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Sustaining pedagogical change via faculty learning community



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Abstract

Background: The necessity of a science, technology, engineering, and math (STEM) literate population continues to be a high priority worldwide. One approach to build and bolster a STEM-literate workforce is to explore approaches for strengthening the teaching of college-level STEM courses. The use of collaborative student learning pedagogy is broadly accepted as an effective approach to improve student learning outcomes over traditional methods, such as lecture. How to encourage and sustain the use of such evidence-based teaching practices in STEM fields is a critical topic. To achieve pedagogical change among college faculty, research supports a faculty learning community (FLC) structure. FLCs are a way to facilitate deeper understanding of a topic within a community of practice. Of particular interest for this paper is whether any FLC-supported pedagogical change was sustained by the faculty after the FLC ended and if so why.

Results: Engineering faculty found success in implementing paradigmatic pedagogical changes by engaging in an FLC that intentionally provided structures to promote a community of practice. This paper reports on the endurance of these pedagogical changes up to 2 years following conclusion of the FLC, with evidence summarizing reasons why many of the faculty had absorbed much of the once-new pedagogical approaches into their ongoing practices.

Conclusions: FLC structures that faculty credit to their pedagogical change and the enduring impacts of those changes are described. These results offer evidence that it is possible to structure faculty support for them to make enduring pedagogical change, rather than temporary or one-time changes as part of a particular initiative. The findings, discussion, and conclusions of this study are likely to be of interest to faculty developers, innovative university leadership, or faculty exploring ways of sustaining a pedagogical change.

Keywords: Sustaining pedagogy, Faculty learning community, Community of practice, Collaborative student learning

Introduction

How to encourage and sustain the use of evidence-based teaching practices among science, technology, engineering, and mathematics (STEM) fields is a critical topic. Professional development in teaching for university faculty is often scattered and not supported in a coordinated way by STEM Department administrators (Borrego, Froyd, & Hall, 2010; Fairweather, 2008). For several decades Professional Learning Communities (PLCs) have been a common practice in the K-12 teaching community, and they provide means for teachers to learn, share, and encourage

each other to develop and test new pedagogies (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). More recently, practitioners of higher education have adopted a similar community professional development model to assist university teaching development and encourage pedagogical changes, referred to as a faculty learning community (FLC) (Cox, 2001). PLCs and FLCs are both examples of communities that share a common interest and practice, known as communities of practice (Lave & Wenger, 1991). This study takes a retrospective view of the enduring pedagogical changes initiated via faculty participation in an FLC and provides evidence that supports sustainable pedagogical practice acquired through the community of practice experience.

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This research was conducted within the context of an engineering school at a large urban university. The administration of the engineering school, with support of its faculty, created a center dedicated to promoting educational excellence in the teaching of engineering. That center promotes professional development opportunities for faculty, with a mission to foster outstanding teaching and learning among engineering faculty. One specific goal is to advance the use of evidence-based teaching strategies. The faculty and the administration were aware of the challenge by Prince (2004) for engineering faculty to promote collaboration in their classes. Additionally, the accrediting agency for engineering programs (ABET, 2018) specifically links collaboration to the engineering curriculum via two of the 7 required student outcomes (ABET, 2018). The two outcomes directly related to a student's ability to collaborate refer to "an ability to function effectively on a team" and "an ability to communicate effectively." Also, employers desire graduates who can collaborate on teams but have reported that engineering students are not well prepared to do so (Jaschik, 2015). To encourage the faculty to use collaborative learning techniques, the dean of the school of engineering specifically redesigned one learning space for active and collaborative learning. As a result, he asked that the engineering education center provide professional development for faculty to make proper use of the new space. This led to the choice of collaborative student learning as the specific evidence-based teaching strategy as the focus for the FLC.

The engineering education center partnered with the university's professional development unit and a faculty member from the university's education college to encourage and engage faculty in the use of collaborative student learning techniques throughout the engineering disciplines. Using the FLC framework, they offered two community of practice cohorts focused on the implementation of collaborative student learning techniques in engineering courses. One cohort was conducted during a full school year in 2014–2015, and another in 2015–2016.

The challenge to encourage evidence-based change in teaching is not only how to educate faculty about the particular strategy, in this case, collaborative student learning techniques, but also how to support them as they attempt to implement paradigmatic pedagogical changes. We (Ralston, Tretter, & Brown, 2017) described the approach and the initial impact on the first cohort of faculty participants, including support structures that enabled faculty to implement collaborative learning techniques, as well as the benefits participants experienced from pedagogical shifts. However, in addition to supporting initial pedagogical change, an additional challenge is to understand if such change would be *sustainable, long-term (beyond FLC duration)* and what may have supported any long-term changes.

Purpose of the study

The purpose of this study was to determine if an FLC experience focused on collaborative student learning can have sustainable impacts 2–3 years after completion of the FLC. This study first identified what FLC structures were considered critical for initial implementation, given that faculty perspectives may have changed since the original implementation. Subsequently, it documented what collaborative learning techniques were retained, modified, or discontinued within faculty teaching practices in order to more fully characterize what might or might not have been sustained post-FLC. Finally, it illuminated characteristics and potential follow-up activities to support and sustain a community of practice focused on pedagogical change.

Identifying ways faculty can sustain a long-term pedagogical change through an FLC experience is of high interest (Cox, 2004; Richlin & Cox, 2004). Although FLCs have been shown to be effective for initiating change (Furco & Moely, 2012), there is sparse evidence whether these changes are sustained or sustainable beyond the FLC participation. Determining what FLC structures encourage the long-term sustainability of any evidence-based teaching strategy within a faculty member's teaching practice is of particular interest as universities work to implement professional development opportunities to encourage the widespread use of effective pedagogies grounded in how students learn (Borrego & Henderson, 2014). This study explored the institutional and community supports necessary to sustain pedagogical change.

There were 14 total faculty participants from two FLC cohorts. Of the 14 participants, two did not fully engage with the educational goals and suggested pedagogical changes of the FLC during the initial FLC implementation and were therefore not invited to participate in this follow-up study since there had been no meaningful change to be sustained. The remaining 12 participants were interviewed, and their comments analyzed to answer research questions related to sustaining pedagogical change.

Literature review and conceptual framework

Despite the body of evidence that should inspire engineering and other STEM faculty to incorporate evidence-based strategies in their courses, lasting changes in teaching practice have been slow to take place (Borrego & Henderson, 2014; Fairweather, 2008). Fairweather (2008) noted that faculty perceive that curricular change will take valuable time away from research activities critical to promotion and tenure. Other potential barriers to pedagogical change for STEM faculty include situational constraints such as fear that time taken would prevent necessary content coverage, perceived student attitudes (including laziness and resistance), lack of ongoing

professional development, unsupportive institutional or departmental culture, and personal beliefs and expectations of faculty about teaching and learning (Henderson & Dancy, 2007; Michael, 2007; Sunal et al., 2001; Walczyk, Ramsey, & Zha, 2007).

Until recently, efforts to effect change in undergraduate STEM education focused on individual faculty innovators to test, create, and disseminate reform approaches (Kezar, Gehrke, & Elrod, 2015). This method of change has been challenged as unsuccessful (Fairweather, 2008; Kezar, 2011). Kezar et al. (2015) emphasize the need for faculty to serve as change agents that develop explicit change theories rather than work from implicit theories that do not show reasonable proof of success. They describe the need to create professional dialogues and support networks to implement and spread reform. Borrego and Henderson (2014) identify and categorize eight change strategies supported in STEM literature, one of which is the faculty learning community (FLC).

Faculty as learners

The belief that learning is most effective when performed in a community is not new. When faculty engage in a learning community, they essentially take on the role of a learner by participating and internalizing the content of inquiry. John Dewey (1910, 1913) originally emphasized the role of shared inquiry in education, noting that “setting up the conditions which stimulate visible and tangible ways of acting is the first step” (Dewey, 1916, p. 18). The completing step, he described as “making the individual a sharer or partner in the associated activity so that he feels it’s success as his success, it’s failure as his failure” (Dewey, 1916, p. 18). For our study, the content of inquiry for faculty’s engagement to make pedagogical changes was teaching that included collaborative student learning. This study focuses on faculty’s sustainment of pedagogical change beyond the FLC year.

A community of practice (CoP) consists of a group of people who share a concern or passion for something they do and learn how to do it as they interact regularly (Lave, 2009; Lave & Wenger, 1991; Wenger, 1998). CoP literature suggests considerations should be made in terms of CoP design and the relationship design has with identified goals toward pedagogical change (Kezar, Gehrke, & Bernstein-Sierra, 2017). Intentional considerations of the natural and emergent growth of a CoP enhances the individual faculty member’s learning experience (MacDonald, 2008), including explicit attention in the design to bring out the community’s own internal direction, character, and energy (Wenger, McDermott, & Snyder, 2002). There is no single best CoP design; the structure varies to ensure active engagement by community members and enable the community to meet its specific goals (Cox, 2005;

Iaquinto, Ison, & Faggian, 2011). A key characteristic of a CoP is that it brings faculty together who share a common interest in the pursuit of deeper understanding of a topic (Wenger et al., 2002). An effective CoP, as described by Iaquinto et al. (2011), includes members that demonstrate a sense of ownership, willingness to participate in expertise building, continuous communication, and engagement with reflective practices that focus on self-identified professional areas of improvement.

A type of CoP in K-12 education, commonly referred to as professional learning community (PLC), has been credited for progress in K-12 educational reform (Stoll et al., 2006). Necessary for CoP effectiveness using PLC structures is strengthening teachers’ individual and collective capacity for school-wide learning. Capacity encompasses a complex blending of motivation, skill, positive learning, organizational conditions, culture, and infrastructure of support (Stoll et al., 2006). PLCs are a long-standing practice used within the K-12 context as a structured way for teachers to strengthen their pedagogy within a systematic support structure (Hipp, Huffman, Pankake, & Olivier, 2008; Hord, 1997).

In the higher education context, a model like a PLC emerged, referred to as a faculty learning community (FLC). An FLC is defined as a specifically structured, year-long academic community of practice, comprised of interdisciplinary faculty members engaged in an active, collaborative program designed to foster scholarly, evidence-based teaching and enhance student learning (Cox, 2004). Research suggests that faculty learning communities foster growth in pedagogical innovation and scholarly teaching (Furco & Moely, 2012; Richlin & Cox, 2004), increase faculty interest and confidence in teaching (Cox, 2004), and lead to increased student learning and retention, as well as higher rates of tenure (Cox, 2004). Faculty learning communities have also been demonstrated to generate a knowledge base accessible to the broader university community, thus improving teaching more broadly (Cox, 2003, 2004; LePage, Boudreau, Maier, Robinson, & Cox, 2001). An FLC is based on the concept of a CoP (Wenger et al., 2002), recognizing that learning is social and co-constructed within a situated and particular context (Lave & Wenger, 1991).

FLC focus

This study targets faculty from two FLC cohorts to examine whether the faculty members sustained the changes made during an original FLC experience. The topic of common interest embraced by both FLC cohorts was to integrate evidence-based strategies of collaborative student learning techniques into their teaching practices. See Ralston et al. (2017) for additional details about the FLC implementation and initial pedagogical outcomes.

Collaborative teaching techniques have been shown to offer tremendous benefits to student learning for several decades (Johnson, Johnson, & Smith, 1998; Prince, 2004; Springer, Stanne, & Donovan, 1999). Benefits include improvements in student achievement, quality of interpersonal interactions, self-esteem, student attitudes, and retention. Collaborative student learning falls under an umbrella term that includes or overlaps with many terms associated with active learning in the literature, but in this paper, we use the term as defined by Barkley, Cross, and Major (2014). They described collaborative learning as any structured form of small group interactions among students (Barkley et al., 2014). This definition was adopted by both FLC cohorts for the implementation of collaborative student learning techniques. In addition to content learning and understanding gains, collaborative activities improve students' communication and social skills necessary for the global workplace. CoPs serve as a vehicle to enhancing the likelihood that faculty will employ student-centered pedagogy, such as collaborative student learning (Tomkin, Beilstein, Morphew, & Herman, 2019). Of interest for this research study is whether and why faculty may have sustained any pedagogical change initiated through their FLC participation.

Conceptual framework

The conceptual framework that guides this study incorporates the theoretical direction from the literature on CoPs, PLCs, FLCs, and collaborative student learning techniques. With an original FLC cohort goal to achieve the outcome of faculty initiating pedagogical change, our approach was to adopt an FLC structure that incorporated the CoP features that emphasized shared growth (see Ralston et al., 2017 for details about the FLC implementation). The specific FLC pedagogical target of encouraging faculty implementation of collaborative student learning was the selected evidence-based practice which

afforded faculty flexibility in implementation. With this particular FLC focus as a common target, having established and implemented a year-long FLC and established a community of practice with these faculty, our conceptual framework guides this paper's exploration of, and why, this particular community of practice may have been helpful for faculty to sustain pedagogical change beyond the FLC support year. Fig. 1 is a pictorial representation of this study's conceptual framework.

(Ralston et al., 2017) selected the FLC approach as a structure to effect change among a multidisciplinary group of engineering faculty. The results from that approach included three elements supporting success in faculty initial implementation of collaborative student learning techniques: (1) faculty member's philosophical position in relation to the value of collaborative student learning for a particular course, (2) aligning appropriate collaborative techniques with course objectives, and (3) a fully developed pedagogy (i.e., structured follow through and integration with the course) (Ralston et al., 2017). Among the faculty participants of the FLC, almost all were successful in initial implementation of collaborative student learning techniques. What remains uncertain, both for this FLC and within the body of FLC literature, is if and for what reasons faculty successfully sustain long-term pedagogical changes beyond the initial FLC.

Research questions

The first FLC cohort we studied concluded at the end of the 2014–2015 academic school year, with results from that FLC reported in Ralston et al. (2017). A second FLC cohort with similar results was conducted during the 2015–2016 school year. This study explored the sustainability of these FLC efforts, given that over two academic school years had elapsed since the conclusion of the FLC support. This research will answer the following questions:

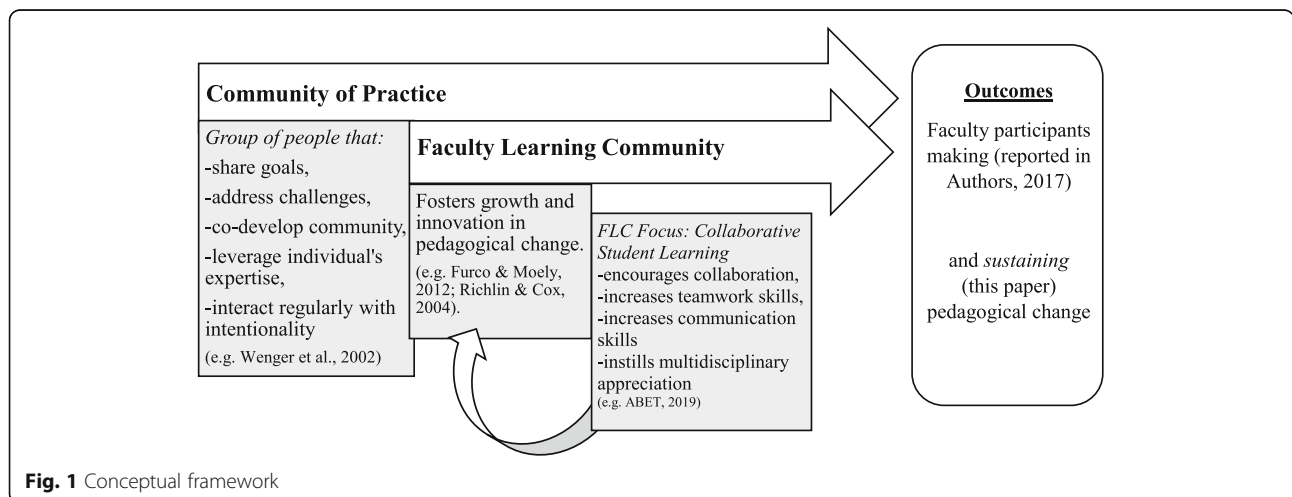


Fig. 1 Conceptual framework

- 1) What, if any, positive long-term (2–3 years, post-FLC) outcomes from the FLC are still evident in faculty teaching practices?
- 2) What FLC structures enabled any of the long-term impacts?
- 3) What supports are necessary to sustain a community of practice focused on faculty embracing evidence-based pedagogy?

Methods

A professional development initiative at an urban, research university between a university faculty developer, an engineering faculty member, and a science education faculty member emerged to create necessary support structures (see Ralston et al., 2017) for engineering faculty wishing to explore integration of collaborative student learning pedagogical strategies into their engineering courses. The engineering faculty member was the director of an engineering learning center whose mission was to foster outstanding teaching and learning at the engineering school, and the education faculty member was director of an education center that targeted research in science/engineering/mathematics K-16 teaching. These two individuals along with the professional developer from the university's center for teaching and learning unit were the three instigators and facilitators of the initial FLC (Ralston et al., 2017).

From an initial charge from the Dean of the School of Engineering to encourage faculty to embrace collaborative student learning strategies, the facilitators of this FLC used a variety of training methods within the FLC framework. They included providing a common book to create shared understanding of collaborative student learning and how specific strategies might be incorporated, conducting workshops prior to and following participants' implementation of collaborative student learning activities and coordinating whole-group sharing and reflection on the experience, including lessons learned through experience.

A study of the FLCs identified two main barriers or challenges: (1) the concern that collaborative activities would reduce time for content coverage and (2) the fact that faculty needed support in pedagogical change and a community of peers to share concerns and frustrations with as they made pedagogical changes. These challenges were overcome, faculty participants reported strong satisfaction with our FLC structure, and they were still able to achieve appropriate coverage of content while making class time for students' collaborative activities (Ralston et al., 2017). This study reports on the sustainability of that pedagogical change several years after the conclusion of the FLC support.

Participants

FLC follow-up participants

Of the 14 original FLC members from the two cohorts, as noted in the introduction, two participants did not

embrace pedagogical change in the initial FLC and were therefore not included in this follow-up study since there was no change to be sustained. The remaining 12 faculty participants were members of seven of the eight departments within the School of Engineering. These faculty members had been at the university for at least 3 years, had a range of experience from junior faculty to department chairs, and included both tenured, pre-tenure, and term faculty. Only one faculty member participant had systematically experimented with collaborative student learning techniques prior to joining the FLC. See Table 1 for a summary of key demographics of these FLC participants. More detail about the faculty and FLC context (e.g., faculty identification and recruitment, engineering specialties, tenure status or term status, courses taught) are provided in Ralston et al. (2017).

The courses taught by FLC faculty included a spectrum of topics (introductory to capstone), class sizes, programs (undergraduate and graduate), and types (lecture, group-project, problem-solving focus). This wide variety of experience and courses afforded the opportunity for faculty to explore collaborative student learning techniques that were most appropriate to their course context. These differences encouraged faculty sharing and discussion around modifying their pedagogy appropriately, based on their needs for the course they chose for implementation. In this way, the FLC effort and support was individualized, emphasizing the adaptability of collaborative student learning approaches. Differences among courses strengthened faculty learning because they were able to observe different applications of collaborative student learning techniques used by their faculty peers.

Researchers

The four researchers for this paper included two faculty and two graduate students. The faculty researchers are both professors at the university and are directors of education research centers within their respective schools and were facilitators of the original FLC. Both graduate students are Ph.D. students in science education with experience in STEM and STEM education.

Table 1 Description of FLC cohort participants

Cohort	Number of participants ^a	Number of engineering departments	FLC participant level of teaching experience
1	6	6	1 Senior faculty 3 Mid faculty 2 Junior faculty
2	8	7	3 Senior faculty 2 Mid faculty 3 Junior faculty

Note: Senior more than 15 years of teaching experience when starting the FLC, Mid 5–15 years of teaching experience, Junior less than 5 years of teaching experience

^aTwo FLC participants did not embrace pedagogical change (see Ralston et al., 2017)

Data sources

The 12 faculty FLC participants were invited by email to participate in individual interviews. The potential for a follow-up study was not discussed during either of the two initial FLC implementations, and the support structure provided by the FLCs was not continued after the completion of each FLC. We anticipate that this lack of prior knowledge about any follow-up interview offered a context where faculty could reflect on their teaching as it naturally evolved, rather than the faculty having a priori expectations of being interviewed about their teaching post-FLC. Overall, the participants' lack of expectation for following up after the conclusion of the FLC provided an authentic context (as opposed to an influenced context) for exploring the sustainability of the FLC efforts. This is especially important because if the participants were still using collaborative student learning in their courses, it would be due to their own belief in the efficacy of collaborative student learning. Had the faculty participants known there would be follow-up they could have continued to use the techniques because they felt they needed to rather than wanted to use them. These interviews occurred 1–2 years after the completion of the participant's FLC experience and lasted for 30–60 min each.

The semi-structured interviews were conducted by graduate student researchers using a protocol developed by the research team (see [Appendix 1](#)). After jointly conducting the first interview to strengthen the subsequent consistency of individual interviews, each graduate student completed six interviews, which were randomly assigned. During the interview, both digital recordings and field notes were taken. The interviews were then transcribed by the interviewer.

Data analysis

Guided by our research questions, we utilized the inductive analysis approach of consensual qualitative coding (Hill, Thompson, & Williams, 1997). We chose this method because of the assumption underlying the consensus process entailing multiple perspectives and levels of awareness that increases the ability to describe the lived experiences of the faculty participants. Complex issues, like teaching and the influence of the FLC experiences in our study, necessitate the involvement of many different perspectives and levels of understanding. Consensual qualitative research is more likely to reduce research bias since the common themes are informed by the iterative coding process involving the varying perspectives of multiple people.

Because our research questions are about faculty sustaining pedagogical change after an FLC, rather than initiating change with the support of a CoP, we did not use a-prior codes from the CoP literature since those codes are documenting how a CoP effectively supports the process of change, not the sustenance of change. Given this different research focus and lack of a substantive body of literature about sustaining pedagogical change, we chose to use emergent coding as our core data analytic strategy.

The data analysis involved a 3-step process: (1) clustering the data into domains, (2) condensing the data into core ideas, and (3) cross-analyzing to extract common themes across all participants (Hill et al., 2005). After transcribing their six interviews, each graduate student individually identified potential, fruitful domains into which interview responses might be categorized. The domains were broad categories with the potential to address some aspect of our research questions. For example, when faculty described specific collaborative student learning pedagogical strategies they were still using or had modified over the course of the past few years, these comments would be grouped under a domain loosely labeled *continued pedagogical practices*. Interview responses indicating the converse of this, sharing pedagogical practices they no longer used, were likewise grouped into this same domain because it provided data as well about the continuance (or not) of pedagogical practices. Sometimes a given interview response may have been categorized into multiple domains, for example when referencing continuing pedagogical practices but also including comments about how the initial FLC supported them in making the initial change, or sometimes how FLC discussions with other faculty led them to modify their particular approach to this pedagogical practice (domain label of *supportive FLC structures*).

All four researchers met and discussed the emergent domains, with the two faculty researchers serving as auditors reviewing the interview responses associated with each domain to ultimately reach a consensus about how to initially categorize interview responses into broad domains. Domains for this study, guided by our research questions, included continued or discontinued use of collaborative student learning pedagogy, FLC structures faculty identified as pivotal in the sustainment of their pedagogical change, and any CoP features that were helpful—including in some cases the decision by some faculty to independently continue 1:1 peer observations and discussion post-FLC, for example. At this first stage of data analysis, the raw interview data was not interpreted or synthesized any further than simple initial

categorization into domains, with those domain assignments subject to revision and reconfiguration via consensus as described above.

The second step of data analysis involved all four researchers independently inductively coding the raw interview data (per faculty participant) for core ideas within each domain. A core idea was defined as specific potential interpretations that may be accorded specific interview responses. For example, if a faculty member indicated that since the FLC, he had made what we judged to be small tweaks to a specific pedagogical strategy that would be classified under a core idea of *continuing the same pedagogical strategy*. If, however, an interview response described a major change or perhaps even use of a related but different pedagogical strategy (still under the broad domain of *continued pedagogical practices*), this would fall under a different core idea within this domain of *new or adapted pedagogical practice*. Core ideas were at a much finer grain size than the broad domains.

Each researcher presented their synthesis of core ideas within each domain, per faculty participant, to the 4-person research group. Through a second consensus process, the researchers were able to generate a list of core ideas directly grounded in the interview data. The consensus of core ideas brought the researchers into the final step of data analysis which was to cross-analyze the data and extract common themes across all participants. Because this final state of data analysis was structured to be across the 12 faculty cases rather than within faculty as had been the structure of data analysis up to this point, the specific themes to be extracted were expected to be multiply-influenced by different faculty responses and thus likely to not be in a one-to-one correspondence with core ideas. Additionally, we discussed and understood that the extraction of common themes across participants would likely result in themes with a larger grain size than the core ideas. Thus, the 3-stage data analytic process can be thought of as follows: (a) condense the raw interview data into broad domains for each individual faculty participant; (b) expand detail within each individual faculty's domains with relatively numerous, fine-grained core ideas; and (c) recondense the fine-grain core ideas into larger themes that tracked across faculty.

To audit and check reliability during the final data analytic stage of theme extraction, the 12 transcripts were randomly and evenly divided between the two faculty researchers so that each researcher coded six interviews—three from each graduate student researcher. The graduate student researchers also exchanged transcripts and coded the other six transcripts

that they had not generated. During this process of theme extraction across faculty participants, each researcher continued to evaluate whether they thought the consensus-determined domains and core ideas were correctly identified and accurately reflected the data corpus. Suggested modifications and/or additions to the initial domain or core idea list were identified for future group resolution.

After independently completing this stage of data analysis, the team met again and discussed the domains (as needed), core ideas (as needed), and extracted common themes. In particular, since each individual researcher had extracted common themes across an overlapping 6 of the 12 participants, we merged and combined our themes to represent the entire corpus of data. This process ultimately resulted in 4 common themes presented below.

Results

The cross-case analysis led to 4 common themes that participants' responses informed (see [Appendix 2](#)): (1) benefits for faculty, (2) benefits for students, (3) positive features of FLC experience, and (4) next steps. In reporting the results, we avoid specific numbers of how many faculty members mentioned each topic because what faculty chose to convey in interviews varied quite a bit, thus, any reporting of numbers may suggest others did not agree, which would be a false inference. In keeping with qualitative research norms (Maxwell, 2010; Hannah & Lautsch, 2011), qualifiers such as all, most, many, some, several, and few, will be used to convey a more appropriate sense of the extent of specific faculty expression in agreement with the four themes.

Twelve of the 12 FLC participants reported that they had continued integrating some aspect of collaborative student learning techniques within their courses. Many stated that their integration has transitioned from being a time- and labor-intensive practice to common in their practice of teaching. As one faculty member stated, "The FLC greatly improved on what I was doing...I think through my goals, why I am doing things in certain ways or how to better facilitate the activity. I now think through how I was doing things and see different ways I could change; it's definitely helped."

Benefits for faculty

Many FLC participants credited their experience within the FLC as transformative toward either starting or emphasizing the importance of collaborative student learning within their teaching practice. Faculty described four categories of benefits for themselves from incorporation of collaborative student learning approaches in their

teaching: (1) the opportunity to provide real-time feedback within the classroom, (2) enriched interactions and connections with students, (3) better techniques for teaching teamwork, and (4) positive faculty peer collaborations the FLC facilitated and afforded.

Real-time feedback

Many of the faculty members explained how using collaborative student learning techniques allowed more real-time feedback about their teaching and their students' understanding of the material. One faculty member described real-time feedback as a key element of successful collaborative student learning because, "[without real students trying it], you won't understand what live real-time feedback looks like and what students will do in response to what you do." Another faculty member explained that he "liked hearing students talking it out" and "if they are in the weeds, I can intervene." A third faculty member detailed how using formative assessment in the form of pre-quizzes guides the focus of not only his next class meeting but potentially the next two or three classes. The pre-quizzes facilitated the way he planned his instruction, "I can give them a pre-quiz at the beginning of class just to make sure they're ready to go... set them up to provide that feedback right then and there." His in-class feedback to students had become more fluid and he noticed an improvement in overall student understanding.

Enriched student interactions

All faculty members expressed how their implementation of collaborative student learning techniques within their classroom bolstered their interactions and connections with students. "You get these high-quality interactions with students, but the facilitation is really how you structure and run the classroom" is how one faculty member explained his implementation. Comparing his teaching experience before and after implementing collaborative student learning techniques, his reflection strongly indicated the importance of communicating with students the reasons behind his instructional choice to implement collaborative student learning in their classes. Another faculty member came to the FLC with the intention to increase the teacher-student interaction within his course(s). He shared, "I've learned that there needs to be balance. I think there is a blend there where teachers can interact with the class and combine that with students working collaboratively with other students and the teacher." The faculty member described his first implementation of collaborative student learning as "trying too much." Adjusting his approach, he found an increase in student-teacher interaction through the co-creation of understanding, a process he called "collaborative thinking."

Most faculty members informed their students at the beginning of the semester of the reasons for their instructional choices to implement collaborative student learning in their classes. While some discuss with their students in an open-forum style discussion, others shared that they reference research (i.e., Oakley, Felder, Brent, & Elhadj, 2004) as a way to convince students of collaborative student learning's effectiveness toward their learning. One faculty member, focused on team homework assignments, includes a citation on the front of the team packet that each student group is to complete for that assignment. She explained that being able to present the literature background is important and had it not been for the FLC she would not have the knowledge to share with students, nor the understanding of how to implement the collaborative student learning techniques.

A final way the use of collaborative student learning techniques enriched interactions and connections with students was how it forced some faculty members to rethink the importance of teaching. One faculty member discussed how she had to reorganize the way she prepared for class. Instead of thinking of the material in a way that it was "easy for me to present" she needed to "think about whether this is easy for the students to accept what you presented or not." This shift in thinking helped her to realize that "teaching is important, because for us as [engineering] faculty, we talk about tenure and promotion all the time," but for her, more attention and thought needs to go into teaching in higher education. This faculty member also noted that this change helped with her connection to the students both in class and individually, stating "I think the students appreciate professors spending time in the classroom and after class...I think that's [an] important part." Another faculty member said that in the past he also had not given much thought to the "students' perspectives and students' learning" even though he knows that "what students learn in my class" is the most important thing. He explained that when preparing for lecture, there was not much time to think about it, but the FLC gave him that opportunity and dedicated time. Similarly, one faculty member explained that the experience "made me think more about the practice of teaching, I am more cognizant now of how I am doing things." The faculty went on to explain that the FLC had brought on a change in pedagogy that he now extends to other classes he teaches. Another faculty said "[the FLC and the focus on collaborative student learning] gave me a brand-new chance to review what I had done before...I think about teaching much more seriously than before." Extending this idea, the faculty member discussed looking at

teaching from a different perspective. His view is now from the student's perspective, stating, "you're talking about how students learn, not how you want to present your material."

Techniques for teaching teamwork

Most of the faculty members described how using collaborative student learning aided the teaching of teamwork. The way in which this occurred was largely based on what type of class the faculty member taught. Many of the faculty members of the FLC already taught courses that were collaborative in nature or had large collaborative components. For example, several faculty members taught seminar-style courses intended for upperclassmen or classes that introduce teamwork to students as part of the course objectives. One of these faculty members who teaches a seminar-style course explained "If you do want to get into the nitty-gritty or some examples of how groups work or not this is a good way to do it." She shared how important teamwork is, not just in her course but in the profession of engineering; an aspect that she felt more empowered to discuss with her students following her experience in the FLC as she said "it's backed by the literature." She also described how she talks with her students throughout the semester about the necessity of reaching beyond their comfort zone and that in real life you do not always get to choose who you work with, but you must get the work done.

A few of the faculty members who had taught traditional lecture-based courses redesigned their courses to be much more collaborative. One faculty member now organizes teams of students using a software program that automatically groups students with one another. Within a specified timeframe, student teams must work together to solve problems and present an answer prior to other student group submissions. While the upfront work in setting up the software and planning each class is daunting, his excitement grew as he discussed the final computer button click he makes to initiate the collaborative teamwork portion of his class. When peer-faculty observers are in his class, he draws their attention to that final click by saying, "watch this" and the class erupts as students scurry to find their groups to begin working together. His reflection also included how he must facilitate groups at the beginning, "it doesn't just happen," he says. It takes several weeks of classes before he feels the classes are ready for that final click into teamwork, but when they are, he feels his course has not just taught them the content knowledge but also allowed them to connect with each other as they form teams and work together to solve the problems of the day.

Another faculty member completely redesigned his course so that it "borders on doing a flipped classroom." As the semester progressed, the students started

"developing a little bit more of a group mentality." On days when they were working through problems in groups, the students came into class prepared to group up and get working: "as long as they know that the timeframe is, 'oh we're doing group work today', they just go." He also noted that he does "random pairing or partnering because [he] want[s] them to circulate through the classes" so that they have an opportunity to work with all different kinds of people. He said that this choice was different from how most other faculty he knew paired students.

Positive faculty peer collaborations

All faculty members expressed the benefit of positive peer collaborations the FLC facilitated and afforded. It provided them with a platform for discussing their teaching, learning about how others handled issues, and being able to both observe and be observed in the classroom. Most felt their FLC experience shifted their understanding of teaching from an individual effort to an appreciation of collaboration among peers. "[the FLC has strengthened my] desire to collaborate with faculty on matters other than, let's get together to talk about how we teach our class, I've come to value that and recognize when you start to think about what it takes to get students to collaborate, there's a give and take. It's not trivial to do." The FLC facilitated partners among faculty that then conducted peer observations. Almost all faculty mentioned (without interview prompt) being observed as beneficial to their teaching and many mentioned that observing others was just as beneficial, "every time I sat in someone else's class I've found something helpful in seeing how someone else does it."

The second element of the positive peer collaborations that almost all faculty members described was the accountability to their peers to investing the time before each meeting to try collaborative student learning techniques (or portions of the techniques) that they could then discuss during the monthly, face-to-face meetings. One faculty member that strongly expressed her appreciation of all the FLC participants stated, "It's a commitment thing-that people showed up." She went on to discuss how the FLC offered a space where "we held each other accountable." Her feelings were echoed by other faculty members, as many found it difficult to pinpoint one single aspect of the accountability; but all included the opportunity to discuss their collaborative student learning implementations, explore further literature on collaborative student learning, and making connections outside of their department that they would not otherwise have had the opportunity to make.

Other faculty members mentioned how the focus on collaboration helped in venues outside of the classroom. For example, one faculty member explained that the use

of collaborative student learning techniques improved collaborations in his research, “I learned a lot of the things from the collaborative student learning approach...basically, how I can collaborate with the others as teacher and a researcher.” Another noted that “it’s just helped me to listen more, listen carefully. And I think one of my strengths is listening.”

Benefits for students

Faculty persisted due to the benefits they observed for student learning. The vast amount of research indicating collaborative student learning techniques as effective for student learning may have initially inspired faculty to participate in the FLC. However, this may not be enough to sustain pedagogical change. Our results show that faculty did sustain their pedagogical change because they were able to identify specific benefits for student learning. Their participation in the FLC enabled faculty to build their own beliefs and perspectives about the virtues of collaborative student learning. The benefits faculty identified for students included (1) improvement of attitudes and effort, (2) improvement of thinking and understanding, and (3) improvement of teamwork skills.

Attitudes and effort

Among the greatest benefits for students due to the faculty’s implementation of collaborative student learning was their attitudes in class. One faculty member that instructed only through lecture prior to the FLC, expressed her students’ attitudes as, “more interested” during collaborative student learning days. She went on to describe their increased effort and attitude, “it’s not because they’re trying to get a grade, the credit that they get is just contingent on them showing up.” Another faculty member said that the students were more engaged as he believed the students noticed the real-life connections; with many students looking toward employment with companies that value collaboration in the workplace.

A few faculty members noticed their course evaluations at the end of the semester included comments from students pointing to their appreciation of the collaborative student learning days (instead of lecture). One faculty member reiterated that result, “I get a lot of good comments from students after the semester is over that they liked learning that way,” and he did not recall any negative comments in relation to his use of collaborative student learning techniques.

Thinking and understanding

Many faculty members also highlighted improvement in student’s thinking and understanding the course content. One faculty member’s reflection emphasized student’s deeper understanding, “I thought they understood

concepts taught this way better than they normally would [talking about students working together to compare engineering theories of practice].”

A faculty member explained the students’ deeper understanding was due to being able to work in groups because “if they didn’t understand the answers or how to do the problem, they could work with their [student] peers and also see two different approaches.” Alternatively, the faculty went on to explain student’s deeper understanding as due to using new “step-by-step examples which can lead students to the deeper concept gradually.” A third faculty member explained that by having students do projects that connected to real life or work in industry, they “appreciated the concepts more.”

The collaborative student learning techniques bolstered other elements of faculty members’ courses as their implementation allowed for more discussion in classes among students, “based on feedback and lessons learned, I later relied less on collaborative problem solving and more on collaborative thinking.” In combination, almost all faculty found benefits for students as the most important characteristics of implementing collaborative student learning. This judgment was not only based on literature which articulated benefits for students but was more directly evident to them through their own experience of implementing the collaborative student learning techniques and working with students to grow as learners.

Teamwork skills

While some faculty discussed the hesitation of students to work in groups at first, all faculty indicated students eventually come around to the idea and appreciated the experience. One said, “It takes effort and experience to make the groups work well-it doesn’t just happen.” Another faculty member explained that at the beginning of the semester, most students did not like working in groups, so they would complain and get in their groups but not actually participate in the group. However, by the end of the semester, “the vast majority of students accept it as part of the class.”

Most faculty members discussed the collaborative nature of engineering and that through these experiences within the classes students are more prepared for higher-level courses as well as their future potential career(s). A faculty member stated, “Students need that time, individually to orient themselves.” Another faculty member added to that idea, “there are more guidelines for getting everything right”; thus, teaching teamwork to students and providing the structure for student teams allowed them the opportunity to experience the unexpected difficulty of working collaboratively as a team.

Positive features of the FLC experience

Having experienced these positive student outcomes, faculty chose to sustain complex and difficult pedagogical

change. The FLC structure was critical to enable faculty to have this transformative experience. Our results also include faculty-identified features of the FLC structure that proved to be vital for this pedagogical change to occur. All faculty members reflected positively on the FLC, identifying a number of positive features of the FLC structure including (1) accountability and support provided by the monthly meetings, (2) faculty peer relationships developed within the FLC, and (3) identification of resources for collaborative student learning techniques.

Accountability

All faculty appreciated the monthly structure of meetings and reflected on how the face-to-face meetings held them accountable in executing collaborative student learning techniques within their classes. One faculty member stated “One of my favorite things about FLCs is just being able to talk about the stuff. I always enjoyed our conversations.” Another echoed “when I hear and listen to their [other faculty members’] voices, that is the most valuable part.” One faculty member stated “getting to talk and ask questions, hearing that a lot of other people had the same kinds of issues and questions, and then hearing what other faculty were going to do was really good.” Most faculty indicated an integral part of their professional growth with collaborative student learning techniques was due to the FLC structure. A faculty participant described her experience as transformative because of the meeting, she stated “the fact that we even had an FLC versus just an open-ended initiative... there’s some realness to that, with real supports of people doing it together and meeting to share ideas was very helpful.” Her reflection maintained the importance of active participation by the FLC participants; passive participation, often stemming from online structures of one-time meetings, would not yield the same long-term positive impact that this FLC experience did.

For many of the faculty, the monthly face-to-face meetings were important because they forced them to “do what they said they would.” For another faculty member, the face-to-face meetings brought another level of scrutiny to implementing a collaborative student learning technique. She stated “I had to think about things differently, I’d ask myself, ‘how do I know whether this works or doesn’t’, as opposed to just trying it and saying, ‘that felt better.’” For this faculty participant, the FLC was an accelerant to her beginnings of implementing collaborative student learning within her courses. Similarly, one faculty member said “I really enjoyed the monthly [FLC] meetings, and those were always really helpful because of the dialogue that I had between myself and other faculty members.” She also noted that this was the one place where she talked to other faculty about teaching: “We might talk to each

other about research in our particular fields, but very little to almost nothing on teaching in most departments.”

One faculty member described the necessity of FLC’s structure because it provided them not only with dedicated time but they also “had the FLC support structure as [they] went through that transition” (to using collaborative student learning techniques in the classroom). Because of the support, one faculty member noted that it “kept me on track” with implementation. Furthermore, it helped emphasize the need for preplanning before implementation. After the FLC some faculty members noted that they still met with individuals from the FLC and discussed their teaching or sought help.

Faculty peer relationships

Collaborative student learning was used through the FLC structure in part by instituting faculty peer partners and facilitating peer observations of other faculty participant’s classes. Almost all faculty participants referenced the peer observation process as not just beneficial to their professional development within the FLC but instrumental in their understanding toward implementing collaborative student learning techniques within their classroom(s). “Sitting in on some other people’s classes was, I think, really powerful for me” stated one faculty member. Another faculty member explained how her peer observer confirmed students were working together and learning, “I never really get feedback from students, but [the peer observer], confirmed that they were not only doing what they were supposed to, but students were shifting roles and working together to understand.” This confirmation from her peer observer re-affirmed the faculty member’s choice on student group formations (i.e., partner groupings versus three-person groupings) and aided in her confidence to pursue developing her use of collaborative student learning techniques.

Resources

Some of the faculty mentioned that they found the book used in the FLC helpful, as one faculty member described it, “the book actually gave specifics [instructions] of how to implement it, the places that I could actually then figure out how I could combine things to implement for my own implementation.” Another faculty member even pulled the book off her shelf and opened it up to provide an example. Others explained that they still use some strategies found in the book for things like forming better teams and how to evaluate peers.

One faculty member described how they used the FLC as an opportunity to improve and has continued to develop those skills, “I continued to read up on how to create more effective groups, how to handle conflict in groups, how to determine or how to find ways in which

you can more accurately measure the contribution of each team member. So, I'm continually reading up on literature regarding those issues to try and improve that part of the classroom."

Next steps

All faculty participants indicated a desire to continuing work within a similar FLC structure as their initial experience. When asked to describe the type of support they would like to continue their work in collaborative student learning technique, the overwhelming response was continued community support in terms of regular meetings and faculty members with similar goals in mind. "It's just a part of what I do now [referring to the use of collaborative student learning within her classes] ...the only thing I would really think about changing is being able to do more of it [collaborative student learning]" stated a faculty participant, reflecting on continuing her teaching with collaborative student learning techniques.

Many described the support from the FLC aided in their professional development within collaborative student learning techniques. Through his experience, one faculty member shared this related to tenure-ship. "The need for professional development for faculty arises beyond instructional training, or instructional development...professional development ought to be part of research, service, and teaching [three components of tenure], and not necessarily just teaching." From his perspective, newer faculty are hesitant to join professional development experiences like this FLC due to the impression that it only bolsters one (teaching) component of tenure; however, he feels a commitment to teaching bolsters all three components of tenure.

The majority indicated a desire for continued support and community for faculty members who are interested in learning and improving their teaching. As one faculty member reflected on the training secondary school teachers receive continued training, "but there's never, ever any training for college professors." Many of these faculty members are interested but need assistance toward "fostering conversations or allowing people who are interested...having a way for them to communicate on a regular or semi-regular basis." Another echoed, "We're all busy and I think if we're not deliberate about continuing [FLC tasks], it tends not to happen...I know personally, that's definitely true."

Some of the faculty asked for another FLC with a new cohort. One faculty member hoped this would drive an improvement in teaching within the engineering school, "And I think if it's possible, this [FLC] should be there and eventually all of the engineering school faculty will have a turn and then gradually that will change the teaching style for the whole school, moving more towards a modern teaching style."

Discussion

Positive enduring outcomes

Although it may be relatively common for any FLC impacts to dissipate after the completion of the FLC experience, particularly in a domain as personal as teaching approaches, in our study, we found that the *majority* of faculty were continuing to implement some pedagogical strategies they had developed as part of the FLC. Interestingly, for *quite a few* of them, several of the "new" collaborative student learning techniques they had tried in the FLC had become their new normal. This sort of deep assimilation of previously new and unfamiliar teaching approaches offers strong evidence that this particular FLC experience continued to have enduring impact in subsequent semesters.

One key aspect of implementing collaborative student learning that seemed to be an impetus for this ready assimilation into their regular teaching practice was because of the rich interactions with students that the faculty experienced. *Several* indicated that a primary benefit of implementing collaborative student learning was the ability to monitor and give feedback to students in real time, while they were collaboratively solving and discussing problems during class. This aspect of collaborative student learning seemed to have occurred for those faculty who were anticipating this benefit of being able to interact with students on a regular basis. Faculty commented that they found this to be a particularly effective benefit for their students and that they themselves enjoyed the opportunities to interact and get to know their students better than they would have if they had only taught via traditional lecture format.

In addition to citing these positive benefits for self and students, faculty also reflected that the initial FLC required a lot of time and commitment for planning and modifying as the semester progressed. This highlighted that, in order for the enduring positive impacts to become available, faculty must be willing to invest substantial time and effort initially. That may be more palatable for faculty if they understand that these new pedagogical techniques will not always take so much time and in fact may eventually become just a normal part of what they do in their teaching. Emphasizing this upfront cost with ultimate expected worthwhile returns may be a fruitful buy-in strategy for others implementing a FLC focused on pedagogical strategies for collaborative student learning.

Key FLC Structures

Several key FLC structures were supportive to faculty. The face-to-face, scheduled FLC structure with established deliverables at each meeting was very widely cited as critical for each individual to have made the efforts

they did. By agreeing to participate in this FLC with faculty colleagues, having assignments and homework with deadlines and having regular face-to-face meetings, most faculty agreed that this accountability to peers was a necessary incentive for them to undergo the hard work of studying, planning, and then implementing new pedagogical strategies. Faculty found the peer-peer interaction to be motivating and interesting, hearing what others were trying and challenges they were having, which offered them some new ideas to try as well as contribute to a sense of community in this shared effort. They found this peer accountability context to be important for them to commit to making the time for upfront planning and then actual implementation of their chosen strategy(ies).

Another aspect of the FLC meeting structure that was helpful was that the scheduled times were not overly frequent but were carefully sequenced with respect to expected assignments (e.g., reading the assigned text and selecting at least one strategy they would like to try, then next time having a modified syllabus and overall plan of action for implementation, then having follow-up documents/resources/plan for initial daily instructional implementation). The combination of actionable steps such as reading about and selecting a collaborative student learning strategy, along with commitments for implementation reflected in their modified syllabus and initial supporting plans, seemed to have been key FLC structures that enabled participating faculty to successfully and meaningfully stay engaged with this FLC.

A third key FLC structure that many found helpful to sustain interest and engagement was peer-to-peer observation. By pairing up faculty (one who was implementing in the first semester with one who was implementing in the second semester) and asking them to schedule peer-to-peer observations, all faculty were meaningfully engaged in the collaborative student learning FLC even when it was not their semester to implement. Faculty peer observations seemed to combine benefits of accountability to each other with benefits of having a shared mission and focus and faculty expressed strong appreciation for the opportunity to watch a colleague in action and then to have discussions around that. Some of these 2-person pairings were still having occasional pedagogical conversations with their partner even 2 years after the FLC formally ended.

Intentional supports to sustain a community of practice

For any FLC initiative to have enduring impact, it is helpful to explore how any such community of practice might be sustained. As noted in the results above, a number of the new pedagogical techniques related to

collaborative student learning appear to have been incorporated into individual faculty teaching repertoires in an ongoing manner, which is one positive aspect of sustaining the FLC impact. However, no matter how much individuals may or may not have enhanced their pedagogical approaches, typically any such change has the greatest opportunity for meaningful impact if there is a vibrant community of practice that supports all participating faculty.

As noted above, some aspects of ongoing community of practice were evident in the results, particularly those who still occasionally had pedagogical conversations with their faculty peer partner even well after the structured FLC was completed. Several of the participants indicated that they wished colleagues in their departments would engage in a similar FLC, acknowledging that anyone who would be forced or otherwise mandated to participate not of their own volition would likely not benefit, given the necessary time and effort that is required for meaningful participation. For themselves, participants indicated that they would find helpful, and supportive, a sort of annual reunion where they could share and hear from colleagues what collaborative pedagogical techniques they were still doing and why. They could also explore new ideas others may have tried and at a minimum would find it supportive to know that others were also continuing to try to find the most effective—and efficient—approaches for teaching.

If there were to be an annual follow-up for past FLC participants, a sort of advanced level FLC for those sustaining their collaborative student learning pedagogical efforts, there was a unanimous request that this follow-up be in a face-to-face format rather than virtual because of the stronger sense of accountability to each other. This approach may offer a productive pathway for supporting and encouraging ongoing communities of practice within those who had experienced a full-year intensive FLC, without requiring a large commitment of time on their part. Simultaneously, this may also serve a useful function for recruiting and welcoming new faculty into a growing community of practice, giving them some perspective from those who had gone before.

Limitations

One limitation of this study was that while sustained pedagogical change occurred, it did so with faculty who were identified as being interested in improving teaching by making pedagogical changes. The participants accepted invitations to participate in the FLC presumably because of their interest. Additionally, the faculty participants agreed that they could not have made the pedagogical changes without the dedicated time, structure, and support the FLC afforded them; not only during their implementation but also

to sustain their new techniques. Faculty also needed a means to discuss and share with others who were engaged in the same process. Any potential future participants who were not already interested in or receptive to pedagogical change could have a very different experience and may not be as likely to sustain pedagogical change after the conclusion of the FLC. As may be noted in our reporting of results, faculty participants did not share any negative comments about their experiences with the FLC beyond commenting on challenges such as time and effort commitment needed. This may in part be due to the self-selection of these faculty who voluntarily chose to be part of the initial FLC cohorts.

A second limitation is that the faculty self-reported the pedagogical changes rather than being directly observed by the researchers. However, because these researchers were FLC facilitators and have maintained ongoing relationships and conversations with these faculty, we are confident in their willingness to honestly share their actual practices and continued use of the pedagogy they initially implemented through the FLC. While relational influences have the potential to positively dispose faculty's interview responses, the long-term professional relationships held between the faculty participants and FLC facilitators/researchers have consistently exhibited shared value in honest reflection practices. Further, there was no incentive or penalty for inaccurate representations or replying to the interview invitation.

Conclusions

FLCs can be meaningful tools for implementing sustainable change under the right conditions. As discussed above, with adequate support and the willingness to invest time and energy up front, many faculty members realized enough benefits from their incorporation of collaborative student learning strategies that they continued to include those in subsequent iterations of their courses. For some, this has simply become a "new normal" for them, which suggests that this pedagogical change is likely to endure indefinitely. That suggests that if a year-long FLC can support faculty in making changes they are interested in making, there may be ongoing long-term changes when the faculty experience adequate positive feedback in terms of benefits for their students and for themselves.

Although this FLC targeted collaborative student learning techniques as the pedagogical change, we expect these results would be independent of the specifics of the pedagogical change. These results are widely applicable to others who may wish to enable structures for pedagogical change through an FLC model. From this study, others may be encouraged to use the FLC model not only to introduce but also to sustain pedagogical

change. Engineering teaching was the context of this study; however, the pedagogical changes sustained by faculty could be just as applicable in any non-STEM discipline.

Additionally, these results offer some guidance for what fruitful next steps could be to systematically support sustainable, long-term change beyond what faculty may do individually. As discussed, there may be value by instituting an annual FLC follow-up. This could be a structure for sustaining a dynamic and involved community of practice beyond the initial FLC, while simultaneously not being overly burdensome in terms of time commitment. As noted, this may also serve an additional function as a recruitment tool for new faculty to participate in new cohorts of a FLC. By having successful veteran FLC participants play key roles in contributing to and guiding discussion in this annual FLC follow-up, this would also be consistent with Wenger et al.'s (2002) recommendation that each community of practice needs to develop its own internal direction, character, and energy.

Finally, the positive ongoing incorporation of collaborative student learning strategies by a number of engineering faculty across multiple departments offers promise for enhancing student learning in ways consistent with national certification emphases (ABET, 2018) on teamwork and communication skills. Additionally, these faculty efforts may contribute to strengthening national priorities such as more STEM graduates and a STEM-literate workforce. For any disciplinary context or domains, it may be helpful for FLC organizers to consider a larger context (e.g., national trends or certifications) when identifying a FLC focus. To the extent that a specific set of pedagogical changes can be attached to a larger context, it would be easier to convince both students and other faculty that such an effort would be worthwhile. As a result of first achieving success in the FLC-supported pedagogical change, we found that such change can be sustainable, either through individual faculty member persistence or with additional follow-up support when the formal FLC has concluded.

Appendix 1

Interview questions

General questions about experiences with FLC and collaborative student learning (CL) techniques

- Tell me about what you remember about your experience in the FLC.
- Describe the most helpful aspects of the FLC.
- What were any challenges you had with the first implementation of CL techniques?

Reflecting on CL implementation

- What techniques learned from the FLC are you still using in your courses?
 - If none, why?
 - If none, do you see yourself using CL again in the future?
- What are some things you have changed since that first implementation?
 - Have you implemented any new techniques?
- What problems have you encountered in implementing CL?
- Describe how you use CL in a typical class.
- Do you see yourself continuing to use CL in this or other courses?
- How do you see your use of CL changing in the future?

Students' reactions

- How have students reacted to your use of CL?

Ongoing support and efforts

- Do you keep in contact with other members of the FLC to discuss your courses?
 - About the use of collaborative student learning in your courses?
 - Have you discussed CL with other non-FLC faculty?
- Have you sought any additional support for your courses?
 - Would you find additional support helpful?
 - What support and communication would you like?

Impacts outside the classroom

- How has your experience impacted other areas of your professional life?
- Are there any additional comments you would like to make?

Appendix 2

Core themes and sub-themes extracted from interview data

Benefits for faculty

For themselves

1. Ability to give real-time feedback
2. Interaction/connection to students
3. Techniques for teaching teamwork to students...(ABET accreditation)

4. Positive peer collaborations/finding collaborators (faculty peer observations)

Benefits for students

Improvement in...(for students, noted by faculty)

1. a. Knowledge transfer.
- b. Student thinking and understanding

Attitudes

2. Learning to be good team members.

Positive features

1. FLC structure
2. Book
3. Faculty peer relationships
4. Faculty peer observations

Next steps

1. For themselves
2. For others

Abbreviations

CoP: Community of Practice (CoP); FLC: Faculty learning community; PLC: Professional Learning Community; STEM: Science, Technology, Engineering, and Mathematics

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Authors' contributions

TLT composed the introduction, literature review, and analysis section. TLT and MM collected interview data and completed the initial coding structure. MM composed the "Methods" section. PR composed the "Introduction" section and collaborated with TLT and TRT on the "Discussion" section. TRT composed the "Conclusions" section. All authors collaborated on the analysis of data. TLT, PR, and TRT revised the manuscript, per reviewer suggestions. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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