, 2012; Wildman et al., 2000). Yet, there is often little incentive for faculty to dialogue about their teaching at a level which moves beyond learning technical teaching strategies (Bryant, Niewolny, Clark, & Watson, 2014; Rowland, 2001). Furthermore, the notion of studying and publishing research about one's own teaching may not be fully understood or valued by administrators and faculty within higher education (Kahn, Goodhew, Murphy & Walsh, 2013).

As an innovative and emerging approach for faculty development, self-study methodology provides faculty with a reflective means to study and write about their teaching practices while engaging with colleagues for support and critique (Pithouse-Morgan & Samaras, 2015a, 2015b; Samaras, 2011; Samaras & Pithouse-Morgan, 2018b). A key difference of self-study learning communities from other faculty learning communities is that the self is data with self-study

methodology centering community interactions and support provision. As an astrophysicist who participated in an earlier faculty self-study learning community exclaimed to the facilitator, "Oh, I get it. In self-study research, I'm the data!"

Self-study has been reported as transformative for faculty working within transdisciplinary faculty self-study learning communities. The polyvocality representing the alternative points of view within the faculty self-study learning community has supported this transformative process (Harrison, Pithouse-Morgan, Conolly, & Meyiwa, 2012; Pithouse, Mitchell, & Moletsane, 2009; Samaras et al., 2014; Samaras & Pithouse-Morgan, 2018b). In transdisciplinary self-study faculty learning communities, participants dialogue about their research, exchanging information and discipline-specific approaches. "Transdisciplinary research allows investigators to transcend their own disciplines to inform one another's work, capture complexity, and create new intellectual spaces" (TREC, 2018) and with a common scientific goal (Rosenfield, 1992). In addition to transformative changes via dynamic collaboration, self-study methodology creates products that are sharable via journal articles, presentations, and other products that faculty in STEM departments need for promotion and tenure (Dolan et al., 2017).

The purpose of this study was to explore the experiences of STEM faculty who participated in a year-long faculty self-study learning community to improve their teaching. It included faculty who teach in the fields of astronomy, bioengineering, biology, geology, information sciences and technology, and mathematics at a large public, research-extensive (R1) university in the United States. The faculty self-study collaborative was situated within a National Science Foundation (NSF) funded grant which entailed a design framework grounded in Laurillard's (2012) conceptualization of teaching as a design science. The overarching goal of the grant was to explore how to broaden STEM instructors' adoption of interactive teaching with evidence-based teaching practices.

Foundations for the Study

Significant research has been conducted about collaborative models to support faculty in their efforts to improve their teaching practices. Many have focused on the need for a community of learners with a shared practice and peer support (e.g., Cox, 2003, 2004; Kahn et al., 2013). For example, McKenna, et al., (2009) examined how to create collaborative partnerships between engineering faculty and learning scientists to encourage collaborative, reflective, and improved teaching. Although research for improving STEM faculty's teaching has been conducted, research for improving STEM faculty's teaching in a faculty self-study community using self-study methodology for faculty outside of teacher education has not been conducted. Research facilitating the learning and enactment of self-study methodology for faculty inside and outside of teacher education has been conducted both within and beyond the United States (Lunenberg & Samaras, 2011; Pithouse-Morgan et al, 2015; Ritter et al., 2018; Samaras et al., 2016).

Collaboration in faculty's development of their teaching has been shaped in diverse and productive forums including those relevant to this study: supporting teaching in faculty learning communities; supporting teaching in teacher educator self-study groups; and supporting teaching in faculty transdisciplinary self-study learning communities.

Supporting Teaching in Faculty Learning Communities

There is a great deal of research about the value of situated learning communities of practice for learning in general (Lave & Wenger, 1991; Wenger, 1998) and learning communities *in* practice to support teaching in diverse educational contexts (Samaras, Freese, Kosnik, & Beck, 2008; Lassonde & Israel, 2010). There are university centers committed to supporting faculty teaching in collaborative forums (Cox, 2003). However, when there is limited support, faculty must rely on their own resources. The implementation of faculty learning communities has been an avenue for faculty to gain the needed support (Dawson et al., 2006).

The scholarship of teaching and learning (SoTL) has been a prominent professional development forum in higher education (Becker & Andrews, 2004; Cox, 2003). Engin and Atkinson (2015) note that the basis of faculty learning communities (FLCs) are as "communities of practice" (p.1) which build upon Cox's (2004) work as faculty engaged in active collaboration to enhance their teaching and learning in "the scholarship of teaching and community building" (p. 8). Faculty learning communities also function to meet personal and professional needs of faculty by providing "resources, social networks, and innovative ideas" (Dee & Daly, 2009, p. 2) and to promote self-efficacy and agency. Additionally, participation in FLCs has been shown to have encouraging effects for both students and faculty in institutions where a specific instructional innovation or teaching and learning practice is being studied (Gordon & Foutz, 2015; Ward & Selvester, 2012).

In a study conducted by Smith et al., (2008), researchers sought to determine the effects of a FLC on the use of new instructional strategies to support STEM faculty to "enhance the achievement of underrepresented and disadvantaged students in the STEM fields" (p. 203). Data supported that goals were met, with collegiality, awareness,

and understanding of teaching methods all ranking high among participating members. In another study involving STEM faculty, Nadelson (2016) created what he termed a "faculty community of practice (FCP)…to increase capacity, engagement, and collaboration of faculty members" (p. 44). Nadelson's findings suggest that the implementation of a year-long FCP can lead to an increased understanding of instructional strategies and how students learn, as well as increased collegiality due to conducting research in collaborative ways.

Supporting Teaching in Teacher Educator Self-study Faculty Groups

Self-study of teaching provides faculty another type of professional development opportunity to improve their teaching as they design a self-initiated and situated inquiry that entails self- and peer assessment in a supportive culture for learning about pedagogy. It originated with teacher educators of the Self-Study of Teacher Educators Special [S-STEP] Interest Group of the American Educational Research Association. These teacher educators wanted to practice what they were asking their teacher education students to do: undertake a systematic and transparent pedagogical inquiry with the support of colleagues to improve their professional practice (see Loughran, Hamilton, LaBoskey, & Russell, 2004). As Feldman, Paugh, and Mills (2004) assert, in self-study of teaching, faculty are a resource for their research about their teaching and "problematize their selves in their practice situation'' (p. 971). It requires a "willingness to publicly problematize [one's own] teaching and learning [about one's own teaching] … be open to, and act upon, the curiosities, surprises, and challenges of everyday teaching practice; and to actively seek out alternative perspectives on practice" (Berry, 2015, p. 964). As noted by those who have engaged in self-study (Samaras et al., 2014):

> In more conventional forms of the scholarship of teaching and learning…faculty tend to see change in themselves, even transformative change, as a by-product of change in them, their students. Self-study of teaching, which requires focus first on the teacher, the ''I,'' locates the struggle for efficacy within the self, rather than externalizing it as under the control of the actions of others (p. 381).

Self-study is about the study of changing one's role in teaching by examining oneself, rather than the study of the effectiveness of instructional strategies by examining only student outcomes. The goal of self-study is for teachers to be active agents in examining their beliefs about their teaching practices and educational problems for improvement-aimed purposes beyond themselves as they contribute to a knowledge base of education (Loughran & Northfield, 1998).

In addition to teacher educators undertaking individual self-studies of teaching (e.g., Berry, 2007; Brown, 2002), they have joined with colleagues and small groups of other teacher educators to collaboratively explore practical problems in teacher education and/or work to support each other's individual inquiries in faculty self-study groups (Grierson, Tessaro, Cantalini-Williams, Grant, & Denton, 2010; Hoban, 2007; Kitchen, Ciuffetelli, Parker, & Gallagher, 2008; Lunenberg, Zwart, & Korthagen, 2010; Samaras, Kayler, Rigsy, Weller, & Wilcox, 2006). By dialoguing with critical friends, faculty have opportunities to explore a chosen dilemma about their teaching and deepen their awareness of the tensions and taken-for-granted assumptions about their practice (Berry, 2007).

Supporting Teaching in Transdisciplinary Faculty Self-study Learning Communities

Although self-study methodology originated with teacher educators, it has been extended as a professional development model to faculty who work outside of colleges of education offering opportunities for faculty from various disciplines and contexts to study their teaching (Harrison, et al., 2012; Hernández Gil de Lamadrid & Román Mendoza, 2015; Pithouse, Mitchell, & Moletsane, 2009; Samaras et al. 2014; Wilcox, Watson, & Paterson, 2004). Individuals working in these transdisciplinary collaboratives are extending their knowledge and perspectives about the research of teaching by dialoguing with peers outside their disciplines, with the self-study methodology, rather than their disciplines, centering their dialogue. Self-study learning communities transcend discipline, position, and context.

Self-study joins term faculty (non-tenure track whose work is more focused on teaching) with non-term faculty (tenure-track or tenured). Self-study learning communities connect early career academics with more senior academics in a polyvocal design that entails plurality, interaction, interdependence, and creative activity (Samaras & Pithouse-Morgan, 2018b; Smith et al., 2018) linked to Bakhtin's notion of polyphony (1984):

> A plurality of independent and unmerged voices and consciousnesses, a genuine polyphony of fully valid voices . . . with equal rights and each with its own world, combine but are not merged in the unity of the event (p. 6).

The Methodology of Self-study

Self-study methodology is a postmodern qualitative research genre entailing various self-study methods

(LaBoskey, 2004; Tidwell, Heston, & Fitzgerald, 2009). It is used by faculty to deconstruct their teaching practice from an ontological stance or their ongoing development in knowing and re-knowing their teaching (Pinnegar & Hamilton, 2009). Distinguishing features of self-study from other collaborative methods are its specific methodological components (LaBoskey, 2004). Its methodological components include: personal situated inquiry, openness, reflection, peer review for validation, and transparent data analysis for improvement-aimed purposes which contribute to personal professional learning while generating knowledge for the field (Barnes, 1998; LaBoskey, 2004; Loughran, 2004; Pinnegar & Hamilton, 2009; Samaras, 2011). Self-study methodology entails methodological inventiveness to explore a personal inquiry (Pithouse-Morgan, Coia, Taylor, & Samaras, 2016; Whitehead, 2004). In this way, self-study deepens personal reflection to a critical internal reflection that is supported and critiqued by a critical friend, as well as a larger peer group. Both externally-oriented and reflective methods are important strategies for faculty development and are dynamic and iterative for continuous learning.

LaBoskey (2004) has noted the multidimensional aims of self-study methodology, arguing that its proponents "wish to transform [themselves] first so that [they] might be better situated to help transform [others], and the institutional and social contexts that surround and constrain [them]" (pp. 820-821). Nonetheless, faculty do not work alone in self-study but with peers in order "to step outside themselves" (Loughran & Northfield 1998, p. 14) for their deeper questioning about improving their teaching practice. Faculty peers work as critical friends (Costa & Kallick, 1993; Schuck & Russell, 2005) providing reciprocal, thoughtful, and insightful feedback on the actions and engagement of each other's practice. More particularly, self-study is combined with the location of inquiry in the self and with the ability to change aspects of that self because of the collaboration with others (LaBoskey, 2004; Samaras & Freese, 2006). Self-study methodology paradoxically demonstrates the power of the "we" to develop the "I" for improving teaching practice (Pithouse-Morgan & Samaras, 2015b, p. 6), and that work takes place within a learning community.

Methods

The purpose of the study was to explore the perspectives of STEM faculty engaged in a faculty self-study learning community to improve their teaching. The faculty self-study learning community was envisioned as the penultimate project of a NSF grant designed for faculty who were ready to move beyond simply trying out new interactive teaching strategies to exploring the role they play in improving their teaching. Participants also had the opportunity to write about the enactment of their new pedagogies and were supported in that process. In the second year of the grant, the faculty self-study learning community was launched and facilitated by a teacher educator who is a self-study scholar. Specific to the faculty self-study learning community was the goal of facilitating participants' learning, enactment, and dissemination of their individual self-studies with ongoing support from a facilitator who employed design elements.

The study was conducted by a diverse research team which included: a teacher educator/self-study scholar, a mathematics educator, an electrical engineering faculty member, an educational psychologist/program evaluator, and a teacher education doctoral candidate. The group was facilitated by the teacher educator who is an expert in self-study methodology and served as a Co-PI of this NSF-funded research grant. This is the fourth faculty self-study collaborative she has facilitated/co-facilitated. Data were collected throughout the project to explore the following research questions:

- What did participants report about their experiences in learning and enacting self-study methodology in this faculty self-study learning community?
- What did participants learn about classroom-based self-study research?
- What role did the collaborative design play in their experiences?

Participants

The six people who participated in this faculty self-study learning community taught undergraduate STEM courses and included four females (one each from the fields of astronomy, bioengineering, geology, information sciences and technology) and two males (one each from the fields of biology and mathematics). Four faculty were term (non-tenure track) with positions focused on teaching at the assistant and associate ranks. One female faculty was tenure-track faculty at the assistant rank, and one male faculty was tenured at the full professor rank. Three faculty held administrative roles in addition to their teaching which included a coordinator, a department chair, and a graduate studies administrator. Faculty had between 5 and 26 years of service at the university, with an average of 14 years.

Project Design: PAIDIA Design Elements

This learning community was enacted using design elements for facilitating what is known as polyvocal

transdisciplinary faculty self-study learning communities - PAIDIA (acronym, see below). PAIDIA design elements were developed by two teacher educators (one was the facilitator in this study and the other is a facilitator in South Africa) to be inclusive of the needs of faculty inside and outside of colleges of education (see Samaras & Pithouse-Morgan, 2018b). They co-constructed the design over time from their repeated explorations of enacting it which validated the design elements in actual practice (Samaras & Pithouse-Morgan, 2018a). They have also conducted numerous individual and collective self-studies of their co-facilitation in their respective institutions in the United States and in South Africa (Pithouse-Morgan et al., 2015; Samaras, 2013; Samaras et al., 2013, 2014; Smith et al., 2018). To learn from each other's experiences, they dialogued on a transnational and transcultural level (Samaras et al., 2015, 2016).

PAIDIA design elements are rooted in Neo-Vygotskian (1978; 1981) tenets of interpersonal and intrapersonal learning with communities *in* practice (Samaras et al., 2008) and from a conceptual perspective of "reflexive Ubuntu," explained as "understanding the value of locating oneself in the experiences of others as a form of demonstrating an ethics of care and trust" (Harrison et al., 2012, p. 17). Key conceptual underpinnings for the facilitation of polyvocal transdisciplinary self-study learning communities include: encouragement and nurturing of collaborative conversations across disciplinary, programmatic, status and spatial divides; sharing multiple expertise with participants supporting each other's learning through continuous dialogue; and using visually rich digital tools as symbols to mediate written language. Also central to the PAIDIA design is co-flexivity or "being reflexive together through thinking deeply about and questioning our professional practice and selves in dialogue with significant others" (Pithouse-Morgan et al. 2015, p. 148). Another central tenet to the design is co-creativity or connecting in arts-informed ways with critical friends to promote imaginative and responsive ways that can transform practice (Harrison et al., 2012; Pithouse-Morgan et al., 2015).

PAIDIA elements include:

> **P**ersonal Situated Chosen Inquiry. Participants choose to join the collaborative and choose their inquiries situated in their immediate professional contexts and in relation and response to wider socio-cultural-historical-political contexts.
>
> **A**ccountability**.** Accountability begins with each participant reconsidering her/his professional practice with input and support from critical friends to build self-regulated, authentic professional learning.
>
> **I**ntegrated Critical Creative Collaboration. Participants engage in an interactive and interdependent learning that proves to promote diverse ways of seeing and knowing with others in order to deepen and extend their professional learning. Central to the groups' work are ongoing, intellectually safe structures for reciprocal mentoring with critical friends to recognize and value co-flexivity and co-creativity.
>
> **D**esign ↔ **D**issemination. By sharing ongoing drafts of their research, participants make their efforts public through informal presentations and writing, noticing their attention to a transparent research design that clearly and accurately documents the unfolding research process.
>
> **I**mproved Learning for Self and Others. Participants engage in critical and deep questioning about the status quo of their practice in order to improve and impact learning and contribute knowledge.
>
> **A**uthenticated and Invited Leadership. The facilitator authenticates self-study research by practicing it herself while also inviting leadership and encouraging participants to contribute their diverse expertise and experiences.

Project Structure and Pedagogical Activities

The yearlong collaborative began in early September 2015 with an invitation sent by the research team to participants who had been involved in year one of the grant, stating:

> We would like to personally invite you to an amazing professional learning opportunity where you along with colleagues in STEM will engage in rich dialogues, research, and writing about interactive teaching strategies…the goal of the collaborative is for you to learn about and conduct a self-study research project that would help support your efforts with evidence from your classroom.

The project was launched at the end of September 2015 with a focus on participants learning self-study while they enacted individual self-study projects. The group met monthly for one year in two-hour meetings. All meetings were face to face except for one which was a virtual meeting held during the facilitator's sabbatical.

At the first meeting, of the dozen faculty who attended, six remained and attended monthly meetings, working with critical friends during those meetings. The program evaluator and a graduate student research assistant also participated in the monthly meetings. Of the twelve who attended the first meeting, two did not continue, indicating that studying their teaching does not

count as research productivity. This was also noted as problematic by Graham (2015) for engineering faculty. Some faculty stated they had significant programmatic responsibilities and could not devote adequate time, and/or perhaps others were just not interested.

The monthly group meetings focused on introducing self-study of teaching and included learning self-study as a research method; developing a topic for self-study; designing self-study research questions; working with critical friends; and writing, presenting, and publishing a self-study of teaching research. The facilitator launched the initiative by asking participants to bring an artifact or an object that symbolized the main focus of what they wanted to study about their teaching (See Samaras, 2011), which they first shared in small groups. All activities were posted on an online discussion forum for sharing and documenting. For example, the astronomy faculty brought a box of lights and memoed about it:

> I am struck by the idea that learning involves making connections between new knowledge and former knowledge. I devise ways to try to see what students know, and I get patterns back from students based on what I have designed…tests are so limited. I am only seeing the surface. … I am looking for a way for students to show me not just the neat clear design flowing from a traditional test, but also the tangles and unconnected nodes that would be valuable to build learning toward and from (See Figures 1 and 2).

As participants worked to find the focus of their chosen teaching inquiry, they shared their ongoing thinking and drafts in two groups of three critical friends. The facilitator utilized various pedagogies informed by her earlier co-facilitation with faculty outside her discipline. She came to understand how faculty development advances when participants are provided opportunities for "unaccustomed ways of experiencing our questions, unaccustomed ways of deciding what constitutes data, and unaccustomed ways of relating to our teaching and our research." (Pithouse-Morgan & Samaras., 2018b, p. 321).

Figure 1

The test I design to see what is inside

Figure 2

Lots of light I cannot see, but tangles too and sometimes disconnects or misconnections

For example, she asked participants to write and present a haiku, a 17-syllable Japanese poetry form to help break their writer's blocks about their inquiries and rationales (See Samaras, 2011). She also utilized pedagogical activities using visually rich digital tools adapted from her work from another transdisciplinary faculty self-study group she co-facilitated (Smith et al, 2018), such as a research knot. Participants were asked to locate a knot which represented a tension and/or a strength in their thinking about their teaching. They were then asked about the knot using a reciprocal interviewing method where they interviewed each other with an observer offering feedback after the interview (see Meskin, Singh, & van der Walt, 2014). Another visual tool utilized was mind mapping where participants sketched a draft of their research design. Interspersed with those activities, the facilitator continued to present and post resources about self-study methodology, including published exemplars of faculty self-study, some authored by members of the research team.

The last group meeting was September 2016 where participants were asked to assess their work and learning about the methodology. After the last meeting, the facilitator engaged in email correspondence with the participants in order to support their work on presentations and publications.

Data Collection

The project met IRB approval, and each of the six participants agreed to be interviewed. Data were collected from multiple and varied sources: (a) individual semi-structured interviews with each of the six participants; (b) memos, artifacts, and visuals created and presented by participants during monthly meetings; and (c) exit slips written by participants at the end of the project. Posters from professional conference presentations where participants shared the results of their self-studies were also examined. Secondary data sources included: (a) notes of seven monthly meetings, (b) notes and recordings of four research team meetings, (c) ongoing analytical memos written by the facilitator, and (d) four individual semi-structured interviews conducted with the facilitator.

After the project ended, one of the research team members conducted six individual semi-structured interviews lasting about 45 minutes with each participant. Another research team member transcribed each interview, as well as an audio recording of a final research team meeting where the research team examined processes and outcomes of the experience. During their individual interviews, participants were asked about their experience in the learning community: what it was like to learn a new methodology, how the experience differed from other collaborative experiences, what stood out in the group activities, how their participation informed their teaching practice and research, and what contributions were made to and from the group (See Appendix).

The four interviews with the facilitator were about her experiences leading the collaborative and were conducted during the project and at the end of her facilitation; two were conducted by a research team member who was the grant program evaluator, another by a master's degree student studying program evaluation, and another by a doctoral student studying faculty research. The interviews with the facilitator were useful as secondary data sources and aligned with the PAIDIA design element of "Authenticated and Invited Leadership." The facilitator studied her role in leading this collaborative, and that study was reported elsewhere (Samaras, Hjalmarson, Bland, Nelson, & Christopher, 2017).

Data Analysis

The data analysis was informed from the diverse lenses of the transdisciplinary research team from the perspective of a self-study scholar who facilitated the group, from the perspective of the NSF STEM faculty PI and Co-PIs on how this faculty self-study group served to address the larger goals of the grant for STEM faculty development, from the perspective of the grant program evaluator, and from the perspective of a PhD doctoral candidate studying effective teaching in higher education. These multiple perspectives both widened the lens and validity of the analysis to explore the experiences of this faculty self-study group.

The research team worked individually and then collectively to analyze the multiple and varied data with the research questions posed to guide their initial and final analysis. They used pattern coding or "repetitive, regular, or consistent occurrences of action/data" (Saldaña, 2016, p. 5) through cycles of coding and analysis of the data set. For the first cycle of analysis, they shared their identified segments of participant interview comments that addressed the research questions and collectively noted preliminary coding and categories. They then negotiated overlapping categories for the interview data. Additionally, the doctoral student on the research team analyzed and check coded individual interviews. After analyzing participant interviews, a second cycle of analysis entailed using constant comparative analysis (Fram, 2013) analyzing the memos, artifacts, visuals, and exit slips, again with the research questions guiding their analysis and to consider how the data sources added new information. The research team met again collaboratively to discuss their analyses focused on delineating and negotiating categories and connections across the data (Maxwell &

Miller, 2008) and identified preliminary themes (Braun & Clarke, 2006; Butler-Kisber, 2010; Ryan, & Bernard, 2003). They worked as a writing team to draw meaning across the full data set, resulting in four themes with attention to how participants perceived and utilized the faculty self-study group experience to improve their thinking about their teaching.

Results

Analysis from the multiple and varied data sources resulted in the following themes: (1) learning self-study methodology, (2) examining who I am as teacher, (3) collaborating with critical friends, and (4) understanding teaching as research. Each theme is discussed, integrating the reporting and work of participants. Pseudonyms are used.

Learning Self-study Methodology

Learning self-study methodology was novel to participants, and they found it complex to learn. As one participant stated, it was "a very inward kind of form of experimentation" which runs counter to studying others or other kinds of research in STEM. Participants expressed discomfort as they struggled to learn a methodology which required using themselves as subjects and as data−as one expressed "definitely outside my comfort zone!" Vicky indicated:

> …[I]t took me quite a while to realize what self-study was about …[W]hat I did in the group didn't make any sense. I'm an engineer, I want hard data. If it doesn't have data, what's that? … I couldn't understand why are we doing this, and how it is helpful, but after having gone through the process, I can understand.

Reid offered his thoughts in his interview: "It's a different environment where faculty members are talking about reflective practice…and I, you know, have not been in a group that's done that before."

Nonetheless, self-study stretched participants in unfamiliar and useful ways. For example, Becky shared, "What I like about self-study is it can be a lot looser in some ways than what we would do in physics where we would have to have a control group over here and a test group over here." Julia, describing her experience, reflected:

> We had to write about things and talk about things, look at things in a different way. I'd been helped all the way through, but this made me really pause and think about it and, almost analyze where I was, where I'd come from, and what I was doing now. That really did help me in doing my portfolio [for promotion] and thinking things through and writing things out.

Examining Who I Am as Teacher

This study brings attention to issues of teacher identity in higher education. As Geursen, de heer, Korthagen, Lunenberg, & Zwart (2010) found, it is important for faculty to have opportunities to develop their teacher identities. By investigating their practice, participants discovered a shift from the focus of changing students' actions to changing one's own. Participants expressed that shift as they embraced self-study as "a mechanism for thinking carefully and reflectively" about their role as a teacher and with the group's support. Vicky stated:

> …[T]o look at the process with a much more critical eye…a level of questioning I wasn't even aware existed …the group made me realize that, I was looking at the product, but then I realized it's not just the product, there's this step behind the product that's me designing the product.

There were significant insights about how participants saw themselves as teachers and as researchers with the PAIDIA element of design to dissemination underlying the teaching and research processes. Julia shared her revelation about what it means to teach as a long-time academic:

> I've been thinking about, where am I? Can I just be at homeostasis and just keep doing what I'm doing? Where do I go from here? I'm now full term faculty, and I have this award [for excellence in teaching]. You can't get the award more than once, so for the next part of my career, do I just kind of bum along?

The busy life of academics can throw people into what Vicky calls a "survival mode" instead of teaching by design, as she explained:

> If you ask me to design a heating system, ok, I'm not just going to go and buy two space heaters. Well, I might, but I shouldn't…the first step and then realizing ok, now you're taking not the survivor attitude, but in the designer attitude, and there are rules to designing…that's how my point of view has changed. …The scary part was realizing that I was doing the same mistakes I was telling my students not to do… just making ends meet is not what should be happening if you want to produce a good product. Where I could change my own approach to make this more efficient, so

> product, design process, and that's me looking at it. At both things because of this group experience.

Reid explained how self-study "lets you get into what you are thinking as you're getting into how are you structuring things… a hypothesis space…to make tacit knowledge explicit." Participants noticed that they had allowed themselves to explore their teaching and use time in a way that mattered away from "the day to day minutia to thinking about where we need to be goal-wise." Julia stated, "I think the only barrier was allowing yourself to make time for it."

During the process of researching an inquiry about teaching practice, a broader search of "[W]hat am I doing as a teacher?" and "Who am I as a teacher?" were at play. Participation in the collaborative afforded individuals a space and confidence to conduct research about their teaching and talk about what was happening as it unfolded. Julia described that unfolding from her experience:

> It made me think about how to do it and how to do it for me that was different than maybe going to conferences and hearing abstracts and hearing people talk about it like that. This was more, because you were here and you were part of the group, and it was more personal somehow; it kind of made me think that maybe I could do that.

Participants found the visual activities useful, yet challenging, in thinking about their teaching practice. Julia stated:

> The knot thing was really difficult for me to talk about, and it was like, this is really silly, but I ended up being really proud of my knot, and why I had chosen that knot and what it symbolized to me. And when I was doing the portfolio there's like a two-page reflective component and…I finished with sharing my knot (See Figure 3).

Her research knot symbolized her teaching intertwined with her Celtic culture:

> I see the 3-fold symmetry as my roots on the bottom that guide me. One base is my childhood… The second base is my role as a mother and links with my daughters. Both of these give me the strong support (base) I need. On these I build my professional life. The three are separate but combine to make a pattern and are linked in the circle. I also teach mineralogy and I love symmetry, and this is a 3-fold axis with no mirrors.

Collaborating with Critical Friends

Participants reported that learning a systematic method for analyzing their teaching with peers was motivational. Motivation and small group work have been reported as influential in faculty professional development (Gast et al., 2017). The research team was curious about what participants learned from being in the group and what they learned from each other, particularly as it related to the PAIDIA design element of "Integrated Critical Creative Collaboration," as well as "Accountability." What we found was that they each learned and made self-study their own from the questions that mattered most to them. Professional development is useful when faculty see it as useful to them. Faculty members recognized themselves as the designers of their teaching and as pedagogical enactors and yet also appreciated what others contributed to their learning. In this sense, the collaboration and the learning are inextricably linked. Bob appreciated that the group involvement "holds you accountable to show up and talk about what I've been doing… so I better organize my thoughts a bit and attempt to make it make sense to a non-math person."

Figure 3
Julia's Knot

We found data to support that participants valued what they were being offered by critical friends to think more deeply about their teaching and make changes in their actual practice. For Ioulia the group experience "generated new research ideas" and taught her that writing about one's teaching is doable if approached in incremental steps and with a narrowing of a manageable focused topic. She shared that it also informed her leadership in her department in terms of "how constructive peer feedback fuels a collaborative." Becky explained how her work in the group informed her work with her students "to see what they saw and adjust teaching accordingly." Julia also saw an influence:

> Becky had some really good ideas about drawing… And I feel a bit more comfortable doing that now. Sometimes in a science, when you're drawing things out people think "Ah, that's a little bit artsy…", but, it really is good for them understanding the complexity of what's happening, and I like that.

Reid reported how his involvement gave him insight on "how to best mentor students" as he began to better understand self-study research as a "proto-synthesis" or hypothesis space. He invited and supported his students into his research and writing (Cundra, Benzel, & Schwebach (2017). He noted that the group helped him reconsider his work on a research team at a meta-level:

> There isn't that kind of thinking in higher education…I understand working with research teams…having groups of people working together to do an investigation but this isn't like that because it's a research team that's meeting for their own investigations.

Related to their critical friends, the "chemistry" of the group was seen as important.

Participants reported that they offered and received feedback and support during the monthly meetings, but not outside that time, largely due to lack of time. Sharing ideas with others helped trigger new ideas. Ongoing informal presentations of draft papers were reported as key to participants' motivation and support. Inviting self-study colleagues as experts into the meetings with a focused reading was also appreciated and allowed a participant "to see herself writing about her research."

Bob indicated that "the framework [of sharing with critical friends] gave me a little bit of permission not to worry." Vicky, recognizing the value of mistakes for herself and improving learning for others, asserted:

> I understand that I am not the only person in the world who does such things, so probably if someone else wants to do it, knowing that someone went through this and these are the most common mistakes, or at least some mistakes can be pointed out, might save them some trouble.

Vicky's remarks align with the PAIDIA element of "Improved Learning for Self and Others."

Understanding Teaching as Research

The grant was designed with a people-driven focus to meet the needs of faculty, and the PAIDIA framework begins with a Personally Situated Chosen Inquiry. The learning community offered each participant an opportunity to identify an interest in their own teaching and consider how it could be research. The six participants who joined and remained in the collaborative did so because they indicated that they found personal value in the project. Yet, they expressed that they were not very familiar with how to conduct educational research of their teaching. For some, the educational research was grounded in work they were already doing, such as mentoring students or differentiating student learning. Nonetheless, learning and enacting teaching as research would be new learning and with a focus on their role, not on how to change their students.

There were expressions of discovery about how to conduct education research and think about their teaching practice, e.g., "I realized I can approach teaching as research." Moreover, writing educational research was, as one participant explained, "a very different style of writing so it's extremely difficult…and extremely different from what I'm used to." Writing about one's teaching seemed unusual: "I never thought that anybody would really be interested in that, or, I should be writing about that." Ioulia expressed that "the whole thing is humbling. I never thought that teaching could be a research subject."

The PAIDIA framework includes design-disseminate as an element with participants designing an inquiry and then disseminating it. An important component of self-study methodology is to subsequently make the study of practice public with other audiences for further examination and validation, resulting in the PAIDIA design element of "Improved Learning for Self and Others". There were also practical concerns and a desire to publish with tangible products in the form of conference presentations and journal papers. Participants appreciated and utilized the publishing resources the research team provided in a web forum. At the end of the project, each participant either presented or published their self-study of teaching or did both. Collectively, the group presented at the annual teaching conference organized by their

university to highlight innovative teaching practices across campus with a participant leading the poster session. (Nord, et al., 2016). Two other participants presented their research at another conference (Samaras et al., 2017). Another participant presented a poster at an annual engineering education conference (Ikonomidou, Samaras, & Kotari, 2016). This is consistent with the need to find ways for faculty conducting research about their teaching in STEM to find ways to document their scholarship for promotion and tenure (Dolan et al., 2017).

Discussion and Implications

Implications for Using Self-study to Improve Teaching

This study reports on the perspectives of STEM faculty who participated in a self-study faculty learning community designed for improving their teaching. Research questions were focused on participants' experiences in learning and enacting self-study methodology, what they learned about classroom-based self-study research, and the role the collaborative design played in their learning. Data supported that participants learned self-study methodology even though it was unique and complex. Their participation helped them think deeply about their teaching and professional teacher identities, also reported as a major finding by Gast et al., (2017). Participants were able to make linkages between education research and their own teaching while they embraced the problematic nature of teaching as work that is always in development. A critical component of self-study is counter-intuitive in that it fosters deep reflection about one's own teaching practice via the sharing of that practice with critical friends. Faculty reported that working with critical friends did help them reframe their thinking about teaching and understanding teaching as research.

For the research team, the study confirmed the larger grant goal: supporting faculty's small changes in teaching over time can lead to larger changes in building individual and collective capacity. Self-study methodology supported that process. This study also raised new and important questions such as the following:

- "What might learning look like for faculty if there were more faculty self-study learning communities across colleges and disciplines?"
- "What are the opportunities for tenure-track faculty to advance their teaching agendas and scholarly profiles?"
- "How might self-study support the teaching of the increasing numbers of adjunct faculty who most often work alone?"
- "How can departments and colleges better support faculty in these roles to advance excellence in faculty teaching?"
- "What needs to be in place for support and sustainability?"

Self-study research is an untapped portal into exploring such important questions to improve the pedagogy of teaching.

More broadly, this study adds to the existing approaches in faculty professional development using self-study methodology. Considering the large number of students taught by faculty and in the critical need area of STEM, the work of faculty studying their teaching is a needed area of research, as well as is studying those who facilitate it. Uniquely, it adds to the literature related to the learning that can ensue among STEM faculty engaging in self-study as educational research. However, there are broader implications of this study such as designing supportive forums for faculty from other disciplines to have communities in which to study their teaching. It also suggests the importance of rewarding such work.

Implications for Institutions of Higher Education and Future Research

For institutions of higher education, faculty learning communities simultaneously emphasize research and teaching, regardless of discipline, years of teaching, or status. Participants in this study differed in background and experience, although each was interested in improving his or her teaching. Each participant had expressed earlier interest in their teaching through their involvement in the university center for teaching; one had participated in an earlier self-study community, and several had received university awards for teaching. They had demonstrated a persistence in their faculty development−the engaged, enthusiastic, and committed ones. Further research might investigate personal and institutional barriers for those who did not remain in the group and how they might be incentivized to study their teaching.

This study also offers a window into the complexities of supporting teaching in higher education for faculty at different points in their professional careers. There is a great deal of research on the socialization of new faculty in the academic lives (Bond, 2015) but less on those who have been in the academy for a number of years. Further research might explore how faculty are socialized in their teaching at later points of their careers and how those who have been teaching for a number of years may have opportunities to renew their teaching (Blaisdell & Cox, 2004). Noteworthy in this study, term faculty stated that they benefited in working with non-term faculty.

For term faculty it offered them an opportunity to explore their teaching as a research practice since their primary position at the university is teaching. From a practical perspective in terms of faculty evaluations/promotions, engaging in work that produces publications provides evidence of scholarly activity for all faculty. It may be useful to explore the reciprocal benefits of term faculty working with non-term faculty.

As institutions explore new learning environments such as online learning, blended learning, and classroom spaces designed for interactive teaching, self-study allows faculty to examine how they can use these new environments and share their learning with others who are also teaching in these new contexts (Garbett & Ovens, 2017). Similar approaches indicate that institutional support increases the likelihood of genuine faculty development, as well as improves retention, productivity, career agency, and satisfaction (Balmer & Richards, 2012; Gast et al., 2017; O'Meara, Rivera, Kuvaeva1, & Corrigan, 2017). Ultimately, the mission and sustainability of institutions of higher education depend on improving student learning–and that entails supporting collaborative forums for faculty to improve their teaching.

Conclusion

This study contributed key findings to the research base about the use of self-study methodology for faculty development with STEM faculty. Learning self-study methodology acted as a lever to move faculty from the mode of simply applying strategies to developing a mature teaching identity by examining and researching their roles as instructors. However, the active collaboration with critical friends was necessary to motivate faculty to continue to engage reflexivity as instructors and to then conduct research related to their roles as instructors and the changes they were enacting. Thus, self-study methodology provided an avenue for faculty to transcend an externally-oriented development process to an agentive process of continuous improvement focused on one's own role in students' learning beyond simple implementation of a lesson. This model may be useful as a catalyst for developing an advanced teaching trajectory for STEM faculty.

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Appendix

Interview Questions for Participants

1. How does this collaborative experience differ from previous collaborations about teaching, including if you participated in a TDG?

2. Tell us about a critical incident that occurred during your experience with the TIG group. (Probes: Was there a nodal moment or a time when something clicked because of something that happened?)

3. What was your motivation for joining the TIG? (Probes: How were you involved? What made you come and what made your stay?)

4. How has the TIG group informed your teaching practice and/or reframing of your practice in the classroom? (Probes: How did you think the TIG affected your processes for changing your teaching/your scholarship? Affected your choice of changes? How you enacted those changes?)

5. What teaching strategies did your group suggest? (Probes: Did any suggestion stand out as very helpful? In what ways did something change for you as a result of any suggestions?)

6. What do you think your contributions were to the group as a whole and then to your critical friend group?

7. What do you think about the structure and organization of the group's gatherings through the in-person meeting and then virtually through Zoom? (Probes: What feature worked best for you? Why? What did not work so well? Why not?)

8. How likely are you to want to continue to be a part of your critical friend group and then the larger group as a whole? (Probe: In what ways do you see your work continuing with our TIG group?)

9. Do you see this work in self-study scholarship continuing in your practice and in what ways? Why?

10. What outlets and venues have you considered to disseminate your scholarship of self-study to others?

11. Is there anything else you would like to mention that we didn't ask?
Thank you.