Faculty Online Learning Communities: A model to support the pedagogical growth of physics faculty

by

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While much physics education research focuses on students' *learning*, this thesis explores physics faculty members' *teaching* practices. This focus is needed given the role faculty play as an essential link between students and physics content, culture, and practices. Commonly used change strategies in science education target faculty as change agents, yet these strategies have shown to be insufficient in supporting faculty in making long-lasting instructional change. This thesis explores a novel model of professional development for educational change— Faculty Online Learning Communities (FOLCs). A FOLC connects faculty from different institutions via facilitated videoconferences and an asynchronous communication platform as they collaboratively work toward a shared goal, such as improving their teaching practice. A FOLC leverages the affordances of a community of peers to advance the learning and development *of faculty* around their teaching practice. We focus on two implementations of the FOLC model: one serving a subset of new physics and astronomy faculty and a second serving a group of STEM faculty (more than half of whom are in physics) implementing a particular physical science curriculum for future teachers and non-STEM majors. In focusing on the FOLC model and the participating faculty members, this thesis examines both the mechanisms for supporting physics faculty members' pedagogical development and the impacts of these mechanisms as perceived by faculty.

We start by introducing the FOLC model and describe how it is designed to supplement traditional change efforts, primarily through the affordances of a community. We then present one particular application of the FOLC model to support new physics and astronomy faculty in their teaching development (the New Faculty Workshop (NFW)-FOLC). We illustrate the design of the NFW-FOLC and its six learning objectives for participants. Through an interview study of

NFW-FOLC participants, we next provide empirical support for the efficacy of the NFW-FOLC. We present their self-reports of the impact of participating in the FOLC and their motivations for joining the program. Their motivations indicate that NFW-FOLC participants believe they need more support to implement changes than is provided by a single, in-person workshop and they value and see a need for this support to be in the form of a community. The reported impacts of participating are consistent with the NFW-FOLC learning objectives, such as gaining more teaching knowledge and implementing research-based teaching strategies. The efficacy of the NFW-FOLC according to faculty participants' perceptions provides support for the general FOLC model. We also provide preliminary evidence that participating in a FOLC can continue to impact teaching practice years after the FOLC experience has officially ended.

We next consider the adaptability of the FOLC model to different contexts by exploring its application to support instructors implementing the Next Generation Physical Science and Everyday Thinking (NGPET) curriculum. The NFW-FOLC and NGPET-FOLC differ in their focus and community structure. Nonetheless, they each are achieving their respective learning objectives for participants, including the ones they share in common. Through this comparison, we identify essential components of a FOLC and those which can vary depending on the goal of the FOLC. This thesis additionally contributes a taxonomy that can be used by both researchers and practitioners to study the content and structure of FOLC meetings and similar professional development environments. We end with a discussion of the potential for the FOLC model to expand beyond the two implementations presented in this thesis. Not only can it support the teaching practices of new physics faculty and STEM faculty implementing a shared curriculum, but it also has the potential to support groups of faculty who are underrepresented in their disciplines and to even inform our construction of classroom communities. Through model building and testing, this thesis advances the physics education and broader STEM education communities' understanding of a generative model for the professional development of their faculty.

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Contents

Tables

Table

Figures

Figure

Chapter 1

Introduction

Physics education researchers work to advance the teaching and learning of physics. Regarding the learning of physics, researchers examine a range of topics including (but not limited to): students' conceptual understanding of physics topics, their problem solving approaches and use of mathematical tools, their attitudes and epistemologies towards physics, and their physics identities (see [1] for an overview of research in these topical areas). These topics are influenced by the teaching students experience and studies of student learning influence work on physics teaching. Regarding the teaching of physics, researchers develop a variety of theories and practices to promote improved instruction, including: instructional strategies (e.g. [2]), curricular materials (e.g. [3]), and novel classroom environments (e.g. [4]), and they study faculty members' use of these teaching tools and the impact on their students (e.g. [5]). Of course, this work on the teaching of physics is in service of students' learning of physics. Put simply, the teaching and learning of physics are deeply entwined.

Much physics education research (PER) takes students as the object of study, focusing on their learning or the effect of teaching practices on their learning. In contrast, there has traditionally been a lesser focus on physics faculty as the object of study, although this work has emerged in the last ten years (e.g. [6, 7]). The preponderance of attention on students is appropriate, but increased attention on the teaching practices of physics faculty is needed. Physics faculty, at least in formal education environments, serve as one, if not the, important link between students and physics content, culture, and practices. They are, after all, the ones charged with implementing

the products of PER such as the curricular materials and research-based instructional strategies (RBISs), and they are the ones defining the standards for students and discerning whether or not students are achieving these. Additionally, faculty both enact and have a role in defining their discipline's culture. National reports have called on science, technology, engineering, and math (STEM) faculty to improve their teaching practice [8, 9], and commonly used change strategies in science education target faculty as the agents of change [10, 11]. However, these same historic strategies that have been insufficient for promoting student learning are also insufficient strategies for supporting faculty in making long-lasting instructional change [10–12].

This dissertation takes physics faculty members as well as a model of educational change as its objects of study. In particular, I explore a faculty online learning community (FOLC) model of professional development for educational change. A FOLC connects faculty from different institutions via facilitated videoconferences and an asynchronous communication platform as they collaboratively work toward a shared goal, such as improving their teaching practice. FOLC members support each other in troubleshooting challenges and expanding their knowledge regarding the topic of the FOLC. FOLCs are designed to build a sense of community among members. When I talk about educational change, I am referring to the transformation of faculty members' pedagogical practice away from traditional, lecture-based methods and toward research-based active learning strategies, as well as the development of their views of teaching and learning to align with these new teaching practices and the culture which surrounds them. A FOLC leverages the affordances of a community of peers to advance the learning and development *of faculty* around their teaching practice. Ultimately, this serves to improve the teaching and learning experienced *by students*. In focusing on the FOLC model and faculty members, I study both the mechanisms for supporting physics faculty members' pedagogical development and the impacts of these mechanisms as perceived by faculty.

My dissertation explores two groups of faculty. The first is a subset of new physics and astronomy faculty who have attended an in-person, national workshop on teaching for new physics and astronomy faculty. New faculty are the focus of multiple educational change efforts nation-

ally [13–16]. They often enter their positions with little training in teaching and they have yet to establish their teaching practice; however, they are also untenured and it is potentially risky for them to implement non-traditional instructional strategies. Both of these factors motivate the need to provide structured teaching support to this population. I also study a group of STEM faculty (more than half of whom are in physics) implementing a particular physical science curriculum for future teachers and non-STEM majors. The students enrolled in this physical science class are well served by STEM instructors who use teaching techniques which increase students' experiences with authentic science practices.

The work presented in this dissertation is the result of collaborative efforts with a number of scholars. It is perhaps particularly appropriate that the research on a community model of professional development for educational change was conducted with a community of collaborators. In this dissertation, I often use "we" when describing work that was done in partnership with others. That said, for all the work I present I am either the lead researcher or my contributions were extensive and fundamental to the research even if I was not involved in the initial conception of the project. Who the "we" refers to in each chapter is noted by the author list of the publication the chapter is drawn from, or as a footnote on the first page.

This dissertation engages in model building and testing. In Chapter 2, I present the theoretical framework undergirding my thesis and the literature upon which it builds. In particular, I draw on the construct of a community of practice [17, 18] and the idea of community as a mediator of change to think about how we might empower and support faculty in their pedagogical development. In Chapter 3, I introduce the FOLC model of professional development for educational change and I describe how the FOLC model is designed to supplement traditional change efforts, primarily through the affordances of a community. I then present one particular application of the FOLC model to support new physics and astronomy faculty in their teaching development (the New Faculty Workshop (NFW)-FOLC). I illustrate the design of the NFW-FOLC and its six learning objectives for participants. These six learning objectives state that participants will: Develop reflective teaching habits and a dedication to continuous improvement of teaching; Increase their

knowledge and awareness of research-based instructional strategies (RBISs); Maintain or increase their motivation to implement RBISs; Implement RBISs consistent with recommendations from research; Persist in their implementation of RBISs; and increase their sense of empowerment regarding themselves as teachers. In Chapter 4, I provide empirical support for the efficacy of the NFW-FOLC. Based on an interview study of 34 NFW-FOLC participants, I present their self-reports of the impact of participating in the FOLC and their motivations for joining the program. Their motivations indicate that NFW-FOLC participants believe they need more support to implement changes than is provided by a single workshop and they value and see a need for this support to be in the form of a community. The reported impacts of participating are consistent with the NFW-FOLC learning objectives, such as gaining more teaching knowledge and implementing research-based teaching strategies. I also present analysis of survey data which shows that NFW-FOLC members do feel a sense of community with their cohort. Community is an important mechanism for change and also outcome for participants. I use the interview and survey results to argue that the NFW-FOLC is meeting its learning objectives for participants by the mechanisms in its design (specifically the community of peers). The efficacy of the NFW-FOLC according to faculty participants' perceptions provides support for the general FOLC model. In Chapter 5, I turn to the question of the longitudinal impact of NFW-FOLC participation. Through a preliminary study of one participant's experience, drawn from an interview conducted soon after their FOLC experience and another interview conducted two years later, I provide proof-of-concept that FOLC participation can continue to impact teaching practice at least two years after the FOLC experience has officially ended. This participant was still using teaching strategies they learned through their time in the NFW-FOLC.

In Chapter 6, I introduce another implementation of the FOLC model in the context of a group of faculty implementing a shared physical science curriculum. I consider the adaptability of the FOLC model to different contexts by exploring its application to support instructors implementing the Next Generation Physical Science and Everyday Thinking (NGPET) curriculum. I compare the design and outcomes of the NGPET-FOLC to those of the NFW-FOLC. In design

and implementation, the two FOLCs differ in their focus and community structure. Nonetheless, they each are achieving their respective learning objectives for participants, including the ones they share in common. Based on these results, I discuss implications for the FOLC model overall (e.g. What are the essential elements in the model). Using the NGPET-FOLC as context, in Chapter 7 I present a taxonomy for analyzing learning opportunities in FOLC meetings. The taxonomy helps describe what occurs in a FOLC meeting and it can also serve as a tool for identifying why those things are happening. I present the development process of the taxonomy, describe the elements which comprise the taxonomy, and illustrate its analytic and practical applications both to a FOLC and similar professional development environments. In Chapter 8, I summarize the contributions of this thesis and provide directions for future work.

Portions of this dissertation are drawn from my publications and manuscripts in preparation. Chapters 3 and 4 are largely drawn from an article which appears in print in Physical Review Physics Education Research and on which I am co-first author: Dancy, Lau, et al. 2019 [19]. Section 3.4 of Chapter 3 is adapted from a paper which appears in print in the 2018 PERC Proceedings: Lau, Dancy, et al. 2018 [20]. A portion of section 4.3.2 in Chapter 4 appears in print in the 2017 PERC Proceedings: Lau, Dancy, et al. 2017 [21]. Portions of Chapter 6 are adapted from a manuscript in the final stages of preparation, to be submitted to the International Journal of STEM Education: Price, Lau, et al. 2020 [22]. And Chapter 7 represents a manuscript in the final stages of preparation: Lau, et al. 2020 [23] and is expanded from an earlier conference proceedings paper [24].

This thesis adds to the PER and broader STEM education communities by presenting and testing a new model of faculty professional development– Faculty Online Learning Communities. Through description and analysis of two implementations of the FOLC model, we see the impacts of FOLC participation on faculty members' teaching practices, both during the FOLC experience and long after it has ended. By comparing these two implementations, we identify essential components of a FOLC and those which can vary depending on the goal of the FOLC. This thesis additionally contributes a taxonomy that can be used by both researchers and practitioners to

study the content and structure of FOLC meetings and similar professional development environments. There is potential for the FOLC model to expand well beyond the two implementations presented in this thesis. Not only can it support the teaching practices of new physics faculty and STEM faculty implementing a shared curriculum, but it also has the potential to support groups of faculty who are underrepresented in their disciplines and to even inform our construction of classroom communities.

Chapter 2

Theoretical Framing & Literature Review

This chapter presents the overarching theory and literature upon which this dissertation builds and expands. Background that is specific to individual chapters will be reserved until those chapters are reached and then will be presented accordingly.

2.1 A sociocultural perspective on learning

Before I present my research on faculty learning about their teaching practice, I must first define what I mean by learning. While few would argue with the statement that learning is a complex process, there are different perspectives on what the key areas of focus are when considering learning. A traditional, cognitive view of learning views knowledge as being stored in individuals' minds in the form of mental representations and learning entails acquiring mental representations of new information one has been exposed to [25]. In contrast, a sociocultural perspective on learning considers the effect of the environment and history (i.e. prior knowledge) on an individual's learning [17, 25, 26]. Rather than exclusively focusing on an individual's mind, a sociocultural perspective is attuned to the culture, people, and tools with which a person interacts; knowledge resides both with the individual and their environment [17, 25–28]. As Gee summarizes, "A situated/sociocultural viewpoint looks at knowledge and learning not primarily in terms of representations in the head, although there is no need to deny that such representations exist and play an important role. Rather, it looks at knowledge and learning in terms of a *relationship* between an individual with both a mind and a body and an environment in which the individual thinks,

feels, acts, and interacts" [25, p. 81]. It is not that the mind plays no role in learning, but the mind is situated in a context that expands beyond the individual and this context must be considered when studying learning. The cognitivist and sociocultural perspectives are complimentary views of knowledge and learning; they are simply attuned to different scales of focus, the former focusing on an individual's mind and the latter focusing on the culture and environment within which the mind operates. The work presented in this thesis focuses on this larger scale that considers the situated and culturally bound nature of learning. This thesis is grounded in the sociocultural view of learning and it is fundamentally why I examine the role of community in faculty members' learning.

One of the main concepts in the sociocultural perspective on learning is that of a mediating device. A mediating device is a tool that people use in the process of learning to expand what they can do beyond what they could do alone [25, 26, 28]. Tool is a broad term that includes other people, objects, language and other sign systems, and representations. Vygotsky posited that in higher order cognitive processes, there is a direct connection between subject (e.g. a student) and object (e.g. the thing they are trying to learn), and the subject is also connected to the object through a mediating tool (e.g. a mathematical equation or graph) [26, 29]. In considering mediating devices, we concede that knowledge is distributed between the learner, the mediating tool, and the interactions between them [25, 27, 28]. For example, when a student takes notes in class, their memory of what is being talked about exists not only in their mind, but is also embedded in the page of their notebook and the act of writing those notes with their pencil.

A sociocultural approach takes as its object of study the individual and the mediating device(s) they use to learn [25, 27, 28]. Taking one further step back, we can analyze learning by considering the larger activity system [30, 31] or community in which a learner is situated and acts. According to a Vygotskian perspective, an individual interacts with their environment via mediating devices, and it is through interacting with others that one learns to use these tools [25, 26]. One can think of community as a tool that mediates learning, or more specifically, one can understand community as the place where individuals are connected with the devices which directly mediate

their learning.

One way to conceptualize the larger system in which a person acts and in which they acquire and learn to use mediating devices is through the lens of Communities of Practice [17, 18]. A Community of Practice (CoP) is comprised of, "people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this areas by interacting on an ongoing basis" [32, p. 4]. The area in which the CoP is working to gain expertise is sometimes referred to as their "joint enterprise" [17, 18, 33]. Members of a CoP are mutually engaged in their joint enterprise and they collaborate in their endeavors using the shared repertoire (e.g. tools, language, norms of behavior) developed by the community [18, 33]. Learning for an individual entails changing their participation in a CoP, that is moving from peripheral to more central participation in the community [17, 18, 34, 35]. Learning by the community overall entails a change in its practices. In this dissertation, I consider learning by individuals who are members of a community of practice (Chapters 4-6) and by the community of practice itself (Chapter 7). This dissertation uses the lens of Communities of Practice because it foregrounds interactions between individuals in a community; this is well-suited to a study of a community of faculty members and their professional development.[1]

2.2 Effect of active learning and faculty adoption of active learning strategies

For the past thirty years, the physics education research (PER) community and larger discipline-based education research community have been engaged in studying student conceptual understanding, problem solving, affect, and epistemology in the science, technology, engineering, and math (STEM) disciplines. This work has resulted in a number of research-based instructional strategies (RBISs) that actively engage students in their learning. Some characteristics of these RBISs include having students work with peers, explicitly explain their thinking, and engage in problem solving activities [36].

[1] In future work with a focus on scaling and replication of the FOLC model, activity theory [30, 31] may be a productive framework to use given its focus on the larger system within which a community operates.

It is well-established that use of active learning techniques over traditional lecture leads to a number of positive outcomes for students. For example, a quantitative meta-analysis of 225 studies which had compared performance and failure rates in STEM courses using traditional lecture versus active learning techniques found that students in lecture courses were 55% more likely than those in active learning classes to fail [37]. Additionally, the study authors found performance on exams and concept tests was on average 0.47 standard deviations higher in classes that used active learning techniques (equivalent to a half-letter increase in final grade). Results held across STEM disciplines, size of class, and level of course. The results from this meta-analysis provide strong support for implementing active learning techniques in STEM classes. Considering studies of only physics courses, the conclusion still holds that students' conceptual gains are higher in active learning classes as opposed to traditional lecture classes [36, 38]. Research also shows that the teaching techniques students experience are consequential for their decisions to persist or leave the STEM disciplines; poor teaching is a common factor in students' decisions to leave a STEM major [39].

Reviews of the research on STEM education by national committees have resulted in calls for faculty to increase their use of research-based active learning techniques [8, 9]. The 2012 *Engage to Excel* report by the President's Council of Advisors on Science and Technology (PCAST) provides recommendations for achieving more STEM graduates to address the economic needs of the country. The first of these recommendations is to increase use of evidence-based teaching practices in STEM courses. The report explicitly states, "STEM faculty need to adopt teaching methods supported by evidence derived from experimental learning research as well as from learning assessment in STEM courses." [9, p.iii]. Knowing of effective teaching strategies is insufficient for large-scale educational change; faculty must also adopt these research-based teaching practices.

Unsurprisingly, change is often difficult and faculty encounter a number of barriers to shifting their teaching practice away from traditional lecture. In an interview study of five tenured physics faculty members, Henderson and Dancy found that even when faculty have conceptions of teaching and learning that are aligned with the current research on STEM education, that does not

always translate into practice [40]. Through the interviews, they identified a number of barriers to the adoption of research-based instructional strategies including: student resistance to teaching practice; content coverage expectations; physical limitations of classroom and class size; lack of instructor time to learn and incorporate new techniques; department norms regarding teaching practice; and lack of time for students to devote to the class. The authors conclude that dissemination efforts need to attend to the local context and situational constraints faculty face. These findings influenced Dancy and Henderson's design of a large-scale survey of physics faculty on their teaching practices [7]. The results from the survey of 722 physics faculty show that many faculty know of and are motivated to try RBISs, but their practices are still mostly traditional. Faculty are interested in using more RBISs and if they are aware of a strategy, the majority will try it [7]. However, faculty often make modifications to the strategies they try, sometimes eliminating the key design elements and essentially reverting it to traditional instruction [7]. The most frequent reason provided by survey respondents for why they don't use more RBISs was time.

Commonly cited barriers to change in instructional practice across the STEM disciplines include the lack of incentives for reformed teaching, the lack of time faculty have to change their practice, and the lack of training they have in RBISs [41, 42]. Brownell and Tanner also hypothesize that STEM faculty members' professional identities which are often centered on their research and with little value given to teaching, act as a barrier to change [42]. A more recent study on the barriers and drivers to STEM education reform support these previous findings [43]. Responses from faculty across ten STEM departments indicated 18 categories of barriers to change such as lack of time and constraints of physical classroom space. Importantly, the frequency of the barriers cited depended on the department, a result which emphasizes the need to consider faculty members' local context, *both* departmental and institutional, as well as their disciplinary context. All of the research on barriers to change in the pedagogical practice of STEM faculty show that simply convincing faculty of the effectiveness of RBISs is insufficient for change to occur; at the very least, faculty need abundant support to address the situational barriers they encounter.

2.3 Instructional change models in higher education

A range of change models underlie the various STEM education reform efforts in higher education. These models each carry assumptions about how change occurs and they direct the actions of change agents. Resulting from a literature review of over 100 change efforts in undergraduate STEM education, Henderson, Finkelstein, and Beach identified four categories of change strategies present in the articles [10]. These categories include (a)disseminating curriculum and pedagogy; (b)developing reflective teachers; (c)developing policy; and (d)developing shared vision for instructional improvement. The categories differ in their intended outcome (prescribed vs. emergent) and the target of the effort (individual vs. environment). For example, the disseminating category is focused on individuals and prescribed outcomes. The literature reviewed came from three fields of research: STEM education, faculty development, and higher education research. The authors found that the most common category of change strategy used by STEM education researchers is dissemination. This method focuses on specialists developing educational innovations and then distributing their "final product" to potential adopters. This strategy assumes that data will convince faculty to use the innovation and uptake will be easy (not context-dependent). In her own work on studying change practices in STEM education, Seymour describes this assumption as, "good ideas, supported by convincing evidence of efficacy, will spread "naturally"–that, on learning about the success of particular initiatives, others will become convinced enough to try them" [44, p. 92]. She points out that there is little evidence supporting this assumption.

Regarding the other categories of change strategies, Henderson, Finkelstein, and Beach found that the developing reflective teachers category was most common in the faculty development literature related to STEM education reform [10]. The developing policy category of change strategies was most common in the higher education literature. They found that while there were articles that used strategies aligned with the developing shared vision category, these were not common in any of the three bodies of literature reviewed. The authors argue for more inclusion of faculty in the change process and more focus on structural change. Said another way, they suggest that

STEM education researchers should incorporate some of the other categories of change strategies into their work.

Henderson, Finkelstein, and Beach expanded this initial analysis of 100 articles to include a review of a total of 191 articles [11]. In this phase of work, they aimed to address questions like, "What research-based assertions can be made about best practices for creating change?" Based on the evidence reported in the articles they reviewed of the success or failure of the change strategy employed, they concluded there are two change strategies which do not work. First, the strategy of developing "best practice" materials and then making them available for others to adopt, without any structured training program for potential adopters or formative feedback and assessment provided as they try the implementation, does not work. This is one example of a strategy in the disseminating curriculum and pedagogy category of change strategies. Second, the strategy of top-down policy change that is meant to effect instructional practice (one example in the developing policy category) was not found to be an effective change strategies. The authors also identify qualities of *effective* change strategies: they focus on the conceptions of instructors regarding teaching and learning; they involve a long-term intervention/support for making the change; and they understand that context is complex and the strategy is designed with context in mind.

Borrego and Henderson explore this framework for understanding change strategies by reporting on eight specific strategies, two from each of the four categories of change strategies [45]. Importantly, they do not advocate for any one category of change strategy, and in fact they identify affordances in each category. The current literature lacks robust guidance as to when it is best to use each change strategy and how the strategies can be combined. In the literature, studies often use only one strategy; Borrego and Henderson, as well as the two Henderson, Beach, and Finkelstein papers [10, 11], suggest that *collectively* the change agents working in a given area of STEM education change should employ strategies from all four categories. This is not to say that any *one* change effort should employ strategies from all four categories.

2.3.1 Development and dissemination change strategy

As noted above, the dissemination model of change (also referred to as development and dissemination, D&D) is commonly used by STEM education researchers [10, 11, 44]. Under the D&D model, experts conduct research on student learning and teaching practices and develop curricular materials based on their research. Then they share these products with faculty (via a publication, conference talk, workshop, etc.), who are expected to implement the materials in their classrooms. While this model makes intuitive sense there is ample evidence (e.g. [11, 44]) that it is insufficient as a mechanism for *sustained* change. For example, the D&D model does not acknowledge the difficulties faculty face when implementing a new technique and it fails to support them adequately in using research-based instructional strategies. (A detailed critique of the D&D model will be provided in Chapter 3).

A large-scale survey of physics faculty members' teaching practices and knowledge helps explain the claim that the D&D model is *insufficient* for creating sustained and wide-spread change. The results from the survey of over 700 physics and astronomy faculty identify the percent of faculty at each stage of the innovation-decision process and the factors that correlate with continuing or leaving from given stage. [12]. The innovation-decision process is a model presented by Rogers to describe how individuals decide to adopt a change [46]. The five stages of this process are knowledge, persuasion, decision, implementation, and confirmation. For the purpose of analyzing the survey results, Henderson, Dancy, and Niewiadomska-Bugaj collapsed the persuasion, decision, and implementation stages into one category of "trying" an innovation or not. They found that the largest loss of faculty in the innovation-decision process to adopt RBISs is in continuation stage; one-third of faculty who have tried an RBIS discontinue use. Their results indicate that more support is needed during the implementation process. They also found that 88% of those surveyed knew of at least one RBIS and of those who knew of an RBIS, 18% failed to try the RBIS. Thus, current dissemination efforts are actually very good at providing *knowledge* and getting people to *try* a research-based instructional technique, but the efforts leave room for improvement in terms

of getting adopters to *continue* use.

2.3.2 Propagation paradigm

In response to the shortcomings of the D&D model of instructional change, researchers have advocated for a focus on propagating innovations [47]. While the D&D model focuses on the developer of an educational innovation, the propagation paradigm focuses on adopters of an innovation [48]. Change efforts which subscribe to the D&D model are predominantly concerned with raising awareness of the efficacy of an innovation, whereas change efforts aligned with the propagation paradigm are equally concerned with the usability of the innovation [49]. Based on an analysis of successfully propagated STEM education innovations, the propagation paradigm forwards three aspects of effective propagation plans: interactive development of the innovation, interactive dissemination, and support for adopters [47, 48, 50]. In this model, development and dissemination are pieces of a propagation plan, but they are intended to be much more interactive than as enacted in traditional D&D efforts because the fit of an innovation is a large propagation consideration [49]. Moreover, support for adopters acknowledges the variety of contexts in which adopters are situated and is the key propagation activity for promoting sustained adoption of an educational innovation. Unfortunately, support for adopters is also the least understood propagation activity and work is needed to identify effective support mechanisms [48]. This dissertation addresses this gap in knowledge.

The type of support adopters need depends on the nature of the educational innovation; the more change required of an adopter from their current practice, the more support the adopter will need [47]. Support for adopters comes in two forms: materials-based support (e.g. users' guides; website with product materials that can be easily modified by adopters) and people-based support (e.g. individual consultation with adopters; workshops; faculty learning communities). As I explain below, people-based support for change is the focus of this dissertation.

2.4 Community models for learning and change

Together, the identified barriers to instructional change, the shortcomings of the D&D model and the suggestions from the propagation paradigm point to the promise of a community-based model of change. By this I mean a model and associated strategies for change that leverage the support of a community of instructors to facilitate change in teaching practice. Recall from above that learning can be understood as a change in practice; therefore, when I talk about strategies for educational change directed at faculty members' teaching practices, I understand these as strategies which direct and support the *learning* of those faculty. My focus on community comes from my grounding in a sociocultural view of learning in which community can be understood as a mediator of learning.

2.4.1 Student learning

While my dissertation is focused on faculty learning, it is worth making an aside here to note that the research on STEM instructional materials and learning similarly acknowledges and values the role of community in learning. An important element of many active learning instructional strategies is the inclusion of group work and other opportunities for students to learn and construct knowledge through interactions with their peers [36]. Physics Education Research work on community models for learning at the student level is primarily comprised of the literature on group work. Patricia Heller and colleagues conducted some of the earliest research on group work in physics [51, 52]. They implemented a cooperative group problem-solving method in introductory physics courses and showed that a group's solutions to context-rich problems were better than the individual solutions of the best student in the group [51]. More recently, Bruun and Brewe used social network analysis to study student interactions in a physics course and how their centrality in a network correlates with course grade [53]. They found that engaging even in "off-topic" discussions with peers in a physics class seems to be beneficial for course performance. In addition to studying the effect of group work on individual content understanding, others have worked to

categorize how students engage with group work. Pawlak, Irving, and Caballero developed the Modes of Collaboration framework [54]. The framework analyzes group work independently along three dimensions: social, discursive, and disciplinary content. By using the framework to analyze nine groups of students working on an electromagnetism task, they identified four different modes of collaboration. Physics education researchers have also studied student perceptions of group work. This has included work on students' epistemological framing of group work [55, 56] and their perceptions of group work itself, both the social and discursive aspects [54]. Cooperative learning strategies, including group work, are also studied and promoted in other STEM disciplines such as biology [57, 58]. It is common for educational innovations in STEM to incorporate ways for students to collaborate during the learning process.

2.4.2 K12 teacher professional learning

At the K12 level of education, teacher communities are an encouraged and promising method of teacher learning. In particular, professional learning communities (PLCs) comprised of teachers and administrators at a given school have become increasingly common in professional development efforts over the past 25 years [59, 60]. Synthesizing the work of Louis, Marks, and Kruse [61], and a number of other scholars [60, 62–64], Turner, et al. write that the essential elements of an effective PLC are, "At least a minimal level of (a) shared values and norms, (b) collaboration, (c) focus on student learning, (d) reflective dialogue, and (e) norms of making practice public" [65, p. 51]. PLC members work together to improve their instructional practice with the goal of increasing student learning. PLCs facilitate learning among peers. Hargreaves echoes the ideas of collaboration and making practice public stating, "Teachers can only really learn once they get outside their own classrooms and connect with other teachers. This is one of the essential principles behind PLC" [66, p. 98]. A PLC is an example of a community of practice [17, 18]. Their joint enterprise is to improve student learning, and they accomplish this by collaborating (mutuality) using their shared norms (shared repertoire) including reflective dialogue and making practice public.

While PLCs can vary widely in their enactment, a number of studies show that PLCs have

the capability to effect positive changes in teachers' pracitces [61, 65, 67, 68]. Some researchers are focusing their attention on studying how effective PLCs form [65] and others are working to connect the discourse used in PLCs with the opportunities to learn the PLCs offer members [69, 70]. I will provide a detailed explanation of opportunities to learn in Chapter 7.

2.4.3 Faculty learning about teaching in higher education

Faculty learning communities (FLCs), analogous to PLCs, operate in higher education to support the pedagogical learning of faculty. FLCs were pioneered at Miami University in Ohio and are defined as a multidisciplinary faculty group of around ten members that meets regularly over the course of year with a focus on improving their teaching and the resulting learning of their students [71]. FLC members complete scholarship of teaching and learning projects in order to formally reflect and assess their practice [71, 72]. The underlying logic of the FLC model for faculty change is that, "STEM undergraduate instruction will be changed by groups of instructors who support and sustain each other's interest, learning, and reflection on their teaching" [45, p.233]. Community is at the heart of FLCs and it is through interactions with community members that learning is promoted. The members of an FLC come from a variety of departments at a given university and intentional efforts are made to build community among members. The FLC model has spread to many different institutions [73, 74].

A number of studies demonstrate the effectiveness of FLCs at changing faculty members' instructional practices and improving student learning [71, 74–76]. Results from a large-scale survey of FLC participants show that participation expanded faculty members' perspectives and interest in teaching and learning, their understanding of scholarly teaching and the scholarship of teaching and learning, and increased their use of active learning techniques which they perceived improved student learning [74, 75]. Other studies have demonstrated the efficacy of FLCs at increasing faculty buy-in to educational innovations [77] and at facilitating the development of new courses and programmatic learning goals [76]. FLCs can also produce sustained pedagogical change; Tinnell et al. found that participants in an FLC focused on the implementation of collaborative student

learning practices into engineering courses continued to use these techniques two years after their FLC participation [78].

This dissertation explores the adaptation of the FLC model to an online environment, connecting physics and astronomy faculty members across a number of institutions. How the faculty online learning community (FOLC) model compares to the FLC model will be detailed in Chapter 3. For now, I mention two studies that motivate the use of online technology for faculty professional development. First, Hayward and Laursen report on the use of an email listserv to connect participants following an in-person workshop for college mathematics instructors [79]. The week-long, in-person workshop introduced participants to inquiry based learning as a technique to use in math classes. For the year following the workshop, participants (including workshop facilitators) were connected via a listserv as they were trying to implement the inquiry based techniques. Based on survey data and a social network analysis of listerv posts, Hayward and Laursen found that listserv activity was high and provided intellectual and emotional support to participants as well as positive feedback on the strategies members were trying in class. They identified prompts by facilitators, push notifications via email, and the just-in-time characteristic of people's posts as aspects that made the listserv successful. This study demonstrates the potential efficacy of an online, asynchronous platform in supporting faculty as they are making instructional changes.

Second, Pelletreau et al. report on a professional development program that utilized video conference technology to connect sixteen faculty members across five institutions as they worked to address student conceptual difficulties in biology [80]. In particular, the group collectively developed an instructional unit to address conceptual difficulties surrounding the effect of mutations on DNA replication. The faculty met first in person and then virtually one to two times a semester to revise the materials based on their classroom experience with the unit and student assessment data. At each participating institution, the local faculty also met in-person (three times a semester) as part of a topical FLC on formative assessment in STEM courses. Participation in this professional development program which combined in-person and online components resulted in student conceptual learning gains and increased used of active learning techniques by participants. This provides

further evidence that the use of online technology in professional development programs can be productive, connecting faculty at multiple institutions and enhancing what can be accomplished in-person.

Together the theory presented above and the literature reviewed, as well as the national calls to focus attention on improving faculty members' teaching practices, direct the focus of my dissertation to the use of community in supporting physics faculty members' pedagogical development. The FOLC model I present in this dissertation combines video conference technology and an asynchronous communication platform to create an online professional development program with a particular emphasis on community formation among participants.

2.5 Methods

In this dissertation, I use predominantly qualitative methods although I do incorporate mixed methodology where appropriate [81]. The reason for my emphasis on qualitative methods derives from the types of research questions I ask. My research questions focus on uncovering the meaning of experiences for participants, understanding the process by which an outcome occurs, and identifying the components of a context that influence action. Qualitative methods are particularly well-suited for answering all of these questions [81]. As Maxwell explains, "quantitative researchers tend to be interested in whether and to what extent *variance* in x causes variance in y. Qualitative researchers, on the other hand, tend to ask *how* x plays a role in causing y, what the *process* is that connects x and y" [81, p. 31, emphasis in the original]. In order to produce detailed description of contexts and to address questions of "how" and "why," I draw on a range of data sources including interviews, video recordings, and surveys.

Chapter 3

The Faculty Online Learning Community (FOLC) Model and the New Faculty Workshop FOLC

This chapter is largely from an article which appears in print in Physical Review Physics Education Research and on which Lau is a co-first author: Dancy, Lau, et al. 2019 [19].

This chapter presents a new model of faculty professional development- Faculty Online Learning Communities (FOLCs). FOLCs, an extension of the Faculty Learning Community (FLC) model, typically bring faculty together virtually for periodic meetings over the course of a year or more to support teaching growth. FOLC members are united by a common pedagogical interest. Teaching growth is accomplished through a supportive community in which members troubleshoot teaching challenges and learn from peers and experts in education. FOLCs are designed to increase the sustained adoption of research-based instructional strategies and to foster lifelong reflective practitioners who will continue learning and improving their teaching throughout their careers. We present FOLCs as a needed improvement upon the more commonly used Development and Dissemination (D&D) model for educational change. This chapter starts with a description and critique of the D&D model. We then introduce the FOLC model and highlight the ways it addresses D&D shortcomings. Finally, we present an application of the FOLC model to support physics faculty who attend the Physics and Astronomy New Faculty Workshop (NFW) [13].

3.1 Motivation

Over the past thirty years, the physics education research community has developed and tested a number of research-based instructional strategies, demonstrating their impact on a range of student outcomes. A research-based instructional strategy (RBIS) is a teaching method, generally student-centered and active-engagement based, that has been developed through an iterative cycle of research and design [12, 82]. Examples include Just in Time Teaching [83], Interactive Lecture Demonstrations [84], Scale-Up [4], and Peer Instruction [2, 85]. RBISs encompass both research-based curricula and research-based pedagogies. Commonly, RBISs are spread to faculty through dissemination-oriented methods such as talks, workshops, websites, and journal articles. This strategy works well for increasing awareness of innovations [12]. Additionally, many faculty are interested in implementing these innovations since they often fit their own teaching intuitions and are typically supported by data showing increased student outcomes. However, evidence indicates that while knowing about innovations and being motivated to try them can result in attempts by faculty to change their instruction, knowledge and motivation alone are insufficient to bring about sustained and impactful change [12].

In a survey of physics faculty it was found that $\frac{1}{3}$ of faculty who tried an innovation report discontinuing its use [12]. This represents the largest loss in the adoption process and suggests that efforts to support faculty in continuing use are needed [12, 46]. Additionally, while it is expected that faculty will make some adaptations to an RBIS so it fits their local population and needs, it is not uncommon for a faculty member to modify a new instructional strategy to such an extent that the outcomes are in line with traditional instruction [6, 86]. These findings indicate there is a need to re-envision change efforts to address the high rate of abandonment and ineffective modification by faculty who are interested in and willing to engage in changing their instruction to align with research-based practices. In this chapter we offer a model for educational transformation that addresses these challenges. In the next section we discuss typical change efforts and offer insights into why they fail to bring about sustained and impactful change.

3.1.1 Development and dissemination (D&D) model critique

The FOLC model is designed to supplement change efforts that operate within the development and dissemination (D&D) model for educational change. In order to motivate the need for the FOLC model and justify design principles, we offer an analysis of the D&D model, highlighting aspects of the model that need improvement, and discuss how the FOLC model addresses these shortcomings. We then present the FOLC model in more detail.

Under the D&D model, experts conduct research and develop curricular materials, often in their local context with little consideration for the variety of instructional systems in which their potential adopters are embedded [10, 49]. Once developers have a final product, they share the innovation and evidence of its effectiveness with potential adopters, who are expected to then implement the materials in their classrooms. This model focuses on the developer of an innovation and on the innovation itself, assuming that spreading knowledge of an innovation and the positive effects of the innovation on teaching and learning will be sufficient for widespread adoption [44, 48, 49]. While this model makes intuitive sense and is quite successful at spreading awareness of and motivation to use new RBISs, there is ample evidence that it is insufficient as a mechanism for *sustained and systemic* change [11, 45, 48, 49, 87–89].

Below we highlight some of the reasons why the D&D model is insufficient for producing long-lasting change. Understanding where the D&D model falls short points toward ways it can be supplemented for improved results.

1. The D&D model does not adequately support faculty through implementation difficulties.

The implementation of an RBIS is not trivial and faculty typically encounter problems as they try to implement a new RBIS [40]. For example, a faculty member may attempt to implement a method that utilizes group work only to find their students resist talking with each other. Or the faculty member may have difficulties finding or writing tasks for students that support productive group work. When faculty encounter these difficulties they need help figuring out solutions. If they

do not have someone to turn to for ideas and support they may give up on the RBIS and could potentially decide the RBIS itself does not work. The D&D model does not provide this support because interaction with potential adopters is limited to raising awareness of an innovation and convincing people to try the innovation [49].

2. The D&D model does not support faculty in adapting RBISs to their unique local environment.

It is rare for a faculty member to be able to take an RBIS and adopt it "as is" into their local environment. The demographics of their students may be different than the population for which the RBIS was developed, or they may have to adapt to a much larger class size, or differing content coverage expectations. Under the D&D model faculty must make decisions about how to adapt an RBIS on their own, with little guidance. Developers under the D&D model do not focus on the fit of their innovation to the different contexts of potential adopters [10, 46, 49]. While many faculty are able to navigate this challenge, research [6, 86] suggests that many either modify the RBIS to such an extent so as to lose its positive outcomes, or faculty may get frustrated and simply abandon the RBIS.

3. The D&D model views faculty as passive receivers of teaching knowledge.

Under the D&D model experts (for example, education researchers) develop materials and faculty are viewed as passive receivers [10]. It is assumed that evidence of an innovation's efficacy is a sufficient condition for adoption, and any resistance to change can be overcome by more evidence [49]. Changes to the innovation by adopters are often discouraged. The model does not encourage faculty to view themselves as capable of taking an active role in instructional decisions, or to view themselves as knowledgeable experts of their own instructional systems. By ignoring the importance of the fit of an innovation, the D&D model does not empower faculty to reflect on their unique teaching situation nor does it acknowledge that faculty are experts on their own students.

4. The D&D model assumes faculty can implement RBISs if they want to without acknowledging structural, environmental, and cultural barriers faculty may face.

Many faculty are in situations that perfectly support a traditional lecture-based model of teaching

and conflict with many research-based reforms. For example, they teach in rooms with chairs bolted to the floor, have expectations of content coverage they have little control over, or have colleagues who teach traditionally and cannot provide resources or role models for a new approach. The failure to account for structural barriers, both physical and cultural, can result in a tendency to blame faculty for not changing their teaching while simultaneously failing to support faculty to overcome very real barriers they have little power to change [49].

5. The D&D model does not encourage faculty to develop as reflective teachers with a growth mindset.

As detailed above, successful implementation of a change in one's teaching is not an easy process. Faculty may have the best of *intentions* for changing their teaching practices, but that does not always equate with successful *behavioral* change. The D&D model does not help faculty develop realistic expectations about the challenging nature of implementing an RBIS effectively in their classroom. This is because emphasis is placed on the innovation itself, with little attention paid to the potential adopters and their affordances and barriers to change [10, 49]. With the D&D model, faculty may come to believe that if their initial implementation of an RBIS fails, that means the strategy itself does not work, or they as the teacher are incapable of using the strategy correctly. In other words, the D&D model for educational change does not support the development of a growth mindset [90] and it does not give attention to the development of reflective practice. Therefore, faculty may fail to see teaching as a process of continual improvement and they may not develop the perseverance that they need to succeed.

The D&D model for educational transformation appears to be a good start as it is effective at raising knowledge of innovations and encouraging faculty to try them [12]. However, it is insufficient because it does not address the difficulties faculty face when implementing a new technique, it does not support them adequately in using RBISs, and it does not support their development of a productive mindset towards teaching wherein teaching is seen as a process of continual improvement.

3.1.2 Propagation paradigm

An alternative model for change, promoted in response to the shortcomings of the D&D model, is the Propagation paradigm [47, 49]. Under the Propagation paradigm, focus is placed on the users, and the potential adopters, of an innovation [48, 49]. There are three essential propagation activities: interactive development, interactive dissemination, and support of adopters. While the efficacy of an innovation is still important under this paradigm, there is also emphasis on the fit of an innovation to different instructional systems. This is why developers following this paradigm are in dialogue with potential adopters from the earliest stages of product development, through dissemination and implementation. It is assumed that any innovation will likely have to undergo some modification as adopters implement the innovation in their local context, and because of this developers should interact with adopters in order to support their implementation. While the Propagation paradigm suggests that developers are in the best position to provide interactive dissemination and support, many developers are not willing or able to do so.

The FOLC model is aligned with the Propagation paradigm. Importantly, FOLCs provide a way to disseminate interactively and support adopters' implementation of innovations that does not rely on the original developers of an innovation. With this added step of supporting implementation, FOLCs supplement a main shortcoming of the traditional D&D model. FOLCs recognize the importance of the fit of an innovation to adopters' local contexts. As we will illustrate below, in supporting implementation, FOLCs acknowledge, and indeed expect, users to encounter barriers and they aid users in reflecting on and surmounting these difficulties. These aspects of the FOLC model are consistent with the assumptions of the Propagation paradigm and address the areas in which traditional D&D efforts are lacking.

In the following, we describe in more detail both the FOLC model in general and how we applied it to a specific audience. We present the design principles we use to foster the success of our application of the model, the NFW-FOLC. We elaborate on the reasons for these principles

and how they were operationalized in order to achieve our goals.

3.2 What is a faculty online learning community (FOLC)?

3.2.1 FOLCs: An extension of faculty learning communities (FLCs)

The FOLC model was designed around the Faculty Learning Community (FLC) model of professional development. Both FLCs and FOLCs are examples of a Community of Practice (CoP) [18]. As Etienne Wenger describes, "A community of practice is a learning partnership related to a domain of practice" [91, p.143]. Communities of Practice are defined by three dimensions: a joint enterprise, mutual engagement, and a shared repertoire [18]. The construct of joint enterprise encompasses the purpose of the community to learn and develop competence in a domain of practice [91]. Mutual engagement refers to the relationships between community members; in order to belong to a CoP, members must be engaged together in the joint enterprise of the CoP and must trust each other in the learning process [18, 33]. Shared repertoire encompasses the jointly constructed resources (e.g. language, tools, artifacts, and styles of interaction) needed for negotiating meaning in the community [33, 92]. Communities of Practice are premised on a social and situated view of learning [17].

The FLC model is a particular enactment of the tenants of a CoP. The goal of the FLC model is to support the transformation of faculty's teaching practices and subsequently, students' educational experiences; this is the joint enterprise of an FLC. A typical FLC is a faculty group that "engage[s] in an active, collaborative, year-long program with a curriculum about enhancing teaching and learning and with frequent in-person seminars and activities" [71, p.8]. Participants learn with and from each other, mutually engaging in activities and developing and sharing resources. FLCs focus on building a community of support around teaching and learning and members establish norms for interacting in the community. Through the extended experience and numerous activities, FLCs give participants the opportunity to deeply reflect on their teaching. Evidence shows that FLCs increase faculty interest in teaching and learning and provide support to change

longstanding instructional practice [71, 75, 93]. The FLC model was largely developed at Miami University of Ohio. Implementation details and research on FLCs have been extensively reported elsewhere [73–78]. (Similarly, Professional Learning Communities (PLCs) have goals aligned with FLCs but exist in the K12 space to support the professional development of K12 educators. These have also been the subject of previous work [63–65, 67, 68]).

FLCs are traditionally conducted in a face-to-face setting on a particular campus with faculty from multiple disciplines at a single institution. The FOLC model of professional development for educational change builds on the traditional FLC design, but is different in two key ways:

1. A FOLC meets virtually rather than in person.

A FOLC is conducted in a virtual, rather than face-to-face, environment using teleconference technology for synchronous meetings and an online platform for asynchronous discussion between participants. This is potentially negative as it is more difficult to establish rapport and a sense of community online. However, as we will show in Chapter 4, it is still possible. Further, the online environment offers several distinct advantages as detailed below.

2. A FOLC is composed of faculty from multiple institutions, allowing for more targeted professional development.

Because meetings are virtual there is no need for participants to be geographically close. This presents a great advantage as we can form a FOLC composed of faculty with more uniform concerns and interests. This means, for example, that there can be a FOLC of faculty from only one discipline (traditional FLCs span multiple disciplines). Further, FOLCs can be specific to a subset of faculty such as new faculty or faculty all teaching the same course. This allows for more specific support than is possible in a traditional FLC. Also, an advantage afforded by having faculty across institutions is that group members are not in the awkward position of having to evaluate one another, which allows them to be more open and vulnerable about difficulties they may be having. And finally, it affords participants the opportunity to learn about how other institutions operate and how issues may be navigated differently.

3.2.2 Application of the FOLC model: The Physics and Astronomy New Faculty Workshop and the NFW-FOLC

The Physics and Astronomy New Faculty Workshop (NFW) [13] is offered twice a year, typically in November and June, for faculty in their first few years of teaching. For three days faculty from across the country attend talks and workshops by leaders in physics education, exposing them to numerous research-based instructional strategies. From previous work, we know that the NFW is highly successful at increasing awareness of research-based instructional strategies among faculty participants and motivating them to try to transform their teaching, but faculty use of these RBISs drops off over time [12]. For example, a logistic regression analysis performed on survey data of physics faculty found the largest correlation with trying an innovation was attendance at the NFW [12]. NFW attendees were 7 times more likely to report having tried an innovation than non-attendees.

A multi-day workshop such as the NFW can be very impactful at increasing knowledge and desire to use RBISs in faculty, and such learning opportunities are an essential component of a successful model of educational transformation. However, a short term workshop, or even series of similar professional development opportunities, are insufficient to fully support faculty through the implementation process as discussed in the critique of the D&D model above.

FOLCs, designed and implemented to address the ways in which the D&D model is insufficient, represent one potential solution to these challenges. Faculty who attend the Physics and Astronomy New Faculty Workshop are given the opportunity to participate in a year-long virtual community to support their ongoing professional development through bi-weekly virtual meetings and an online platform to facilitate asynchronous communication.

3.2.2.1 Detail on the NFW-FOLC structure

A NFW-FOLC cohort is comprised of, on average, nine new physics and astronomy faculty members who attended the same in-person NFW. Each cohort is facilitated by one or two more

experienced physics/astronomy faculty members. After the first two cohorts, we recruited facilitators from past FOLC participants. At the NFW the FOLC facilitators advertise the program to attendees and the new faculty members have the chance to sign-up. We start a new cohort every semester, in conjunction with each offering of the NFW.

A FOLC cohort meets every other week via a video conferencing platform and members can communicate in between meetings via a private online platform. The cohort meets for a full year following the NFW. During the synchronous video meetings, FOLC members give updates on their teaching and troubleshoot issues with each other. While the focus is on teaching, unsurprisingly these new faculty members also bring up challenges associated with their jobs generally, such as tenure and promotion and finding research collaborators. In about half of the meetings, guest speakers are invited based on FOLC members' interests to talk about particular teaching strategies. The guests are often experienced practitioners of the teaching strategy being discussed. Guest speakers are encouraged to have a dialogue with FOLC participants and participants can submit questions for the speaker before the meeting. FOLC members complete a Scholarship of Teaching and Learning (SoTL) Project during the second half of their FOLC experience [72, 94, 95]. With this project, members are encouraged to choose an aspect of their teaching they would like to change, implement that change, assess the change, and present the results to their cohort. Periodic FOLC meetings are devoted to discussing progress on the SoTL projects and possible assessment strategies. In between the synchronous meetings, participants can share resources, ask questions, and follow-up on discussions using the asynchronous communication platform.

3.3 Design principles of the NFW-FOLC

In this next section we describe design decisions around the NFW-FOLC. These decisions are based on the hypothesis that faculty need more than knowledge of an innovation and motivation in order to succeed at implementation, as detailed above in the critique of the D&D model. In designing the NFW-FOLC our primary goals for the participants were to help them develop as reflective practitioners committed to continual teaching improvement and to support them in successfully

implementing RBISs. We define successful implementation as one that is sustained over the long term and that is adapted to the local environment while still aligning with recommendations from the research literature. These primary goals of the NFW-FOLC reflect the areas in which the D&D model falls short and are consistent with the Propagation paradigm.

In order to reach these large goals there were several "learning objectives" for the participants that we designed the NFW-FOLC to achieve. Underlying these learning objectives is the overarching objective that participants' students experience better learning outcomes. This is the ultimate goal of the FOLC: to improve students' learning experiences by improving the teaching practices of their instructors. The six learning objectives for FOLC participants listed below are actions associated with improved student outcomes.

The NFW-FOLC participants will:

(1) Develop reflective teaching habits and a dedication to continuous improvement of teaching.

(2) Increase their knowledge and awareness of RBISs.

(3) Maintain or increase their motivation to implement RBISs in their classrooms.

(4) Implement RBISs in their classrooms consistent with recommendations from research.

(5) Persist in their implementation of RBISs.

(6) Increase their sense of empowerment regarding themselves as teachers (includes confidence using RBISs, agency, and self-efficacy).

Below we describe NFW-FOLC Design Principles that were explicitly utilized in order to meet the objectives listed above. The design principles frequently address multiple learning objectives. In addition to building off FLC design, these principles are consistent with design principles found in K12 professional development programs [96, 97]. Table 3.1 summarizes our design principles and objectives.

1. Provide ongoing opportunities for participants to continue learning about RBISs. A significant portion of the bi-weekly virtual meetings during the first semester of a NFW-FOLC are set aside for guest speakers. Participants are periodically asked what they want to learn more about and then the facilitator and project team look for an appropriate speaker for

an upcoming meeting. Based on participant feedback from early FOLC cohorts, an effort is made to find a guest speaker who is not a developer or researcher of an RBIS but rather a practitioner with extensive experience in implementation. Speakers are encouraged to structure their visit to be heavy on discussion and light on presentation. Facilitators sometimes collect questions from the participants for the speaker ahead of time. Thus participants in the FOLC receive ongoing professional development related to increasing their knowledge and awareness of RBISs based on their own interests and needs.

2. Provide ongoing feedback and support to help participants through implementation difficulties. As mentioned above, participants have ongoing opportunities to ask questions of experienced practitioners of methods they are implementing or have interest in implementing. Further, a significant portion of each virtual meeting is set aside for discussions among group members. Typically this group discussion time is initiated by a round of what we call "best and worst." Each member of the FOLC, including the facilitators, share something from their teaching that week that they are proud of and something that they do not feel went well. This encourages each member to share something they are struggling with and provides encouragement to the group to offer suggestions, feedback, or even simple affirmation of the person's frustrations. Additionally, in between meetings participants can pose questions or quandaries about their teaching to the group through the asynchronous communication board and receive support between meetings. These structures mean that at any point a participant can get feedback if they are having difficulties. Even if they do not explicitly ask for feedback, they are prompted to do so at least bi-weekly.

3. Encourage a sense of safety within the group and a willingness to be vulnerable. In order to be able to share difficulties openly and therefore learn and get feedback, participants have to feel safe admitting when things are not going well. The "best and worst" activity described above, while intended to elicit difficulties, is also intended to develop feelings of safety. Facilitators are encouraged to share their own difficulties, modeling a willingness to acknowledge mistakes and imperfections. By having each person share their difficulties, the participants are continually reminded that everyone is struggling, and they are often struggling with similar issues. It was our

hope that participants would feel more comfortable talking openly about their own challenges. This normalizes struggle as a part of teaching and encourages a growth mindset. Further, in order to build trust among participants, it is established as a norm that discussions specific to individuals should be treated confidentially. And finally, lurkers are not allowed. If a participant ceases to be an active member of the group they are removed from the group and no longer have access to the asynchronous communication board.

4. Enact a structure that encourages and values the expertise of all participants. As mentioned above, it was our goal to empower the participants. The FOLC therefore is organized as a community effort rather than a top-down structure. Our facilitators are so named, rather than called "leaders," to reflect this choice. As much as possible, FOLC facilitators are previous FOLC participants; therefore, they are also younger faculty who are learning along with the participants. Facilitators are encouraged to not dominate discussions, therefore setting the norm in both the synchronous and asynchronous interactions that everyone can help each other and should not look to the facilitators as the experts. For example, facilitators wait to post a response on the asynchronous board so others can share first. Every participant is treated as having valuable knowledge to share with the group. The facilitators sharing a difficulty in their teaching during "best and worst" (described under #3 above) is also meant to show participants that even more experienced practitioners are not perfect and have not figured out every teaching problem. It was our hope that the focus on distributed expertise would help participants develop their self-efficacy around teaching and develop a growth mindset towards teaching as a process of continual improvement.

5. Encourage completion of a Scholarship of Teaching and Learning (SoTL) project during the second half of the experience. All participants are asked to engage in a SoTL project [94, 95, 98] during the FOLC. The Scholarship of Teaching and Learning is frequently cited as an important component of in-person FLCs [71]. An example of a SoTL project is a faculty member trying clicker questions in their course and then analyzing the effect by exploring how exam scores compare to a previous semester when they didn't use that active-learning

strategy. By engaging in a SoTL project, FOLC participants identify an aspect of their teaching to explore, take data in order to understand this aspect better, and then share their results with their peers. With the support and feedback of the FOLC cohort, participants formulate ways to answer their questions about their teaching and enact those plans. In other words, SoTL projects allow participants to practice assessing changes they make in the classroom rather than relying only on intuition about how the technique worked. By guiding FOLC participants through one iteration of asking and answering a question about their own teaching, we hoped these projects would foster reflective thinking and motivate participants to assess their teaching practices going forward. Further, through engaging in SoTL projects we aimed to instill in participants an attitude towards teaching as a process of continual improvement and to encourage a growth mindset.

6. Foster a supportive community. Finally, the FOLC is designed to foster a community of support. This design principle addresses every FOLC learning objective and we believe it is in fact the most critical design feature. At its core the FOLC is designed to be a community. As discussed above, implementing and sustaining the use of RBISs is difficult and we hypothesize that having a nurturing and supportive professional community can help faculty productively change their teaching and sustain those changes. In designing the FOLC, much effort was put into building the community aspect. For example, participants are encouraged to get to know each others' teaching and broader professional contexts through the "best and worst" activity. In addition, FOLC members engage in informal chatting at the beginning and end of meetings about their lives outside of work. Conversations about professional life (generally and teaching-specific) as well personal life both serve to build a sense of trust and community among the group. There is always time reserved during meetings for the cohort to interact without outside guest speakers.

Facilitators also encourage participants to post brief "What's going on this week" updates on the asynchronous site between meetings. The very choice to have an asynchronous platform was made with community formation in mind. We felt that interacting once every other week was not enough to sustain connections and an asynchronous platform would allow the cohort to communicate at any time.

Additionally, this design principle is bolstered by other design principles listed above. "Encouraging a sense of safety within the group" is also meant to connect the group emotionally and make it feel like a community. "Valuing the expertise of all participants" and "providing ongoing feedback" encourages participants to share ideas and connect intellectually.

Table 3.1: The NFW-FOLC Design Principles and Learning Objectives. The Design Principles often serve multiple Objectives.

Design Principles
Provide ongoing opportunities for learning about RBISs
Provide ongoing feedback and support to help through implementation difficulties
Encourage a sense of safety and a willingness to be vulnerable within the group
Enact a structure that encourages and values the expertise of all participants
Encourage completion of a Scholarship of Teaching and Learning (SoTL) project during the second half of the experience
Foster a supportive community
Learning Objectives
Participants develop reflective teaching habits and a dedication to continuous improvement of teaching
Increase participants' knowledge and awareness of RBISs
Maintain or increase participants' motivation to implement RBISs in their classrooms
Participants implement RBISs in their classrooms consistent with recommendations from research
Participants persist in their implementation of RBISs
Increase participants' sense of empowerment regarding themselves as teachers (includes confidence using RBISs)

Through these learning objectives and design principles we target areas in which the D&D model is insufficient *for producing sustained change.* Namely, we support participants over time as they work through implementation difficulties while encouraging them to reflect on their teaching more generally. This is all accomplished with the support of a community. These principles and goals further reflect the model of change espoused by the Propagation paradigm in which supporting adopters is a key tenant for successful, long-term change.

3.4 A glimpse into a NFW-FOLC meeting

So far in this chapter, we have presented shortcomings of the D&D model and ways the FOLC model would be expected to address these shortcomings (e.g. by focusing on providing implementation support, developing reflective practice of participants, etc). We have detailed one particular instantiation of the FOLC model: the design principles and goals of the NFW-FOLC. We end with a glimpse into a NFW-FOLC meeting; this example serves to demonstrate some of the design principles and learning objectives outlined above, as well as to illustrate the FOLC context for the reader.[1] This example will also describe several facilitation moves used by the facilitator to structure the conversation; this may lead one to consider what facilitation moves are enacted in the FOLC and how they impact the success of the FOLC. To that end, Chapter 7 will present a taxonomy that allows researchers and practitioners to analyze these moves. The taxonomy is compose of three elements which describe what is discussed in a conversation and how people engage in the conversation; this will be presented in detail in Chapter 7.

The following example comes from a fifteen minute conversation during one of our early NFW-FOLC cohort's meetings. Present at the meeting were six out of the nine cohort members in addition to the facilitator of the cohort. In the segment, participants engage in exploration of a core pedagogical issue. Not all FOLC conversations reach the depth and breadth of this example; we classify this as a particularly productive FOLC conversation.

The attendance issues episode:

Prior to the meeting, the facilitator used the asynchronous communication platform to solicit topics members wanted to discuss at the start of the meeting, before a guest speaker was scheduled to join. Grace[2] had posted a question about class attendance policies. Figure 3.1 provides a summary of the ensuing conversation. For brevity, the figure includes mostly paraphrases of the talk. All participant names are pseudonyms.

[1] This section is adapted from a paper which appears in print in the 2018 PERC Proceedings: Lau, Dancy, et al. 2018 [20].

[2] All names are pseudonyms.

Summary of "Attendance Issues" Episode

1. Facilitator asks Grace to "say a few more thoughts" about the question she previously posted to the online bulletin board.
2. Grace says, "I'm trying to figure out how important it is to monitor attendance." She explains that she wants to treat students as grownups but feels they will not be as successful if they don't attend.
3. Facilitator & Andrea - Share humorous anecdote.
4. Facilitator asks cohort if their attendance concerns depend on if it is an intro vs. advanced course or small vs. large class.
5. Grace says in large classes students think it isn't noticeable if they don't show but she notices. She doesn't think students see the connection between coming to class and success. She worries people not coming holds their group back.
6. Facilitator asks cohort if anybody has a different attendance policy based on class.
7. Nicole says there is an implicit distinction between lab and lecture (everyone must show up for lab to get the grade). She talks about when attendance is low or high (i.e. high on quiz days, low on Fridays). States she needs to come up with an attendance policy for future semesters and posits using reading quizzes as a solution.
8. Facilitator says if students aren't convinced of value of class time they view an attendance policy as "high school again." Asks Grace if she is more interested in motivating students to want to attend or wanting to get them to attend because she knows it is best for them.
9. Grace responds, "It's a little bit of both." She says it is important for them to pass, but it is hard to motivate them when it is not their major.
10. Facilitator asks for other input; Asks if anyone has an attendance policy they like.
11. Kristin says her attendance policy is encapsulated in participation grade. This semester she implemented JiTT. She feels JiTT questions motivated students to show up as they had already invested time in preparing for class.
12. Facilitator asks for other ideas/policies.
13. Lin explains that she doesn't take attendance. She doesn't want to force students to come, but she offers bonus points in class to encourage students to attend. She elaborates on situations she has encountered at her institution.
14. Facilitator says he wants to build a setting where students are upset if they miss class because that is where they view learning as happening. Asks if others agree.
15. Mila agrees. She gives one point for a clicker question in class and that motivates them to attend. She tries to emphasize why she wants them to discuss things in class. She states there is 10% of the class you can't do anything about.
16. Facilitator says his preference is not to set a policy. Talks about experience with oral exams. Asks Grace, "where do you think you're going to land?"
17. Grace responds, "It's going to be class dependent." She maybe will allow some absences until a certain level and can't miss lab. Elaborates on her concern for a small class she will be teaching. Says her policy will leave room for students to be adults, but at the same time emphasize her belief that coming to lecture is important.

Figure 3.1: Description of the "attendance issues" episode. This was a fifteen minute conversation during one of the NFW-FOLC meetings. All talk is paraphrased except where quotation marks are used.

Grace explains to the group, "I'm trying to figure out how important it is to monitor attendance." She shares that she makes attendance mandatory in her intro course, but she is trying to figure out what to do in her other courses. She explains that she is conflicted because she wants to treat students as grownups but feels they will not be as successful if they don't attend class. The facilitator shares an anecdote about a colleague who takes personal offense when students skip their class. He then asks the cohort if their thoughts on attendance differ depending on the type of course they are teaching. Grace is able to respond with her thoughts on the matter. She adds, "For me it's a concern that they're not getting everything they could get out of the class. And in instances where there's group components where there's projects or lab components, I worry that they're then holding other students back."

The facilitator moves to ground the conversation in specific practices, asking "Does anyone actually have a distinction in your attendance policy that you required in some and not in others?" Nicole shares the distinction she makes between her lab and lecture courses. She muses about the specific factors that have impacted

attendance in her lecture classes and says that students can become invisible because the sections of her class blend together. After replaying her experience she realizes she needs a better attendance policy for these lecture classes.

The facilitator goes on to ask the group to consider their motivation behind attendance policies. He hands the conversation back to Grace to let her explore her motivations. She both wants students to *want* to come to class and wants them to come because it will help their learning. Returning to the rest of the cohort, the facilitator asks "Who has an attendance policy that, that makes some sense to you?" Kristin shares her experience from the current semester where instead of taking daily attendance, she has implemented Just-in-Time-Teaching (JiTT) [83]. She relays, "And it seems like, once they bothered to do the pre-class [JiTT] questions, then they're going to show up to class." Lin shares that she too does not take attendance, but she will offer bonus points in class to incentivize attendance.

The facilitator asks the group what their "pie in the sky" solution would be to this attendance issue. He elaborates, "Would we love it if, for example, the learning could only happen if they show up to class and so we wouldn't need a policy? Would pie in the sky be that we just have students that do whatever it takes to learn and we don't need to give any sort of policies in our syllabus that address it?" Mila agrees with this and explains how attendance works in her class. The facilitator shares that he aims to not have to set an attendance policy. He then returns to Grace asking, "Where do you think you're going to land?" Grace rehearses a possible attendance policy. She explains that her policy will be class dependent (she teaches some very small classes) and it will balance her belief that coming to lecture is important with her desire to treat students as adults.

Within this one conversation, a number of the NFW-FOLC design principles are salient. First, the group is able to help Grace work through her teaching challenge regarding attendance. This is accomplished through providing Grace the opportunity to articulate her teaching goals and philosophy, and eliciting feedback from other community members. The facilitator repeatedly asks for participants' experiences and ideas (e.g. Events 6, 10, 12, 14 in Figure 3.1), and by the end of the conversation every member has spoken. In eliciting participants' thoughts and experiences, the facilitator encourages the participants to act as experts with valuable teaching knowledge to share. We further see that the group values the expertise of all members through the facilitator withholding his full opinion at first and not attempting to immediately solve Grace's issue. Critically, he repeatedly returns the conversation to Grace (e.g. Events 1, 8, 16) allowing her to articulate her concerns and to clarify her goals. At the close of the clip, the facilitator returns the conversation to Grace so she can synthesize all she has heard and rehearse a solution that is

uniquely hers. No single policy is ever posed as the only "correct" solution.

The conversation includes the voices of all cohort members in attendance, and the group learns more about each others' local contexts and teaching experiences. This acts to strengthen the community. The community also supports Grace through normalizing the attendance issue she is having as a number of other members experience the same issue (e.g. Events 7 and 13).

This example also demonstrates how the NFW-FOLC design principles support our learning objectives. In the process of discussing Grace's attendance policy question, the group has the opportunity to reflect on their teaching choices, learn more about RBISs, and increase their confidence around teaching. The facilitator repeatedly asks questions that direct participants to consider both the practicalities of the problem they are facing and underlying pedagogical issues (e.g. asking Grace to specify her motivation for creating an attendance policy in Event 8, and prompting the group to consider if attendance policies should be class-dependent, guiding members to think about when and why they have attendance policies, Events 4 and 6). All of these prompts lead the cohort members to reflect on their teaching (both what they have tried in the past and what they will do in the future). Because all members' opinions are valued and expertise is treated as distributed throughout the group, members have the chance to increase their confidence around teaching. They share policies that work for them, or practices that have not worked and they can explain why. Either way, they are able to offer Grace knowledge she can act on. The fact that others also are struggling with finding an attendance policy that works in their classes may also serve to increase Grace's confidence because she can learn the issue is not unique to her. Finally, Kristin talks about her use of one RBIS, Just-in-Time-Teaching, and the group can learn how this technique not only can help students prepare for class, but also motivate them to show up.

This is just one example of a NFW-FOLC conversation. The NFW-FOLC meetings last 90 minutes, so a number of different conversations occur over the course of a meeting, often covering a range of topics. Sometimes many voices join the conversation and sometimes only a few. However, we aim to structure each meeting with the design principles laid out in this chapter and with the learning objectives for participants' in mind.

3.5 Conclusions

In sum, we have identified a critical problem in the promotion of research-based teaching reforms: Typical approaches for promoting instructional change are not sufficient for bringing about sustained and impactful reforms. We provided an analysis of why the common D&D model for educational change falls short of these goals and we have presented a FOLC model, an extension of the FLC model and consistent with the Propagation paradigm, to address the shortcomings of traditional reform efforts. This FOLC model of professional development for educational change is designed to meet known challenges in educational transformation primarily through the affordances offered by a community of support. We described an implementation of the FOLC model, the NFW-FOLC, presenting and illustrating its design principles and learning objectives for faculty participants.

Chapter 4

New Faculty Workshop FOLC Outcomes: Faculty Impact

This chapter is largely from an article which appears in print in Physical Review Physics Education Research and on which Lau is a co-first author: Dancy, Lau, et al. 2019 [19].

In this chapter, I turn to evidence of effectiveness of the faculty online learning community (FOLC) model in terms of the impact on participating faculty. In order to test the assumptions behind our specific implementation of the FOLC model and the mechanisms by which it is hypothesized to work, we present data on participants' reports of why they signed up for the New Faculty Workshop(NFW) FOLC and what impacts they felt the FOLC had on them and their teaching. We also discuss the sense of community FOLC members felt in their cohort. We will use the results from the NFW-FOLC as support for the FOLC model overall.

NFW-FOLC data collection and analysis is extensive. Here, we will focus on answering two questions. First, is our implementation of the FOLC model fulfilling a need as hypothesized? Second, are there indications that our application of the model is working as intended? Specifically, we report on an analysis of interviews conducted with participants during or immediately following the NFW-FOLC experience. In turn, we present participants' motivations for joining the FOLC, their self-reported impacts of participating, and a detailed examination of community formation in the FOLC. Encouragingly, self-reports from participants in their interviews indicate we are largely meeting our goals and our design principles are working as anticipated. Long-term impacts of FOLC participation (e.g. *persistence* in using research-based instructional strategies and expanded reflection on teaching practice) will be explored based on follow-up, longitudinal interviews in

Chapter 5.

4.1 Methodology

4.1.1 Data sources and analysis

The NFW-FOLCs have been running since Spring 2015 with two cohorts starting each year to coincide with the two offerings of the NFW. As of Spring 2020, we have run eleven cohorts. During that time we have collected a large amount of data including: pre-post and longitudinal surveys from NFW evaluation data, interviews with participants at the end of their FOLC experience, surveys of participants' experiences of the FOLC community and their teaching practices, videos of virtual meetings, and archives of asynchronous communications. Additionally, we are collecting longitudinal data in the form of additional participant interviews two years after they complete the experience, to understand long term impacts of the FOLC (see Chapter 5 of this dissertation). In this chapter, we focus on analyzing interview data from the first four NFW-FOLC cohorts, collected at the end of participants' time in the FOLC.

We invited all forty participants from the first four cohorts to participate in video interviews about their experiences in the FOLC. Thirty-four participants accepted. For Cohort One, these interviews occurred approximately midway through their time in the FOLC. Because this was our first cohort, we ran it as a one-semester pilot of the FOLC model and we wanted to get feedback from members before the end of the semester. For Cohorts Two through Four, we conducted interviews with members after they completed their year in the FOLC.

In the interview, we used a semi-structured protocol (see Appendix A for the complete protocol). Members of the research team conducted the interviews. Participants and interviewers had limited interactions prior to the interviews. Participants were informed that their interviews would not be shared in any identifiable way with their facilitators. Interviewers made clear that they wanted to know both what in the FOLC had worked well and what had not worked well for the participant. In these ways, we worked to minimize the influence of the interviewer on the

interviewee's responses. Participants were asked general questions about how the FOLC went and what they liked and didn't like about the experience. They were asked about their motivation for joining the FOLC and if they found the experience worthwhile. They were also asked about their teaching and how it has been impacted by the FOLC. Additionally, participants were asked about the different components of the FOLC (synchronous meetings, asynchronous communication, and SoTL projects) and about their impressions of the community which developed among their cohort. In this chapter we will report on participants' motivations for joining the FOLC, their self-reported impacts of participating in the FOLC, and their perceptions of the community that formed among their cohort.

It is important here to note that although we do not have direct observations of participants' teaching practices, self-reported impacts and perceptions elicited during our interviews are quite valuable. Indeed, particularly for impacts regarding mindset (e.g. confidence in teaching) and sense of belonging, participants' perceptions are equally or more important than any more "direct" measure such as a social network analysis of the community. That is, one's *perceptions* influence one's *practice*, so feeling like one belongs to a teaching community is more consequential for future action than perhaps knowing that you have interacted with a certain number of community members a given number of times. Where one may not expect complete fidelity between a participant's reporting and their actual practice, such as what techniques they are trying in their classroom, we tried to elicit implementation details during the interview so we could determine if, for example, they were implementing Peer Instruction [2] in a way consistent with the designer's intent.

Dr.Dancy and I coded the interviews from the first three cohorts. On a first pass, we used organizational categories to sort the data into the major topics discussed [81]. All the responses related to their motivation to join the FOLC were coded as Motivation. This was frequently in direct response to the question "Why did you join the FOLC?". Likewise, anytime the participants spoke about how the FOLC has impacted them, that was coded as an Impact. These impacts arose throughout the interview rather than in response to one specific question. We then developed (separate) sub-coding schemes for the Motivation responses and Impact responses. These sub-codes

were developed inductively [99]; Some of the categories of the sub-coding scheme were developed based on the patterns we had seen in our first-pass at coding, while others emerged as we went through the responses the second time. The sub-codes are substantive categories, capturing with more detail the specific content that was expressed by participants [81]. Dr.Dancy and I sub-coded all the entries separately and then compared our coding for each entry until total agreement was reached. Reaching agreement entailed sharing our reasoning for our coding decisions and comparing the segment-in-question with other responses that were coded with the contested category. This helped us identify how similar (or different) the segment-in-question was from other cases of the code.

Around 6 months after the coding of the first three cohorts' interviews, I began coding the by-then-collected interviews from Cohort Four. I followed the same procedure described above for capturing the major themes of the interview. (Responses to the Motivation question were again coded as such and impacts were noted throughout the interview). On a second-pass through this set of interviews, I attempted to sub-code the motivation and impact excerpts according to our previously developed coding schemes. In doing so, I noticed themes in the interviews that were not sufficiently captured in the existing coding scheme as well as ambiguities in the existing code definitions that made distinctions between some of the categories fuzzy. After discussing these gaps with Dr.Dancy, we decided to amend our sub-coding schemes, adding a few new codes, specifying definitions of existing codes, and reorganizing the code structure as made sense. This included adding touchstone examples from the data into our code book as well as common phrases that appeared in segments coded a certain way; with these additions we sought to minimize uncertainty about when a code applied to a segment as well as document our decision process for tricky cases. All of the changes resulted in a coding scheme that "spanned the space" of our data corpus– the codes comprehensively describe the experiences reported by our participants. (Appendix B includes the codebook for the Motivation and Impact coding.) I then applied these modified sub-coding schemes to the Motivation and Impact excerpts from the Cohort 4 Interviews. Any time I was unsure of how to code a segment, the segment was discussed with Dr.Dancy and we relied on

comparing the segment with other excerpts from our data corpus (e.g. touchstone examples) to come to a mutually-agreed upon coding decision.

After completing the coding of the Cohort 4 interviews, I went back to the interviews from the first three cohorts and revised their coding based on the modified coding schemes. Again, any time there was a segment I was unsure how to code, it was discussed with Dr.Dancy and we compared the excerpt with other interview segments coded according to the categories in question. We relied on similar as well as contrasting cases to make our coding decision that was consistent with the previously coded interviews.

Once the coding and re-coding of all interviews was complete, we found that some of our codes were capturing a wide range of experiences. We decided to further divide these codes into more specific codes. For example, we noticed that the types of knowledge participants reported learning because of their participation in the FOLC fell into three distinct categories. We decided to sub-code all knowledge excerpts into these three categories in order to have a more fine-grained analysis. The data presented in this chapter is a result of our highly iterative cycle of coding and refinement. Additionally, the definitions of our codes and the conclusions we present here were made more robust by feedback we received on written and oral presentations of this work.

4.1.2 Participants

As of Fall 2018 we have run nine cohorts, with a total of 82 people enrolled in the NFW-FOLC. (The participants whose interviews we report on here are included in these 82 people). Members of a given FOLC cohort all attended the same in-person NFW. Out of all our participants, 71 have reported on their gender and 63 have reported on their race and/or ethnicity. Institution-type data is either self-reported or determined by the authors for all 82 participants. Of the 34 participants whose interviews we report on here, we have information on gender for 24 of them and information on race and/or ethnicity for 19. Table 4.1 shows the demographic characteristics for the interview participants, the NFW-FOLC population overall, and the NFW population. For the NFW population, gender and race data were collected for 290 participants, while institution-type

information was collected for 161 participants.

Table 4.1: Demographic characteristics for interviewees, NFW-FOLC participants overall, and NFW attendees. Demographic data are reported based on collection categories which were not identical across groups. Note, the NFW population institution-type data is aggregated over the June 2016 through June 2017 workshops.

Population	**Interview Participants**	**NFW-FOLC Participants**	**NFW Population Overall**
	Members from the first four cohorts, January 2015-June 2017	Aggregated over 9 cohorts, January 2015-September 2018	Aggregated over June 2015 through June 2017 Workshops Pre-Survey
Gender	Female: 46%	Female: 45%	Female: 30%
	Male: 54%	Male: 52%	Male: 67%
		Transwoman: <5%	Prefer not to answer: <5%
		Agender: <5%	
Race/Ethnicity	White/Caucasian: 84%	White/Caucasian: 79%	White/Caucasian: 61%
	Asian: <5%	Asian: 11%	Asian or Pacific islander: 22%
			Asian or Pacific islander & White/Caucasian: <5%
	Black or African American: <5%	Black or African American: <5%	Black or African American: <5%
	Hispanic or Latino: <5%	Hispanic or Latino: <5%	Hispanic or Latino: <5%
		White, non-Anglo: <5%	Hispanic or Latino & White/Caucasian: <5%
		White-Hispanic: <5%	
			American Indian or Alaskan Native: <5%
			Prefer not to answer/NA: 8%
Institution Type	PhD granting Institution: 24%	PhD granting Institution: 29%	PhD granting Institution: 42%
	Masters granting Institution: 9%	Masters granting Institution: 6%	Masters granting Institution: 5%
	Primarily Undergraduate Institution: 68%	Primarily Undergraduate Institution: 65%	Primarily Undergraduate Institution: 52%

Our FOLC participants are self-selected. They have chosen to attend the NFW and from there have chosen to participate in the FOLC. Demographically, they are not representative of either all new physics faculty [100–102] nor of the NFW participants overall. Specifically, our participants are more likely to be female[1] and more likely to come from a primarily undergraduate institution. However, from post workshop survey data collected just after the NFW but before participation in the FOLC, we found FOLC participants were similar to NFW participants who did not join the FOLC in self-reported motivation, knowledge, and confidence in using active learning strategies [104].

4.2 Findings and Discussion, Part I: Motivations for joining the NFW-FOLC

4.2.1 Results: Analysis of motivations for joining

Why do faculty join the NFW-FOLC? Is their motivation to participate consistent with our philosophy, goals, and design principles? In order to help understand the FOLC participants and their expectations we read through the interviews and coded all instances where they were talking about their motivation to join the FOLC. Typically this was in response to the direct question "Why did you join the FOLC?" Perhaps unsurprisingly but significantly, all thirty-four interviewees (from our first four cohorts) expressed a desire to improve their teaching and develop as a teacher as a reason for joining the FOLC. Eight participants did not specify beyond that. Of the participants who did specify further, their responses tended to fall into three broad categories: desire to expand their professional community; getting implementation help; and learning more about teaching strategies. Responses could be co-coded into multiple of these categories. These results are displayed in Table 4.2. It is important to note that these are responses given spontaneously; we did not directly ask, for example, "Did you join the FOLC to get implementation help?" Therefore, we expect that a larger percentage would likely have agreed each was a reason for joining than brought it up on their own as reflected in the data table.

[1] This is aligned with the results of previous studies which have found that females are more likely than males to hold teaching beliefs and practices aligned with interactive engagement methods [103] and that being female is a significant predictor of continuing use of an RBIS [12].

Table 4.2: Specified motivations for joining the NFW-FOLC, beyond "to improve my teaching." People could fall into more than one category. Count represents the number of participants coded to a category. Percentages are out of 34 participants.

Code	**Count (Percent%)**
Learn More about Teaching Strategies	8 (24%)
Get Implementation Help	16 (47%)
Expand Professional Community	25 (74%)

LEARN MORE ABOUT TEACHING STRATEGIES

Nearly one-quarter of interviewed participants expressed that one of the reasons they joined the FOLC was to learn new things about teaching. This code captures participants' desires to increase their teaching knowledge. For example one participant stated, "*I was interested in blocking out some time, basically, to make myself learn more about teaching and learning.*" This sentiment of wanting to learn more was echoed by another participant who stated that one of the reasons they joined was because they were, "*very interested always in just learning new techniques, learning to be more active and interactive.*" One member was more specific and stated that they joined to learn more about pedagogy they could apply to their upper-division courses.

This motivation to join the NFW-FOLC is consistent with our Design Principle[2] of **providing ongoing opportunities for participants to continue learning about RBISs**. Our participants wanted opportunities to learn more about teaching and we have designed the FOLC to provide those opportunities. It is important to note, however, that no participant expressed learning new content as their sole reason for joining the FOLC. Our participants did not want just an extension of the types of presentations they had at the NFW.

GET IMPLEMENTATION HELP

Nearly half of the interview participants said that one of their motivations for joining the FOLC was to get help implementing research-based instructional strategies (RBISs). These participants

[2] See Section 3 of Chapter 3 for the full list of NFW-FOLC design principles.

described a desire to get feedback from the FOLC community as they implemented new teaching techniques; they wanted to increase the usability of knowledge they gained at the NFW. One participant coded in this category said, "*It's very overwhelming when you get to that meeting [the NFW] and you see all of these different techniques and how people do it. I was like okay, maybe I need some help to implement some of that stuff.*" Participants were inundated with information about many different teaching methods at the NFW and they saw the FOLC as a means to help develop their skills in implementing the techniques they had learned about.

Another FOLC member relayed, "*I signed up after I taught my first class ever, which I thought was a big disaster...Yeah, so it [signing up for the FOLC] was just to be able to get more guidance and feedback and enhancing my teaching experience.*" This faculty member was very new to teaching and believed the FOLC would give them feedback on what they were trying in their teaching. Even faculty members more versed in RBISs were motivated to join the FOLC for the implementation help: "*I thought it was a very fun way to chat and to kind of work out these problems with a cohort of people. Because I had learned some PER stuff before and knew the gist of it, I also learned that implementing it was a real pain in the butt.*" Based on their prior experience, this FOLC member knew that implementing an RBIS could be challenging and they saw the FOLC as a way to mediate potential implementation difficulties.

One of our participants specified that they joined to have, "*A place you can talk to other people: hey I did clicker questions and I'm having a terrible time keeping my kids on task, what do you do? Just things like that are what I was really looking for when I signed up...Being able to bounce ideas off people and share ideas.*" This participant joined the FOLC to have a forum where they could troubleshoot the nitty-gritty details of the RBISs they were trying in their classroom. Also, the motivation to "bounce ideas off people" in order to improve the implementation of a teaching technique was echoed by multiple participants in describing their motivation to join the FOLC.

This motivation to join the NFW-FOLC is consistent with our Design Principle of **providing ongoing feedback and support to help participants through implementation difficulties**.

Based on previous research [7, 40], we know faculty members encounter a number of challenges when implementing RBISs and we designed the FOLC to help faculty persist through these challenges and see challenge as a normal part of the teaching process. Participants joining the FOLC to receive implementation support helps validate this aspect of our application of the FOLC model (and the FOLC model more generally); these participants acknowledged that taking ideas directly from the workshop and implementing them would not be trivial.

In describing their desire to receive implementation help, many participants specified that they thought they would receive this support from the people in their cohort. They were not talking about receiving this help solely from the experienced practitioner guests the cohort would invite to speak. This is consistent with the NFW-FOLC Design Principle of **enacting a structure that encourages and values the expertise of all participants**. Our participants recognized going into the FOLC that they could learn and receive assistance from their peers (and the FOLC was a space where this could occur).

EXPAND PROFESSIONAL COMMUNITY

Three-quarters of the interviewed FOLC participants described joining the FOLC in order to expand their professional community. For example, one member explained "*I went to the New Faculty Workshop and met some people there that I really connected well with and just felt like I could talk to about teaching and about classes and about all of the stress and strain of being a faculty member, and I wanted to continue that conversation, and those people were the people that ended up in the FOLC. So yeah, it [joining the FOLC] was just a way to continue that.*" A handful of our participants expressed this desire to "continue the conversations" started with attendees at the NFW. Of the 25 participants who talked about joining the FOLC to develop their professional community, 18 of them specified further than the above example about the types of connections they were hoping to develop. Those who specified fell into one or multiple of the following categories regarding the kind of community they wanted: connection with other new faculty; connection with people outside their local department for broader perspective; connection with people who care about teaching; connection with other faculty because of lack of sufficient local support. Table 4.3

shows how many people were coded at each category, and we define and demonstrate each category in turn, below.

Table 4.3: The sub-codes of the motivation to "Expand Professional Community." People could fall into more than one category. Count represents the number of participants coded to a category. Percentages are out of the 25 participants who joined the FOLC to expand their professional community.

Sub-code	**Count (Percent%)**
Connect with other new faculty	9 (35%)
Connect with faculty outside their department for broader perspective	4 (15%)
Connect with other faculty who care about teaching	4 (15%)
Connect with other faculty due to lack of sufficient local support	12 (48%)

Connect with Other New Faculty

Around one-third of the participants who expressed that they joined the FOLC to expand their professional community specified that they joined to meet other early career faculty members. These FOLC members wanted to connect with other new faculty. One of the FOLC members explained, "*I thought it would be good to especially talk to people who are just starting out, that are trying things out, rather than people that had a lot of experience maybe...it was good to see how people are interacting with something the first time.*" This participant wanted to interact with peers, people who were also new to teaching. Similarly, another participant expressed their motivation for joining the FOLC as, "*Just being a part of a community where I can talk and interact with people who are going through the same things I am, you know...being able to talk things over with other people who are going through the same types of things was I think one of the things that I was really looking for.*" This FOLC member saw the FOLC as a way to gain a peer group, people going through the "same types of things."

Connect with Faculty Outside Their Department for Broader Perspective

Close to 15% of the participants who wanted to join the FOLC to develop their professional com-

munity specified that they wanted to meet faculty members outside their local department and institution. One participant directly said, "*It's nice to have somebody outside of my department.*" This participant was motivated to join to connect with people, "*in addition to [their] department.*" Another participant expressed that they wanted to connect with faculty outside their university because, "*You don't really want to tell them [your local colleagues] I don't know how to teach, help me.*" They saw the FOLC as a way to develop a community they could be vulnerable with in facing their teaching challenges. An additional participant said they, "*wanted some contact with the outside to not just get a broader set of ideas but also to bounce some of our ideas off of other people.*" This FOLC member wanted to connect with people outside their department in order to gain a wider range of perspectives.

Connect with other Faculty who Care about Teaching

Similarly, 15% of the participants who wanted to join the FOLC to develop their professional community said that in particular they wanted to connect with other faculty who care about their teaching and have a desire to improve. For example, one participant said the FOLC, "*seemed to me like a good way of having people to turn to who are interested in and care enough [about teaching] that I trust their opinions.*" These FOLC members wanted to connect with other faculty who were equally passionate as them about teaching.

Connect with other Faculty Due to Lack of Sufficient Local Support

Nearly half of the participants who wanted to join the FOLC to expand their professional community expressed wanting a community that their local environment did not provide. For example one participant explained, "*I feel like our department specifically has gotten a little old fashioned, if you will, and so I was excited to kind of think about some new strategies that could be utilized in physics but really over in engineering as well.*" This FOLC member did not have other faculty in their department who were interested in talking about new teaching methods and they saw the FOLC as a way to fill that gap.

Our FOLCs have also had a number of members who come from very small departments, which is not uncommon for the primarily undergraduate institutions at which a number of them

work. One such participant said they joined the FOLC, "*just because I thought it would help me being able to talk to other physicists, because I am the only person here, about methods and ways to improve my teaching skills in physics specifically.*" Another member from a one-person department stated they joined, "*largely just because I didn't have anybody else to talk to about what I was doing...frankly the social aspect of it was a big draw to me.*" Some of our FOLC members did not have a local community of physics faculty (or that community was very small) and the FOLC supplied that community for them.

Other FOLC members were the newest members to their departments and felt they lacked a peer group in their local department. For example, a participant said they joined because, "*I'm the only one [in my department] on tenure-track right now, that's not tenured and not a lecturer or a researcher, so I don't have anyone in the department to talk to about being on tenure-track, basically, or being young faculty. So I thought that would be a good opportunity for me to talk to people in physics who are in the same boat.*" This participant wanted to talk to people at their same career level, and the FOLC provided this opportunity. This same sentiment is echoed by another FOLC member who explained, "*I felt like in my own department I was kind of lonely and didn't have peers, so it [the FOLC] seemed like a good way to have peers.*"

Either because their department was older, small, or traditional in their teaching, these FOLC members desired a community that was not possible at their local institution. Note, however, that these FOLC members often still felt supported by their local department in other ways. Indeed, some FOLC members said they loved their local colleagues, but they joined the FOLC to connect with a group of people unavailable locally.

This motivation (expanding their professional community) to join the NFW-FOLC is consistent with our Design Principle of **fostering a supportive community**. Nearly three-quarters of our participants were looking to connect with faculty with whom they could talk about teaching, and they saw the FOLC as a place where that community could form. We believed a key function of the FOLCs would be to build community and the majority of our participants were compelled to join for that reason.

The motivation to expand their professional community is also consistent with our Design Principle of **encouraging a sense of safety within the group and a willingness to be vulnerable**. In particular, some of the participants who joined the FOLC to establish connections with people outside of their local department for broader perspective explained that they could be more open about their teaching challenges with non-local colleagues. We expected that as new, untenured faculty, our FOLC participants would need a space where they could honestly share and receive feedback about their teaching and some of our members explicitly voiced this need in joining the FOLC. Also, it is not too much of a leap to assume that all the participants who were motivated to join the FOLC to develop professional connections wanted the community they hoped to form to be a safe and welcoming space.

Additionally, this motivation to join the NFW-FOLC is consistent with our Design Principle of **enacting a structure that encourages and values the expertise of all participants**. In joining the FOLC to develop a professional community with other faculty around teaching, our members wanted to be able to learn from peers. Our members wanted to be able to learn from other new faculty, from faculty outside their department, and from faculty who care about improving their teaching. This motivation shows that our members were not joining to only hear presentations from experienced practitioners nor to learn only from experts.

4.2.2 Discussion of motivations for joining

The motivations of faculty joining the NFW-FOLC provide important insights about the value and potential of the FOLC model generally and the NFW-FOLC Design Principles particularly. Specifically, the NFW-FOLC participants believe they need more support to implement changes than is provided by a single workshop and they value and see a need for this support to be in the form of a community. We discuss insights gained from our analysis of motivations of faculty to participate in a FOLC below:

1. The FOLC provides desired ongoing implementation help.

The FOLC faculty are not predominantly looking for an extended workshop experience of presen-

tation of information by experts. (Recall, no participant was solely coded at "Learn more about teaching strategies" for their motivation to join the FOLC.) Participants recognized that dissemination of teaching techniques is insufficient for them to make big teaching changes; they wanted implementation help from a learning community. It is important to note that faculty who attend the NFW are typically in their first few years of teaching but not their first year. Most of them have had the experience of attempting teaching and have learned more about what they need help with. These faculty have enough experience to realize they are unlikely to come away from the workshop able to implement what they have learned without difficulty. They desire the support the FOLC offers for the same reasons we offer the FOLC.

2. The FOLC provides a valued community of support.

A large portion of our members joined for the affordances of a community. Participants talked about the value of connecting with others who cared about teaching and they also identified several desired and valuable aspects of an online community in particular. They frequently talked about a need for a community that they could not find in their offline, local environment. As a virtual community, the NFW-FOLC is able to provide support in ways in-person learning communities cannot. Departments often hire only one new member at a time, leaving new faculty without colleagues near their career stage. Departments may also be small with only a single or few faculty in physics affording little opportunity for interactions with other physics faculty. Faculty may find themselves in departments with colleagues who are not interested in teaching reforms or they may feel uncomfortable being vulnerable about their teaching difficulties with people who will evaluate them for tenure. Our participants identified all of these challenges as reasons to join the FOLC, recognizing the ability of an online community to provide these connections.

Encouragingly, the reported motivations for joining the NFW-FOLCs align with the NFW-FOLC Design Principles. This is confirmation from our participants that elements in the FOLC design are addressing their needs and wants. Above, we have shown how our members' motivations are consistent with five out of six of our Design Principles. The remaining Design Principle,

encouraging completion of a Scholarship of Teaching and Learning (SoTL) project, is consistent with participants' overarching motivation to grow as teachers. All of our FOLC participants were motivated by a desire to improve and develop as teachers and the goal of SoTL projects is to aid in this development.

To summarize, analysis of the motivations of faculty to join the NFW-FOLC indicate there is consistency between their needs and desires for professional development around teaching and our motivations for offering the NFW-FOLC, which are encoded in its Design Principles. This alignment between design and faculty members' reported teaching needs provides support for the FOLC model in general. The participants of the NFW-FOLC, an application of the FOLC model, see value in an opportunity for sustained implementation support from a peer community. While this was enacted in particular ways in the NFW-FOLC, these are tenants of the FOLC model of professional development for educational change. The FOLC model serves identified needs of faculty.

4.3 Findings and Discussion, Part II: Impacts of participating in the NFW-FOLC

4.3.1 Results: Analysis of impacts of participating in the NFW-FOLC

In assessing the value and success of the FOLC model and instantiations of the model, it is essential to consider impacts of the FOLC experience. Here we report on participants' self-described impacts at the end of their time in the NFW-FOLC. In order to understand the impact of the FOLC experience on participants we read through the interviews and coded all instances where they were talking about an effect the FOLC had on them, either during the experience or something they will take with them after the experience ends. We define impact as anything that had an effect on our participants' teaching beliefs, practices, and/or attitudes. Seven major themes emerged out of the nearly 300 interview excerpts that had to do with impacts of the FOLC. Excerpts were co-coded into multiple categories when applicable. Table 4.4 presents these categories and the number of

participants who fell into each one. These categories are defined below and examples are given. As before, we note that participants were not asked about all of these impacts directly, therefore we expect a higher percentage would be likely to agree on the impact than those who spontaneously reported it. For example, our finding that $\frac{1}{3}$ of participants reported increased confidence does not mean the other $\frac{2}{3}$ did not increase their confidence, only that they did not happen to mention it on their own during the interview.

Table 4.4: Impacts of participation in the NFW-FOLC. People could fall into more than one category. Count represents the number of participants coded to a category. Percentages are out of 34 participants.

Code	**Count (Percent%)**
Implementation Change	28 (82%)
Increased Reflection	18 (53%)
Gained Confidence	10 (29%)
Gained Knowledge	34 (100%)
Students Benefited	7 (21%)
Saved Time	5 (15%)
Resource	31 (91%)

IMPLEMENTATION CHANGE

Over four-fifths of participants talked about an implementation change in their teaching influenced by their participation in the FOLC. This code includes members who because of the FOLC tried (or were planning to try) a Research-Based Instructional Strategy (RBIS); members who persisted in trying an RBIS after encountering challenges; and members who during the FOLC modified a strategy they had tested out prior to the NFW.

Regarding their approach to trying new teaching techniques, one of our participants shared, "*One thing from the FOLC also, what I did not get out of the workshop, is if you try something, try it for a semester, and then you see if it works or not. If you don't try it you can't make mistakes...If you try it, at least you tried it, and then you see very often it works or didn't work*

out." This participant states that one thing they learned from the FOLC (and not from the NFW) is that you should commit to trying a teaching technique for at least one semester in order to get adequate information to decide if you should continue with the change or not. This participant acknowledges that they may make mistakes in implementing a new teaching technique, but that should not stop them from trying, or from persisting with the change once they have made it. This was a lesson they learned from the FOLC. Similarly, another participant admitted, "*For me it's hard to implement some of the new engagement techniques, and I think I would've maybe even given up without being able to get some feedback and learn how to implement things better and kind of just keep up with it.*" For this member, getting feedback from the FOLC helped them persist in trying new teaching techniques.

Some of our participants shared the specific teaching strategies they implemented because of the FOLC. For example one member shared that the FOLC,"*encouraged me to actually jump into the more engaged teaching techniques, you know, trying them out in class. I made a lot of use of whiteboards after getting some help and got some good tips on that from some of my online [FOLC] colleagues...We had a group that could all kind of talk and say if something was going well or not, you know, 'I was trying the whiteboards and couldn't cut them right, how did you manage to do that?'*" This FOLC member attributes their frequent use of the whiteboard technique [105, 106] in their classes to the encouragement and implementation assistance from their cohort.

The scholarship of teaching and learning (SoTL) projects FOLC members were asked to complete were another source of motivation for our participants to try a new teaching technique. As one of our members explained, "*What I did [for my project] was I tried out oral exams in my junior/senior level quantum mechanics class which I definitely think that I wouldn't have done if I wasn't in the FOLC. I had this idea and I thought it sounded really cool. [The facilitator] talked a lot about his oral exams and things like that, so I thought 'oh, I want to try it,' ... but I probably would've just given up and said 'oh well I wanted to do this thing but it's too scary so I'm not going to do it.' But because I had the FOLC and I had said this is what I want to do, and I had other people who said 'oh that sounds really, really cool, we really want to hear how it's going to turn out,*

and here's some ideas for implementing it,' that made it happen." The cohort's encouragement and helpful ideas motivated this participant to implement a new assessment strategy that they thought was "really cool" but also intimidating to put into practice. The FOLC helped this participant push past their trepidation and implement the new technique.

We also heard some of our participants describe plans to try materials and methods they learned about in the FOLC. One member shared, "*Next semester I already have things that other people [in the FOLC] have done and used that I plan on implementing. For example I know [the Facilitator] does like a one minute 'what did you learn, what's still confusing,' and I'm going to start doing that next semester.*" Here we see one member describing teaching strategies, learned from their fellow cohort members, that they plan on implementing during their next term of teaching. This excerpt shows that the FOLC has the strong potential to affect the teaching of its members even after they have completed the yearlong program.

A number of the FOLC members had tested out an RBIS in some form before attending the NFW. The success of those initial attempts varied and some of our participants talked about how the FOLC helped them modify (and improve) their implementation of that previously tested strategy. For example, one participant shared, "*Before [the FOLC] I just gave the clicker questions and then moved on, but based on feedback from the FOLC I now use the clickers mainly for peer instruction where they have to try something on their own to begin with and then spend one or two minutes talking with their peers and trying to come up with solutions. So based on that, I've noticed that the students are less likely to fall asleep and seem to be more invested in the learning process.*" This participant learned from their cohort how to implement clicker questions more effectively and they have seen signs from their students that these changes are working. The FOLC has helped its members implement RBISs with more success.

INCREASED REFLECTION

Over half of our members reported the FOLC caused them to reflect on their teaching practices, what goes on in their classroom, and how to assess changes they have made. One of our members shared that the "best and worst" activity where cohort members share a highlight and low-light

from their teaching in the past week, "*helped me kind of take a moment and reflect on 'oh yeah, I did do that pretty well,' or 'yeah, that really sucked, let's talk again.'*" The FOLC meetings helped this participant pause and process how their teaching was going. In this reflection time, the participant could both celebrate their successes and identify areas that needed improvement.

Another participant shared that their involvement in the FOLC has caused, "*a reflection of what can I do better in, what things am I doing well, and seeing how other people have answered those questions and what are the questions that I should be asking myself.*" As described in the excerpt in the above paragraph, this participant too reports that the FOLC helped them consider their teaching strengths and weaknesses. Further, they have learned other questions they can be reflecting on. Being part of a cohort has also helped this participant develop their reflection skills because they have seen how their cohort members tackle the above mentioned questions. This is exactly the kind of thinking we want to encourage our members to engage in.

Lastly, a number of our participants talked about how the SoTL projects affected their thinking about teaching. As one cohort member explained, "*I think everyone did try new things and were introduced to the idea of thinking about how to evaluate effectiveness. I think that on those fronts it was effective in getting us to try at least one thing that was new, and to think deeply about how to evaluate success, what does success mean. So that was good. I think that's a good skill for all of us to be able to use going forward.*" Through the SoTL projects, participants learned how to evaluate things they try in their classroom and to consider the profoundly important question, "what does success mean?" in the context of their classroom and the method they tried. As this participant notes, this reflection skill is one they can use in the future.

INCREASED CONFIDENCE

Nearly $\frac{1}{3}$ of participants said the FOLC increased their confidence in some aspect of teaching (e.g. gauging student learning; trying a new teaching strategy). One participant said that the FOLC has, "*made me more confident about pushing through some of the changes I was trying to make...I tried to incorporate the small whiteboards as discussion starters. I think hearing about the whiteboards that a couple of other people were having trouble trying to figure...made me feel a little*

bit better about the fact that it wasn't going quite as planned." The FOLC gave this participant the confidence to follow through with a new technique even though it was not going perfectly. This same participant went on to describe, "*we're about to start a new quarter at the end of the month, so now I'm building a syllabus for two different classes, and I guess I feel more confident putting things into that that I might not have otherwise because I know I can go back to folks and say 'okay, I'm trying to do this, tried it in the first lecture and it didn't work, what do you suggest?'...[The FOLC] gives me support that I might not have otherwise to sort of stay with it and figure it out.*" With the FOLC community behind them, this member felt confident trying new techniques in their classes. The member also says the FOLC helps them have the confidence to persist in the changes they make.

KNOWLEDGE

All of our FOLC members discussed learning something from the FOLC experience. Three themes appeared in the types of knowledge they described learning: teaching knowledge, professional knowledge, and awareness they were not alone in the challenges they faced as new faculty members. Table 4.5 shows the number of participants who fell into each category. Participants often fell into multiple categories.

Table 4.5: The sub-codes of the "Gained Knowledge" impact. People could fall into more than one category. Count represents the number of participants coded to a category. Percentages are out of 34 participants.

Sub-code	**Count (Percent%)**
Teaching Knowledge	32 (94%)
Professional Knowledge	11 (32%)
Knowledge They Are Not Alone	19 (56%)

Teaching Knowledge

Almost everyone reported gaining knowledge about teaching. This knowledge came in the form of implementation help, sharing of resources, reinforcing material introduced at the NFW, learning

how to evaluate their teaching, and/or learning about more teaching techniques. For example, one participant stated, "*I think the one [meeting] topic I found really informative for me was the writing exam questions thing that we did...I felt like there was a lot of discussion about cooperative group problem solving and context rich problems and conceptual questions and that sort of day to day stuff, but when it came down to it I feel like a lot of us still had no idea how to write a good exam problem or how to write exams. That really helped me reevaluate things a lot. I think it was helpful because I hadn't really discussed it.*" The FOLC helped this member learn how to better evaluate their students through well-constructed exams. This was a self-reported gap in the member's knowledge that the FOLC helped fill.

Other members talked about how they were able to learn more about a technique they were trying to implement. One member shared,"*I mean having people come in and talk about implementation after we'd had a chance to screw it up was also helpful, because then it's a lot easier to know what questions you should be asking, what problems you're going to have once you've already had the problems. I had some people coming in and talking about whiteboards halfway through this last semester, and I already knew that some things weren't working exactly how I wanted them to, and then I got some ideas as to where to go.*" This member had been introduced to the whiteboards technique at the NFW and was trying it out during their time in the FOLC. They were able to ask specific implementation questions to guest speakers that came to one cohort meeting. In this way, the FOLC extended the knowledge they learned at the NFW. If one thinks of the NFW as an introductory survey course, then the FOLC meetings, especially when there are guest speakers, can be thought of as more advanced seminars on specific topics.

Also included in the teaching knowledge category are instances of the FOLC helping participants retain the knowledge learned at the NFW. As one participant described, "*One of the things that I thought was helpful [about the FOLC] was that all these different teaching methods that I learned about at the New Faculty, Physics Faculty Workshop, it helps just hearing other people talk about them, it helped me remember them, such as Just-in-Time Teaching and collaborative learning and all these little ways of teaching. It just kind of helped enforce and strengthen what I got from*

the New Physics Faculty Workshop." The FOLC helped some participants deepen their awareness and knowledge about teaching techniques through repeated exposure to the ideas.

Professional Knowledge

Around one-third of interviewed participants reported learning professional knowledge: what other institutions are like and how they function. Lessons in "how to be a faculty member" also fall into this category of knowledge. Essentially, professional knowledge gave participants context such that they could compare their teaching situations to others'. One member said about their FOLC experience, "*I'm finding that it's really useful to see the spectrum of how things get done, like even when there's a challenge then other people are like 'oh yeah, our department's crappy about that too.' It's still kind of nice to see okay here's how it looks in several other different departments so if my department does it this way then we're not crazy, or hey, somebody's got a really good idea for that. You know, you do your undergrad at one place and you do your PhD at another place and maybe you do your post-doc at a third place, but that's not really a big sample size...So seeing a range of what is normal in other departments helps me orient, especially when I feel like I'm in new territory...Being able to get a sense of how it works in other places feels like a way for me to learn a bit more about the job without having to take as many risks in my department.*" This participant is describing a unique affordance of the FOLC because it connects people from different institutions, allowing participants to gain perspectives from outside their local context. This is perhaps especially important for new faculty who, as this FOLC member notes, have limited experience with different institution types. The FOLC helped members learn about how different physics departments function and that knowledge could help some of them navigate decisions in their home department.

Some members also cited this contextual knowledge as useful for potential future career decisions. As one participant put it, "*I think I'm going to be a little more cognizant of the type of institutions that are out there when I deal with people, and if I apply to another job at some point I think that's going to be helpful there.*" This participant observed the varying teaching loads and resources their fellow cohort members had at their respective institutions. They predicted that this

information would be useful if they consider moving jobs at some point.

Awareness They Are Not Alone

Over half of the interviewed participants reported learning that they were "not alone" in their teaching challenges. These participants talked about learning through the FOLC that everyone experiences similar issues and has common struggles, no matter who your students are. One member said, "*I mean the thing that really strikes me is that everybody seems to be having the same problem and the same concerns that I have.*" This sentiment was echoed by another participant who said of their FOLC experience, "*I learned a lot. A big part of it was just learning that the problems I deal with are the same problems everybody else has. It was comforting to know that everyone's struggling with the same kinds of problems.*" These FOLC participants saw that other young faculty don't know all the answers either. There was comfort in the shared challenges and concerns. We expect this knowledge to help our participants persist in the teaching changes they try, even if they encounter difficulties, because they now know that struggles are common (and can be overcome).

This is an important finding. Unlike the other impacts which we specifically designed the FOLC to achieve, we did not start the FOLC expecting "learning you are not alone" to be an outcome. And yet, half of our participants reported this outcome. The frequency with which participants reported this to be a significant impact points to both a barrier to reform (faculty blame themselves instead of understanding the difficulty of the task at hand) and the importance of community for sustained and productive faculty development. It is only through participation in a community in which vulnerability is safe that this lesson could be learned. It is a valuable contribution to faculty development that is uniquely afforded by the FOLC model.

BENEFITING STUDENTS

One-fifth of our interviewed members specifically mentioned how their participation in the FOLC benefited their students. They reported students saying an activity/teaching strategy they tried helped them. For example one faculty member said that their SoTL project on peer evaluation of labs, which they completed in collaboration with fellow cohort members, benefited their students.

They described that their students, "*were able to write up their lab reports and then send them off cross country electronically to be reviewed by their peers [another cohort member's students] and get some feedback. The goal was that this would improve their writing…I thought it was a good activity and that students appreciated getting feedback from someone besides me, and I think they maybe took it to heart a little bit more, because they kept hearing the same comments from me over and over and after hearing them from someone else it's like 'oh maybe this really is important'.*" This member's SoTL project allowed their students to write for a new audience and get outside feedback on their work. The participant reported that they thought their students valued this opportunity. In this way, their participation in the FOLC had a direct benefit for their students. Recall, the overarching goal of the NFW-FOLC project is to improve students' educational experiences in physics and astronomy. (Note, too, we are reporting here on the fraction of participants who *spontaneously* reported this impact, but we expect if we had explicitly asked our participants about the impact of the FOLC on their students, we would get a higher percentage saying their students benefited. Our study was focused on the impact of the FOLC on participating faculty, rather than the outcomes for their students. Future studies with a focus on student outcomes can directly probe this.)

SAVING TIME

Fifteen percent of the FOLC members described the FOLC as helping them save time and be more efficient in improving their teaching. For example, one member described a meeting where, "*we had, again, a few, three or four, guest speakers, and they talked about their experiences, and they talked about what they're using in their classrooms…that was a little bit like a crash course on how to do many things. It was like skimming a book on teaching.*" A panel of guest speakers helped this member learn a lot of useful teaching tips during the time span of one, ninety-minute meeting. For another FOLC member the community gave them, "*some new things to try that I wouldn't have thought of by myself, knowing some pitfalls in advance, knowing some other things in advance, that otherwise would take me a year or two to figure out.*" The FOLC not only provided this participant with teaching ideas to try, but also alerted them to implementation challenges they may face. The

FOLC made them aware of these "pitfalls" before they even tried the technique and that saved them the time of having to figure it out themselves.

This is a very important finding and one that while we hoped for, was an open question for us at the beginning of the project. Participating in the FOLC takes time for very busy new faculty. It was a concern for us, and has been brought up by others as a potential negative aspect of the FOLC model, that participation requires time from already overwhelmed faculty. Not only did we *not* see faculty complain about the time spent (nearly all reported the time to be valuable) but we see reports of faculty claiming participation was actually a time saver. This is a very encouraging result for the FOLC model of professional development.

GAINING RESOURCES

Over 90% of FOLC participants talked about gaining some (non-material) resource because they were part of the FOLC. There were a range of responses that fell into this code; often these resources were forms of interpersonal relationships and support. Below we elaborate on some of the most common types of resources mentioned: community of support, accountability, and access to experts.

Many of these resource impacts had to do with interacting with people in the FOLC and having a **community of support**. In describing how they used the asynchronous platform one participant shared, "*I think I posted when things were not going great for me, like within my department, and I kind of needed to vent a little bit, and just to get the emotional support.*" For this participant, their FOLC cohort provided needed moral support. Similarly, another participant said they would recommend the FOLC to other NFW participants because, "*The [NF] workshop itself was great but because it was like a firehose it's very easy to go back to your institution and just not work on stuff. Having a little bit of continued accountability and community to talk about these things was really helpful. It helps you implement some of this...And also just having other people at the same career stage who you could freak out with...it's very important to freak out with fellow people.*" This FOLC member valued their cohort because they were a group to "freak out" with about the challenges of being a new faculty member, and in addition to that moral support they could get concrete implementation advice. In this excerpt we also see another theme

from the resource impacts: that of **accountability**. The FOLC helped this member (and others) actually follow-through on changes the NFW motivated them to want to try. The NFW can be overwhelming in the amount of information presented over just a couple of days, and the FOLC helped this participant act on the information rather than become paralyzed in all the options.

In stating what was the most helpful part of the FOLC one member answered, "*I think talking to my peers is probably the most useful. But as I said before, I think sometimes learning, even if it's just small advice from people with more experience [guest speakers], that's useful too.*" This is another example of the community being a resource for our participants. In particular, a community of peers was helpful for this participant. The value of a peer group was expressed by a number of FOLC members when describing their appreciation for their FOLC cohort. In this excerpt we also see the FOLC member talking about how they found the more experienced guest speakers useful too. This was another resource expressed by multiple FOLC members: having **access to more experienced practitioners and teaching experts**. A different FOLC member said that one of the reasons the FOLC was worthwhile to them was because, "*I can learn from the experts that I don't think I can have any opportunity by myself to get in touch with them. I think this kind of connection is definitely valuable.*" The FOLC helped participants connect with experienced practitioners of the teaching techniques they were trying out. This is a resource of being a FOLC member because part of the design of the NFW-FOLC includes bringing in guest speakers.

While it is perhaps unsurprising that FOLC members gained these resources as we designed the FOLC to provide them, the fact that most of our members cited benefiting from some FOLC resource supports our NFW-FOLC design. For example, participants talking about how they valued the peer group of their cohort supports our Design Principle 6: Foster a supportive community, and shows success in implementing this part of our design.

4.3.2 Community formation in the NFW-FOLC

Above, we have shown that one of the common motivations for joining the NFW-FOLC was to expand one's professional community, and we have also presented evidence that this community does actually form in the NFW-FOLC. One of the resources people gain from the FOLC is a community of support, as well as the knowledge that they are not alone in their teaching challenges. Given the importance of community formation as both a mechanism and outcome in the FOLC, in this section we will explore this dimension in more detail. We will present additional data that supports the claim that a community is formed in our NFW-FOLC cohorts.[3]

In the interviews with FOLC participants about their experience, we asked them about their impressions of community formation in their FOLC cohort. We have analyzed the interviews from the first three cohorts (n=24) for their responses about community. In the interviews participants were directly asked, "Does the FOLC feel like a community to you?" They were then prompted to explain their reasoning if it was not spontaneously offered. In asking this question, we did not define community for them. Almost all interviewed participants (22/24, 90%) said that their cohort did feel like a community. The two other interviewed participants described the community as "weak" or not "quite like" one yet. We note, however, both of these participants were from Cohort 1 which was interviewed after only a couple of months instead of at the end of a year.

When asked why it felt like a community, each participant (n=22) provided multiple reasons. The most prevalent reasons are listed in Table 4.6. One-quarter of the participants who felt a community formed specifically mentioned that meeting first in-person at the NFW helped them start building those connections (which then grew during the FOLC experience).

Forty percent of the participants said that one of the reasons their cohort felt like a community was because all the members were in similar career positions and had shared interests. One person described it as, *"feeling like you had a bunch of people in the same boat."* Moreover, the cohorts were comprised *"of people that are very interested in the teaching, as well as the other aspects of being a tenure-track."* This is perhaps unsurprising as FOLC members are drawn from NFW

[3] A portion of this section appears in print in the 2017 PERC Proceedings: Lau, Dancy, et al. 2017 [21]

Table 4.6: Reasons given for why the FOLC felt like a community. (Percentages are out of those who said the FOLC did feel like a community, n=22. Percentages are rounded to the nearest 5%).

Reason	**Count (Percent%)**
Met in-person at New Faculty Workshop	6 (25%)
Were in similar situations/shared interests	9 (40%)
Got to know each other	10 (45%)
Could be vulnerable & honest	10 (45%)
Felt responsibility to help each other	5 (20%)
Could ask questions, receive help, and/or share ideas	15 (70%)

participants who are mainly young faculty and obviously interested in teaching.

Almost half (45%) of participants said the FOLC felt like a community because they got to know the other members' personalities and professional situations. One participant described, *"We had a number of community sorts of things...as time went on we learned what people's expertise is...I guess it's sort of for me a sense that I know where people are coming from, I know their background...I think it sort of got to feel familiar after about, I don't know, three or four meetings online."* In describing her sense of community another participant said, *"At first I was just trying to remember who was who and where they were from, but for those of us who were able to attend regularly, by the end of the year I felt like I knew a little snippet of their lives and what they were doing and had some kind of a connection to them."* From these two excerpts, one can also see that community took time to form.

Many participants (45%) said that their cohort felt like a community because they were comfortable sharing aspects of their teaching lives with the group. A participant stated, *"I feel safe posting a question or an idea or a confusion online, or even speak up when we are meeting online."* These participants described being able to be vulnerable and honest with the FOLC about their

teaching challenges. (Recall, this reflects one of the design principles of the NFW-FOLC).

Some participants (20%) said they felt their FOLC cohort was a community because they cared about each other and felt obligated to answer each other's questions. One of the participants said, *"I got invested in other people's success, and I really wanted to know how things they tried turned out, and I wanted to hear about how their students did or what kind of feedback they got on something. That made it feel very much like a community."* Another participant talked about, *"if there's questions up there [on the asynchronous platform] that nobody's answering and you know that somebody wants some help, how can I answer this question to help this person along. I think that kind of responsibility is kind of...You know that they're out there, they're working hard, and they're trying to improve and we're all trying to do that, and if there's something that I'm doing well how can I help other people, and hope that something I don't do well and they do well they can help me."* In both excerpts participants are describing a desire to contribute to their cohort and help everyone succeed.

The most common reason for describing the FOLC as a community is that it was a group where members could ask questions, receive feedback, and share ideas regarding their teaching. (Again, this is consistent with a design principle of the FOLC). This reason was given by 70% of the participants who said their FOLC felt like a community. As told by one of these participants, *"I feel like I'm able to go to the group when I have a question or when I have a need and I might be able to get something back, but I also feel like there's an opportunity to give back to them as well. So the fact that it's kind of a two-way relationship and a conversation, that makes it very different than if it was just I'm going to email an expert in the field and hope they bother to answer me."* Participants shared and received knowledge and advice with their cohort.

We have also surveyed FOLC cohorts about their sense of community at the completion of their one-year FOLC experience. For cohorts 5-9, we have asked them on a four-point scale from "Not at all" to "A lot", "How much do you value the following aspects of the FOLC?: The community of peers interested in teaching." Of the 35 responses we have to this question, the overwhelming majority (n=31) replied "A lot," indicating that they feel a sense of community

among their cohort and that this is important to them.

Since running our third cohort, we have included the set of twenty-four questions from the Sense of Community Index 2 [107] on participants' post-experience survey. For each of the twenty-four statements, participants are asked to rate how well the statement represents how they feel about their FOLC cohort. The four-point rating scale options are "not at all," "somewhat," "mostly," and "completely." Not all of the statements are relevant to our FOLC environment, but following recommendations from the developers of the survey items we did not omit any of the statements from our post-survey. However, I will only report on relevant items here. We received 51 responses to the set of questions from the Sense of Community Index 2. In Table 4.7 I report the most common responses to nine of the particularly relevant survey items which speak to participants' feeling about their FOLC cohort.

Table 4.7: Responses to 9 items from the Sense of Community Index 2. For each item, participants marked how well the statement represents how they feel about their FOLC cohort. Rating options were Not at All, Somewhat, Mostly, or Completely. The most frequent response to each item is reported as well as the percent of respondents who chose Mostly or Completely. N=51.

Sense of Community Item	**% of respondents choosing Mostly or Completely**	**Most frequent response**
I can trust people in this community.	100%	Completely
I can recognize most of the members of this community.	88%	Completely
Most community members know me.	78%	Mostly
Members of this community care about each other.	88%	Mostly
When I have a problem, I can talk about it with members of this community.	98%	Completely
I get important needs of mine met because I am part of this community.	69%	Mostly
This community has been successful in getting the needs of its members met.	76%	Mostly
Community members and I value the same things.	92%	Mostly
People in this community have similar needs, priorities, and goals.	90%	Mostly

Most notable, everyone who responded to the survey felt that it was either mostly or completely true that they could trust the people in their FOLC cohort. Trust is needed among participants to feel a strong sense of community so this result reflects positively on the culture of our cohorts. We also note that the majority of respondents report a high level of recognition between cohort members; this indicates that people do get to know each other in the course of their FOLC experience. Not only are they familiar with the people in their cohort, but most also have a strong sense of these members caring about one another. This is evidence that a *supportive* community is forming among participants. Indeed, 98% of respondents reported that it was mostly or completely true that they can talk to their cohort about problems they are facing, and the majority report that it is mostly or completely true that the community meets their needs and those of their fellow members. Participants identify the FOLC as a group of people they feel safe sharing problems with and they can get useful help on these problems. Perhaps one of the reasons for this is that they feel their fellow members are similar to them in terms of needs, goals, and values. (This factor arose in our interviews as well). The fact that around 90% of survey respondents felt it mostly or completely true that their cohort members shared priorities and values signifies a sense of connectedness and recognition in the FOLC groups.

A sense of community among cohort members is an essential design element to the FOLC and the evidence presented here suggests that participants do feel a community forms in their cohort. We see that trust, commonalities in interests and goals, and the capability of the group to help them problem solve all aid this sense of community. Participants also share our belief in the importance of community in a FOLC, as they overwhelmingly report valuing this aspect of their experience.

4.3.3 Discussion of impacts of participating in the NFW-FOLC

4.3.3.1 Outcomes consistent with learning objectives

Above we have presented the major themes that emerged from participants' statements about the impact of being a member of the NFW-FOLC as well as their sense of community in the FOLC. We now consider how these impacts provide evidence that we are meeting our stated learning objectives for participants and the ways these impacts are uniquely supported by the FOLC model of professional development. Table 4.8 shows the connections between our learning objectives and the reported impacts of the NFW-FOLC.

Below we discuss each of our six learning objectives in the context of reported impacts and unique affordances of a virtual community.

1. Develop reflective teaching habits and a dedication to continuous teaching improvement. We assert we are meeting this objective. We also assert that the FOLC model helps achieves this goal more robustly than traditional change efforts.

Many participants talked about the FOLC increasing their reflection on their teaching. They reported the SoTL projects helped them think about their teaching goals and how they can assess their teaching. In addition to their direct self-reports of becoming more reflective about teaching, we observe them reflecting throughout their experience during their virtual meetings and on the asynchronous communication board. It would be expected that engaging in regular reflection would increase reflectiveness in general, as supported by their self-reports. The FOLC also increased participants' confidence in their teaching skills and showed them that they are not alone in the teaching challenges they face; we expect this confidence and knowledge improves their dedication to continuous teaching improvement because they feel more comfortable trying new techniques and persisting with them even when difficulties arise. Indeed, learning that one's teaching struggles are common, and seeing how other people overcome these issues, promotes a growth mindset around teaching.

The evidence we see that participants are increasing their reflectiveness around teaching

Table 4.8: Connections between NFW-FOLC Learning Objectives and participants' reported impacts of participating in the FOLC

Learning Objective	**Reported FOLC Impacts associated with Learning Objective**
Develop reflective teaching habits and a dedication to continuous improvement of teaching	Increasing Reflection
	Gaining Confidence
	Gaining Awareness that you are not alone
Increase knowledge and awareness of RBISs	Gaining Teaching Knowledge
	Gaining Resource of the FOLC: Access to teaching experts
Maintain or increase motivation to implement RBISs	Gaining Confidence
	Implementation Change
	Gaining Resource of the FOLC: Accountability
Implement RBISs consistent with recommendations from research	Gaining Teaching Knowledge
	Implementation Change
	Increasing Reflection
	Gaining Resource of the FOLC: Access to teaching experts
Persist in implementation of RBISs	Implementation Change
	Gaining Confidence
	Gaining Awareness that you are not alone
	Gaining Resource of the FOLC: Accountability
Increase sense of empowerment regarding themselves as teachers (includes confidence using RBISs)	Gaining Confidence
	Gaining Awareness that you are not alone
	Increasing Reflection

comes from reports of activities that are specific to the community of the FOLC. It is through their interactions with others as they learn and share, and as they share their SoTL projects, that they are reporting increased levels of reflection and are indicating a dedication to continuous teaching improvement. This appears to be an affordance specific to the FOLC model.

2. Increase knowledge and awareness of RBISs. We assert that we are meeting this objective and the FOLC model achieves this goal more robustly than traditional

change efforts.

Almost all of the interviewed participants talked about gaining teaching knowledge as an outcome of their FOLC experience. Participants talked about gaining this knowledge both from other members of the cohort as well as from the expert guest speakers. While traditional dissemination methods are also good at increasing knowledge and awareness, the FOLC model offers several clear advantages. First, it allows for an extended learning experience where more knowledge can be gained due to the extra exposure. More importantly, the structure of the FOLC allows the participants to have a say in what knowledge they learn. (In our instantiation of the FOLC model, participants request topics for guest speakers who are selected based on expressed interest). This means the knowledge gained in the FOLC is more likely to be directly applicable to the participants' needs. Indeed, participants have the chance to gain more knowledge about a teaching technique as they are implementing it for the first time. Finally, they have the opportunity to also learn from each other which affords the acquisition of practical, on-the-ground knowledge that is harder to acquire in traditional D&D model efforts.

3. Maintain or increase motivation to implement RBISs. We assert that we are meeting this objective and the FOLC model achieves this goal more robustly than traditional change efforts.

Most participants reported actually implementing (or refining) an RBIS as a result of their FOLC experience. The FOLC is motivating implementation of RBISs. Participants' reports show us not only that they were motivated by the FOLC but also the mechanisms of this motivation. For example, a sizable portion of participants reported the FOLC gave them confidence to try a new teaching technique. Other members reported being motivated to try a teaching technique after seeing a fellow cohort member try the technique. Some FOLC participants talked about how the accountability they felt to their cohort motivated them to try an RBIS. Importantly, none of the interviewed FOLC members reported that the FOLC decreased their motivation to try an RBIS.

It is of note that the ways in which participants reported being motivated are focused on unique affordances of the virtual community. It was through their interactions with others and

the sense of community they shared that the motivation frequently came. While learning about a teaching innovation can motivate faculty to try it, we see from our FOLC participants that having a community to support, inspire, and hold one accountable increases this motivation.

4. Implement RBISs consistent with recommendations from research. We assert that we are likely meeting this objective and that the FOLC model achieves this goal more robustly than traditional change efforts.

We have not observed the classrooms of these faculty. However, we have indications that our participants are reaching this objective. For example, most of our participants gained teaching knowledge from the FOLC, often in the form of implementation help. Participants spoke of receiving implementation help from both the expert guest speakers and other cohort members. Participants valued the opportunity to ask questions based on the teaching difficulties they were encountering and to get specific help and advice. They spoke of the way this impacted their teaching. It is reasonable to assume that the implementation troubleshooting that occurs in the FOLC guides members towards productive instantiations of an RBIS. We also had a few of our members describe how the FOLC helped them improve the implementation of an RBIS they had tried prior to attending the NFW. Finally, at least half of our participants increased their reflection on their teaching, and part of this reflecting was considering areas of their teaching which needed improvement. It can be reasonably expected that if implementation of an RBIS was going poorly our participants would identify that in their self-reflection and bring it up with the cohort, leading to better implementation. What we clearly see from the FOLC impacts discussed in our interviews is that participants are trying RBISs in their classroom and are talking about their efforts with their cohort, eliciting advice and resources for their implementation along the way. The cohort has access to experienced practitioners and facilitators who can guide participants towards implementation consistent with recommendations from the research.

Again, the FOLC model affords unique opportunities to meet the objective of implementing methods consistent with recommendations from research. Participants speak of the ways in which their implementation was impacted by opportunities to troubleshoot with both the group and with

experts. They reported making changes in their implementation (not just in trying new things) as a result of the FOLC experience and specifically the interactions they had with the community, which are absent from traditional dissemination efforts.

5. Persist in implementation of RBISs. We assert we are meeting this objective in the short-term and likely meeting it in the long-term. We also assert that the FOLC model achieves this goal more robustly than traditional change efforts.

A few FOLC members specifically talked about how the advice and knowledge they gained from the FOLC helped them persist with a teaching change, even when challenges were encountered. Others reported the FOLC gave them confidence to stick with a new teaching technique they might otherwise have abandoned. Participants reported learning through the FOLC that the teaching challenges they face are common. The knowledge that they were not alone in their struggles in the classroom was comforting for members, and likely helped them keep going with their teaching changes. Some members also reported that they felt their cohort kept them accountable to follow-through with the teaching changes they wanted to make. The community of the cohort is helping members persist with their teaching changes through the FOLC experience. We are in the process of collecting and analyzing longitudinal data to determine if the changes inspired by the FOLC persist over the years (initial data suggests yes, and we present a preliminary analysis in Chapter 5).

Again, the increase in persistence can be directly traced to affordances of the FOLC that are not present in traditional dissemination efforts. When participants spoke of persisting through difficulties they may otherwise have not, they talked about the impacts of the community. It was their engagement with others that helped them meet challenges and supported them emotionally as they navigated difficulties.

6. Increase sense of empowerment as teachers. We assert we are meeting this objective. We also assert that the FOLC model achieves this goal more robustly than traditional change efforts.

Many participants described the FOLC increasing their confidence as teachers. It also showed

them that they were not the only one struggling with a certain teaching technique or teaching difficulty. This knowledge can be empowering because it can stop faculty from thinking their teaching challenges are due to an individual flaw which can never be overcome. Additionally, because the FOLC encouraged members to reflect on what was going well in their classroom and what needed to be improved, it helped them slow down and acknowledge their successes. These can often be overlooked as people have a tendency to focus more on challenges than successes [108]. Acknowledging one's successes is empowering rather than demoralizing.

Again, the FOLC model offers unique affordances for meeting this objective. It was through the community and their interactions with other cohort members that participants report they gained confidence in their abilities. Helping them understand the inherently difficult nature of implementing RBISs and the ways in which all faculty struggle is essential, but this is challenging to do with other professional development models.

Above we have argued that the impacts reported by the NFW-FOLC participants are uniquely supported by the FOLC model for educational change. Specifically, we have stated that the community aspect of the model helps our participants achieve our learning objectives more strongly than a traditional D&D model would. Figure 4.1 shows the connection between the FLC model and the FOLC model. Both FLCs and FOLCs provide some form of community. The FOLC model, however, enhances the benefits of a typical FLC by providing more targeted learning opportunities and connecting people with similar needs regardless of geographic location. (Above, we demonstrated that FOLC members do feel a sense of community among their group, partially because of their shared interests and needs.) Because the population of our FOLC was solely new physics and astronomy faculty, most of the pedagogical knowledge and techniques discussed were developed for teaching physics and astronomy students. All the examples presented and implementation issues discussed were from physics and astronomy classrooms. Thus, the FOLC model is better able to address discipline-specific challenges and needs than the FLC model which mainly connects faculty from many different disciplines. The FOLC model further enhances the bene-

fits of the FLC model by connecting diverse people with similar interests. The members of our NFW-FOLC are diverse in that they come from different institutions, bringing varied perspectives on physics and astronomy teaching. However, the FOLC members are connected by their specific interests in improving physics and astronomy education. This combination of a discipline-specific, yet institutionally-diverse population allows for deeper learning than in an FLC. Additionally, as reported by our participants, a community populated from different institutions means participants feel more comfortable being vulnerable about their teaching challenges and they receive targeted teaching advice since they are not being evaluated by fellow community members. This is another important advantage offered by an online faculty community.

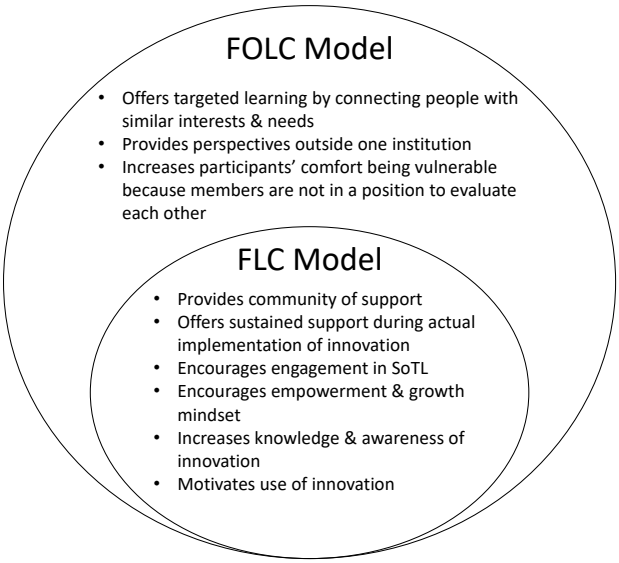

Figure 4.1: The benefits of two change models. The FOLC model incorporates the advantages of FLCs while adding further benefits.

4.3.3.2 Outcomes beyond learning objectives

Some of the reported impacts of participating in the NFW-FOLC suggest participants are learning things beyond our learning objectives:

1. FOLC participants gained professional knowledge. We did not explicitly plan that our participants would gain professional knowledge (i.e. knowledge about how things work

at other universities, not specific to teaching) from their FOLC cohort yet it turned out to be an important benefit from the participants' point of view. FOLCs connect people from across the country at many different institution types. In talking about their teaching, participants talk about the context in which they are teaching. Not only does this help members get to know each other, but it also gives cohort members a sense for how different departments and institutions function. This is an affordance of the FOLC model, specifically over the in-person FLC model.

2. FOLC participation saved members time. The other impact that we did not directly plan for, but were hopeful about, was that the experience saved members time. Faculty members have little free time and some people hesitate to join the FOLC because of the time commitment. We therefore find it very encouraging that some of our members said the FOLC actually saved time in their teaching development. The structure of the FOLC is not onerous for participants.

The NFW-FOLC Learning Objectives encompass pedagogical content, attitudinal shifts, and skills development for continual professional growth. From our interview data, we have presented evidence that our FOLC members are growing in all three dimensions. The success of our application of the FOLC model supports the efficacy of the model itself. We also see that the mechanisms by which we are achieving our objectives are directly tied to the community aspects of the FOLC experience and therefore are not easily replaced by traditional dissemination or professional development.

4.4 Conclusions and future work

In this chapter we showed through analysis of interview data that there is a perceived need for the FOLC model and that participants of the NFW-FOLC are meeting its learning objectives through mechanisms unique to a FOLC experience. These results indicate the efficacy and importance of the FOLC model.

The FOLC model is generalizable beyond the application presented here. The NFW-FOLC is designed for a specific audience (new physics and astronomy faculty). The model, however, can

be applied in a number of other ways: a FOLC could be specific to content (i.e. teaching upper level quantum mechanics or advanced lab), or audience (i.e. community college physics faculty), or pedagogy (i.e. flipped classroom), or topic (i.e. integrating metacognition activities). For example, a FOLC is offered for faculty implementing the Next Generation Physical Science and Everyday Thinking curriculum. This FOLC has seen similar positive impacts as we report for the NFW-FOLC [22, 109, 110, see too, Chapter 6]. This model has been used in other STEM disciplines as well [80].

In looking forward to the use of the FOLC model we note two additional advantages and highlight one challenge for future work. First, the FOLC model, once implemented, is relatively inexpensive. There are numerous technology platforms to support a virtual community which are free or inexpensive and the development of these platforms is rapidly progressing. Even during the short duration of this project we have seen vast improvements in the technology available to support meaningful virtual connections and community engagement. The greatest "cost" to implementing a FOLC is the time of the facilitators. The second advantage we want to highlight is the way the FOLC can support faculty in becoming change agents themselves. As faculty become more expert and confident in their own use of RBISs it is expected that they will be better positioned to impact others in their department (we investigate this more directly in longitudinal interviews, see Chapter 5). We hypothesize, and are exploring in our ongoing longitudinal interviews, that the entire department may benefit from the FOLC participation of one member. So while a FOLC may directly involve only a few faculty, indications are the model can have significant impacts across a broader community.

A significant challenge for future work is documenting how to best facilitate a FOLC for engaged and sustained participation and to encourage deep reflection about teaching among participants. In reviewing recordings of virtual meetings and analyzing asynchronous communications it is clear that deliberate attention is needed to ensure the most productive outcomes. We have conducted some analysis of virtual meetings [20] and asynchronous communications [111] to better understand facilitator moves and structural supports that encourage desired outcomes. Initial

analysis indicates that helpful facilitator moves include: facilitator withholding their own opinion to encourage others to share, giving agency by focusing the conversation on ideas of participants, and encouraging participants to elaborate on their ideas. However, more work is needed in this area. In Chapter 7, we present a tool designed to help identify productive facilitation moves.

Chapter 5

Pilot work on the longitudinal impact of FOLC participation

In the previous two chapters, I have introduced the design of the New Faculty Workshop (NFW) FOLC and presented evidence of the model's efficacy. The NFW-FOLC participants' motivations for joining the program align with our design principles for the FOLC and participants are meeting our learning objectives. In this chapter, I turn to the question of the longitudinal impact of FOLC participation. That is, I ask what impacts (new or continued) are participants experiencing two years after their FOLC participation. As described in Chapter 3, the main goals for our NFW-FOLC participants are for them to develop as reflective practitioners committed to continual teaching improvement and for them to successfully implement research-based instructional strategies (RBISs) over the long term. We also hypothesize that participants may become change agents at their local institutions. I will speak to all three of these potential impacts in this chapter.

Unlike the other chapters in this dissertation which present completed work, this chapter presents the first stage of analysis of the longitudinal interviews we have collected. We have conducted 23 follow-up interviews[1] with FOLC participants approximately two years after the completion of their FOLC. In this chapter I analyze one of these interviews. Methodologically, this work will help us create a preliminary coding scheme for use in our analysis of the full set of longitudinal interviews and it will highlight portions of those interviews to pay attention to based on the questions this one interview raises. Empirically, while I will not be able to make generalizable claims in this chapter, I will be able to sketch the experience of one FOLC member and draw some

[1] I have conducted 19 of these interviews and Dr. Dancy has conducted the other 4.

connections between their current teaching practices and their FOLC participation. This will serve as one example of a post-FOLC teaching trajectory and will become a detailed piece of the broader range of experiences we will eventually report on. The analysis further serves as a proof-of-concept that the long-term impacts we predict for FOLC participants are possible to achieve.

5.1 Methodology

I conducted longitudinal interviews with FOLC alumni approximately two years after their cohort ended. (Recall, NFW-FOLC cohorts meet for one year). Out of the 33 people I contacted, we were able to interview 23 of them.[2] These 23 interviews include participants from our first six FOLC cohorts. (Cohorts 5 and 6 ended in December 2017.) In the interviews we asked about participants' current teaching practices, how they assess their teaching, the nature of the support they have for their teaching, their connection to their FOLC cohort, and if they have impacted others' teaching practices. The complete protocol is included in Appendix C. The interviews were transcribed by a professional transcriptionist.

5.1.1 Selected case

I chose the interview analyzed in this chapter after reviewing my written reflections on the longitudinal interviews I conducted. These reflections indicate salient themes in an interview, responses that I found particularly interesting, and portions of an interview I know I will want to analyze carefully. (These choices of what is interesting are based on the theoretical framework presented in Chapter 2, the goals of the NFW-FOLC, and my knowledge of what other FOLC participants have talked about in their interviews). After reviewing my set of reflections, I settled on a participant who reported some continued use of RBISs and some change agent behavior, but seemed closer to an "average" rather than "exceptional" case. It also seemed possible from their interview to draw connections between their current practice and their FOLC participation. I

[2] Participants who have gone on to facilitate a NFW-FOLC are not included in this data set, although they are being interviewed.

had interviewed this participant, who I will call David (a pseudonym), shortly after their cohort concluded (Interview 1) and again a little over two years later (Interview 2). The data presented in this chapter come from Interview 1 and 2, and any claims I make are based on the evidence provided by these two interviews.

5.1.1.1 Biographical sketch

David is located at a research-intensive university where active-learning teaching methods are encouraged and supported. He teaches introductory physics for engineers and a graduate level course. His teaching load is one course per semester. Prior to his current position, he had no teaching experience. When he joined the FOLC he had one semester of teaching experience in his faculty position. In that pre-FOLC (and pre-New Faculty Workshop) semester he had tried using clicker questions, but his implementation was not inline with Peer Instruction techniques [2]. To get a sense of his prior knowledge of teaching techniques and what contributed to his current understanding, I asked during Interview 2 if the techniques he learned about at the NFW and in the FOLC were new to him at the time. David responded, "Well, I had not experienced them as a student, so it was new seeing them. We also have a local faculty workshop here for new faculty, and some of these practices were also discussed there." David has some forms of local teaching support. In describing his view or philosophy about teaching during Interview 2 David shared, "I think it's been consistent [over the past 2 years]. Maybe it's because I started off with this program [the NFW and FOLC] before I started my teaching, so it's mainly colored the way I view teaching." David was establishing his teaching style and teaching practice while in the FOLC because he had little prior teaching experience; his pre-FOLC teaching practice is solely based on his one semester of prior teaching.

5.1.2 Analysis process

In order to analyze David's longitudinal interview (Interview 2) I followed a three-step process:

(1) I read through David's post-experience interview (Interview 1), noting salient themes in his responses (parts of his FOLC experience he talked about a lot and things I would want to see what he had to say about two years later).

(2) I read his Interview 2, noting topics he mentioned repeatedly and any apparent differences in his responses from his earlier interview.[3]

(3) I went through Interview 2 two more times, on these passes marking similarities and differences from his earlier interview, as well as evidence of the three long-term impacts we hope to see: continued use of RBISs, reflection on teaching practice, and change agent behavior.

5.2 Results with discussion

David's current teaching practice and the long-term impact of his FOLC participation are determined by drawing comparison with his earlier interview and identifying his explicit statements of attribution. In turn, I present David's retrospective view of the FOLC, his current communication with his FOLC cohort, his current teaching practice, indications of his teaching reflection, and change agent behavior. Note, it is reasonable to imagine that people who are more positive about their FOLC experience would take the time two years later to talk about it again. I have this self-selection of interview participants in mind and in the discussion which accompanies the results, I am never making claims about the *whole* FOLC population; my analysis and claims are limited to one participant's experience.

5.2.1 Retrospective view of FOLC experience

During Interview 2, David reported that he still thinks his participation in the NFW-FOLC was worthwhile and he speaks positively of the experience. I asked David, "In general, looking back at the FOLC experience you had, what are your thoughts about it and how it went for you in retrospect?" David replied,

> "I think in retrospect being a new teacher at that point I think it was very helpful to not only just learn new practices from the workshop itself, but also the discussions we had with the FOLC cohort I think were pretty useful in learning everyone's struggles and successes and sharing our experiences with each other,

[3] Some of the questions asked in Interview 1 and 2 were identical, or very similar. Both interviews covered similar topics.

> knowing that the problems we're having here are the same problems everywhere. We were able to get information from each other about how to address some of these specific things...I did appreciate also the diversity of institutions involved. There were a lot of people in the cohort from small schools, from big schools, from research heavy schools, and so on. Just getting that general diverse group of people all having the same common problems, that was competent and helpful...I did appreciate the variety, at least for me."

David recalls that learning that some teaching challenges are universal was helpful to him as a new teacher. The implementation help he received was useful. David went on to explain that he appreciated the diversity of the group not only because he could see that some problems are universal, but "Also things which worked at one place also worked at many other places too." The sharing of common experiences and solutions was valuable.

This response is very similar to what he said in his Interview 1 when asked about how the FOLC went in general for him:

> "It went pretty well. It was great to have a community of teachers who are also starting in the teaching process and experienced teachers sharing common problems. It helped to know that the problems I was facing, being a first time teacher, were not just specific to my course but were general across the board. It was also great to share experiences and techniques, which worked and which didn't worked, and to kind of have a sounding board with colleagues across the country. So I think for me it helped me a lot, just knowing that the problems I was having were general problems, but also through the discussions we had, some of the solutions people suggested were pretty helpful in helping me develop my class."

When his cohort had just ended he also talked about the value of learning about common problems and discussing solutions with a group of faculty from a diverse set of institutions. David's response indicates that he felt a sense of belonging with his FOLC group because he recognized that he was experiencing similar things to other FOLC members and these challenges were normative in the community and resonated with his experience.

The similarity in his feelings about how the FOLC went is striking; what was salient about the experience soon after it was complete was still salient two years later. We see in both responses a few items of note. First, at both time points he reported the impact of gaining awareness that he is not alone in his teaching challenges. As we saw in Chapter 4, this was a relatively common impact

of FOLC participation. Likewise, in both responses he reports gaining teaching knowledge (e.g. feedback on how to address implementation issues). We also see in both responses a description of the benefits of FOLC membership including faculty from multiple institutions. As discussed in Chapter 4, one of the affordances of the FOLC is the ability to connect a discipline-specific, yet institutionally-diverse population. This particular aspect of the community was apparently very valuable for the participant given that it was one of the first things he mentioned in his Interview 2. David found the diverse FOLC membership useful because it demonstrated the universality of some teaching struggles (and solutions).

David's Interview 2 (and Interview 1) response about how the FOLC went highlights a number of elements of the NFW-FOLC design: providing ongoing opportunities for learning about RBISs; providing ongoing feedback and support to help through implementation difficulties; and fostering a supportive community. We intentionally designed the NFW-FOLC to offer these opportunities and David reports experiencing them. It potentially speaks to the strength of these opportunities for David that he remembered them two years post-FOLC.

5.2.2 Current connection with FOLC cohort

In his Interview 1, David reported feeling a sense of community with his FOLC cohort and he hoped to run into members at future physics conferences. I asked during Interview 2 if he has kept in touch with his cohort members. He responded that he has not, aside from a participant who happened to also be a member of his department. In explaining why he had not kept in touch with his fellow cohort members he said, "I think it's mostly I have some resources here [at local institution] which I've been tapping into. Maybe it's just also an issue of time. Research and teaching is many hours a day." He admits that time may be a factor, but also that his local community is supporting his teaching. Later in the interview, I asked David about his need for teaching support now versus when he was in the FOLC. He said, "I think initially starting to teach having that connection [with faculty from other institutions] was good. Fortunately here [at local institution] we have a lot of local resources in the department...But I feel if I was at a different

institution where this was not the case, I'd definitely want this all along." It seems that David appreciated his FOLC cohort and thinks positively of them, but since the FOLC ended he hasn't needed to reach out because he has a local teaching community. In his Interview 1 he also reported having local teaching support, but as he describes in Interview 2, the perspectives from people outside his institution was especially valuable when he was new to teaching.

In Chapter 4 I argued that the community aspect of the NFW-FOLC model was particularly instrumental in helping our participants achieve our learning objectives. For David, the community was an important factor during the FOLC but has not been necessary following the experience. (Of course, it is possible that his post-FOLC experience could have been enhanced by continuing to connect with his fellow FOLC members, but he was satisfied with the way things had gone). This suggests that faculty with local teaching support, while still benefiting from the diversity of perspectives in a FOLC and perhaps being prepared by the FOLC to take advantage of their local resources, do not need to keep up with the community after their official year of meeting in order to sustain teaching changes. This hypothesis is only based on David's experience and will need to be tested against the full set of longitudinal interviews. In my full study of the longitudinal interviews, I will seek to answer if community in some form (either through continued communication with FOLC members or at the local institution) is needed to help upkeep teaching changes made during the FOLC experience.

5.2.3 Current teaching practices

One of the main goals of the NFW-FOLC is to help participants sustain their implementation of RBISs. In both Interview 1 and Interview 2, we asked participants to describe changes to their teaching since attending the NFW and participating in the FOLC. We also had participants specify the source of their changes in practice (e.g. the NFW or the FOLC) to the best of their recollection. In his Interview 1, David explained how the FOLC had helped him improve his use of clicker questions. He said:

> "Before [the FOLC] I just gave the clicker questions and then moved on, but

> based on feedback from the FOLC I now use the clickers mainly for Peer Instruction where they have to try something on their own to begin with and then spend one or two minutes talking with their peers and trying to come up with solutions. So based on that, I've noticed that the students are less likely to fall asleep and seem to be more invested in the learning process."

It was through the implementation support he received in the FOLC that he learned how to use clickers effectively; he attributed increased student engagement in class to this.

The other teaching change he described in Interview 1 was the topic of his scholarship of teaching and learning (SoTL) project. He said this project was the most helpful part of the FOLC. He elaborated:

> "One of my challenges was managing time in the classroom, so my project that I came up with was to move a lot of the time I was spending solving homework problems and new problems in class to doing them in short videos I posted to YouTube for the students to access. I ended up implementing that this past semester, and that freed up a lot of time in class to go in more depth into the content I wanted to cover. I got a lot of feedback from the community as to how to improve those videos and to make them more effective."

David moved some of the problem-solving examples and homework explanations he used to do in class to online videos. He said he got positive feedback from students on these videos on his end-of-semester teaching evaluations and he was planning to use the videos again.

Did David persist in using these teaching techniques after the FOLC ended? His Interview 2 reveals that he has continued to use some of these strategies and has added in other new techniques. When I asked how his FOLC experience impacted his teaching, he replied:

> "I've definitely been trying to implement a lot of non-traditional things we learned from the FOLC experience, trying to make classes more interactive. I did a lot in my introductory physics class and I tried also to do that for my graduate level class...Doing things like peer discussions, having clicker questions, interacting with each other. So I'm definitely still using a lot of the practices I learned from the FOLC workshop."

David has continued to use Peer Instruction and attributes this to the "FOLC workshop." It is unclear if he is conflating his experience at the in-person New Faculty *Workshop* with the FOLC experience, but his statements in his Interview 1 provide evidence that it was the FOLC that helped

him modify his use of clicker questions. He also said in his Interview 1 that instructors teaching the other sections of the introductory course in his department used clickers, although we do not know if they were implementing them in a Peer Instruction way or simply as questions students answer individually. This is just to say that it is hard to attribute David's use of clicker questions to only one factor; it is likely that a combination of his local environment which supports their use, the NFW, and the FOLC experience all contributed to his current implementation.

It is unclear if David is still using his problem-solving videos in his introductory course. He did not mention the videos at any point during Interview 2 and when asked about his SoTL project, he couldn't recall what the topic of his project had been. This does not necessarily mean that he is no longer using the videos, and it was a mistake of the interviewer (me) to not specifically ask about the videos. It is possible that he just didn't remember the videos as his "project." I would need to reach out to David again to see if and how he is implementing video solutions in his course.

In Interview 2, David reported two new things he is implementing in his teaching. One has to do with the graduate course he has taken on since his time in the FOLC. He explained:

> "Yeah, I realized the first time I taught it [the grad class] that I spent a lot of time deriving equations on the board. So what I tried, this was not really peer instruction, more of just a fill-in-the-blank worksheet with- I gave the class a simple problem we're going to discuss and then we filled in the blanks for the different steps as we went through the class. There was no evaluation of what they were putting in but it was just having something prepared for them."

It is rare to see active-learning techniques implemented in graduate-level physics courses so this report from David is particularly encouraging. Fill-in-the-blank worksheets are not the epitome of active learning, and they certainly can be used in a transmissionist fashion where students simply write down what the professor says. However, if students are generating responses to the questions and doing this through group discussion, it would be more inline with active learning techniques. I do not know from the interview exactly how David is using these worksheets, but we can say that he recognized that he did not want to only lecture in the grad course and he is incorporating new strategies into the class. These are promising indications that his use of active learning strategies

is growing.

The other teaching strategy he reported implementing since his time in the FOLC is a technique of peer evaluation in his introductory physics course. David described:

> "What I've started doing this semester which I've not done in the past was also having problems they [students] worked out themselves then having them peer grade. I'll give them a question and then after that I will show a rubric and then we'll discuss it as a class, and then the person next to you will grade it. I'm yet to see how the students are responding to that, but I think it's been helpful for them to see the thought process of their fellow students. It allows me to do problems in a more systematic way rather than just doing everything on the board."

We see here again that David wants to avoid being at the board all the time and he wants students to interact with each others' reasoning. David explained that he implemented peer grading because he noticed, "with the peer discussions [of clicker questions] I think in many cases the stronger students dominated those discussions and there was no good sense of what they were doing individually. So I wanted to try and start having more individual worked out problems." He saw peer evaluation as an effective strategy for grading these individual problems. He described learning the concept of peer evaluation at the New Faculty Workshop.

David's description of his current teaching practice in Interview 2 indicates that he is dedicated to continuous teaching improvement. He is still incorporating new strategies into his class and refining things he has tried in the past. He reported that both the NFW and FOLC have impacted his current practice. We cannot say what David's teaching would look like if he didn't participate in the FOLC; the best we can do is rely on David's self-report. According to him, the FOLC has continued to impact his teaching in a number of ways.

5.2.4 Reflection on teaching practice

Another main goal for NFW-FOLC participants is for them to develop as reflective practitioners committed to continual teaching improvement. There is no single definition of reflection or reflective practice in the literature [112, 113]. Dewey discussed how reflection is based in and necessitated by experience [112, 114]. Reflection is intertwined with experience in the world. Boyd

and Fales write that, "reflective learning is the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self, and which results in a changed conceptual perspective" [115]. Reflection not only results in "changed conceptual perspective," but also change in future action [114, 116, 117]. Through the "best and worst" activity in the FOLC as well as the SoTL projects, we hope to train our participants to repeatedly pause, examine things that have gone well and poorly in their classroom, and choose a way forward, which they will evaluate once enacted. We anticipate that this training will help FOLC participants continue to reflect on their teaching even when the structure of the FOLC meetings is gone.

During Interview 2, I asked David about his view or philosophy about teaching and if that has changed since finishing the FOLC. He reported that it has been consistent and went on to describe,

> "One of my feelings of evaluating effectiveness initially was having students have high grades in the class, but that doesn't seem to change much with the style. But the students seem to learn better. It's hard to really quantify that. It would be nice if all these techniques could increase scores because that's what the students really care about in the end. For those on the high end of the spectrum I get comments about how interactive teaching helps them understand things better."

As a new teacher, David expected that students would have high grades if he was effective in teaching. With experience, he has noted that grades do not seem to vary with the style of his teaching but he has the sense that students are learning better now that he is using active-learning teaching techniques. This experience has caused him to shift his perspective, where now he recognizes that grades cannot tell the whole story about teaching and learning. This shift in perspective is a result of reflection. One perspective that has stayed the same though is the idea that all students care about is the grade; he expressed something very similar during his Interview 1.

One way we try to learn about participants' reflectiveness is asking them how they evaluate their teaching. Table 5.1 shows an excerpt from David's Interview 2 where I ask this question.

Table 5.1: Transcript excerpt from Interview 2 when Interviewer (AL) asks David (pseudonym) how he evaluates his teaching.

Speaker	Transcript
AL	How do you evaluate your teaching? What do you look for? Is it the grades? Are there other things?
David	Generally I think it would be the grades. They also have to write evaluations at the end of the semester, and that's also skewed to those who are failing the class and a few of the good ones. Yeah, I think teaching the introductory classes, it's a complex mix of people. You have those who have already seen the material before, those who have never seen physics before, those who have a strong math background and those who don't have that. My hope is that the Peer Instruction is helping balance that out somewhat. I don't have a good sense of how to quantify that.
AL	So you said you have the sense that hopefully the Peer Instruction is helping them learn better.
David	Yes.
AL	What makes you think that? Is it conversations you have with students or ways they answer certain test problems? Why do you think that's helping?
David	Well, partly from conversations with the students. I think just walking around the classroom every time, I try to do at least one or two in the class, and at least just from hearing students it seems like a lot of them are really into it, actively participating in the class. If you don't see anyone sleeping then I think that's a good sign.

David shares that he evaluates his teaching by looking at grades, end-of-semester teaching evaluations, conversations with students, and the level of engagement in class. When asked about his view of teaching earlier in the interview, he indicated an awareness that grades are not always a reliable measure of student learning or his teaching. However, he hasn't abandoned using grades as a metric for evaluating his teaching; he doesn't rely solely on grades to measure his teaching though. From Table 5.1 and his view/philosophy about teaching response, we see that David is aware of the limits of his current evaluation metrics. For example, his experience has told him that grades do not tell the whole story and teaching evaluations can be biased towards students who are either really upset or happy with how they did in the class. This suggests that he is still in the process of reflecting on how to best assess his practice; he is stuck on how this knowledge of

limitations of his current practice can inform his future action. He has not figured out alternatives to what he currently looks to to evaluate his teaching. He repeats that he doesn't know how to "quantify" the effect of the active-learning techniques he is implementing.

When asked how he evaluates his teaching during his Interview 1, David said he relied on teaching evaluations and on how engaged students are in class. He also stated that students who are getting bad grades are the ones who fill out the teaching evaluations. The similarity of his responses in Interview 1 and 2 demonstrates that David hasn't made huge changes in how he evaluates his teaching since the end of the FOLC. It seems though that he has become increasingly aware that his metrics are insufficient for measuring the impacts of his teaching methods, as evidenced by his statements in Interview 2 about how he doesn't know how to quantify the effect of Peer Instruction in his introductory class.

In Interview 2, directly after asking David how he evaluates his teaching I asked him, "So how confident do you feel in your ability to gauge your students' learning? Do you think you have a pretty good sense of the students who are doing well versus not doing well? Do you think that's still something you're not very sure of?" In his response to this question, we continue to see David's growth in his awareness of the scope of what he can say about his teaching and students' learning. He responded,

> "It's something I'm not very sure of.[4] A lot of students I see are actively engaged but don't necessarily do well on the test. That could also be just the way the test is structured. A lot of these courses, we have seven to eight different sections and they're all taking the same common exam. It's multiple choice. They have to read through these problems in an hour and answer conceptual problems. People approach that- when they have to take a test a lot of people have different approaches. And we don't have any other way to evaluate scores besides this mass testing."

David has reflected on the discrepancy between his sense of students' in-class engagement and their performance on exams. He has reasoned that this could be due to the structure of the tests which is limited by the large size of the class and the need for consistency across course sections. Again,

[4] Note, I potentially primed David to frame his response this way with the wording of my question.

this is an example of reflection-in-progress because he has recognized a problem and identified a potential source of the problem, but he is unsure how this knowledge can inform his future action.

It is also interesting to consider this response in light of what he said during Interview 1 about his confidence gauging students' learning.[5] At that time point he said he was, "Definitely more confident than the first day of the FOLC. I don't know. On a scale of one to five I think I'm more of a four, where five is very confident." This response of being four out of five confident contrasts with his statement in Interview 2 about being "not very sure." This shift towards less confidence perhaps signals a greater awareness of the limitations of his assessment tools.

As described in the Current Teaching Practices section above, we do not know from Interview 2 if David ever followed-up with his SoTL project (problem-solving videos for his introductory course). During the FOLC, his cohort gave him suggestions for how he could assess the effect of the videos more robustly, such as surveying the students specifically about the videos. (During his first implementation he relied on comments in the generic end-of-semester teaching evaluations to gauge the effectiveness of the videos). In Interview 1, David said he was planning on using the videos again and he said next time he will try, "to get better assessment from the students on how it's being used and how effective it is as a resource for them." His plan was to incorporate feedback from the FOLC into his future implementations of the videos. We don't know if he followed through with these plans. From his other statements in Interview 2 about not knowing how to quantify the effect of some of the teaching techniques he was using as well as his confidence response, we do know he is still figuring out how to more formally assess his practice. David's responses in both Interview 1 and 2 about the SoTL projects suggest we could have better supported his teaching reflection. The point of the SoTL project is not only to try something new in one's classroom, but to also assess the effect of that new practice. It seems like David needed more scaffolding to support that second piece.

Even though David is still developing his skills as a reflective practitioner, we see that in some areas his reflection has evolved to the point of informing his future action. During Interview

[5] In Interview 1, this confidence question preceded my question about how David evaluates his teaching.

2 I asked him how he decides that he needs to make a change in his teaching and what indications he looks toward in making this decision. David responded that, "In the past I've had mid-term evaluations just asking the students do you want to do more problems in class, do you want me to do that? A lot of it comes from the feedback from evaluations." He then gave an example of a change he has made to his teaching based on student feedback. He went on to explain a change he is currently implementing:

> "The other thing is that I'm also trying to go back and look at their homework assignments and see problems they've had issues with. In the past I just didn't really go back to evaluate things on a problem-by-problem basis, but I'm trying to do that now. It takes a little bit more time, but I'm trying to- if I see there's a problem they don't understand I maybe at least mention it in class next time before I go through a new problem."

He then explained how he has particularly tried to do this in his graduate course where it is small enrollment and there is flexibility in the schedule to review topics students are struggling with. This is an example of David changing his practice spurred by student feedback and the resulting internal reflection about what he could do differently. He realized he has the time, especially in his graduate course, to provide this formative feedback to students.

Overall, two years after his FOLC experience David is continuing to reflect on his practice. He can critically assess his teaching and identify the limits and flaws in some of his evaluation practices. He still needs to resolve some of the conflicts he has identified, but we can be hopeful about his ability to do this given his demonstrated commitment to continual teaching improvement as well as the local community of support he has. We are not able to say for certain that David has grown in his reflection *because* of his FOLC experience, but we can say that the FOLC offered him *opportunities* to practice reflection.

5.2.5 Change agent behavior

While a NFW-FOLC cohort is comprised of around nine faculty members, we hypothesize that these members will go on to impact the teaching of their local colleagues, increasing the overall

reach of the FOLC. In David's Interview 1, he said he had talked to a new hire in the department about the FOLC and encouraged them to join. Additionally, he reported that he had talked to his colleagues about the teaching techniques he was trying out and they were supportive of his efforts. There was no indication the colleagues had actually taken up anything David shared (although some were already using clicker questions). This level of influence seems to have been maintained post-FOLC. Table 5.2 shows an excerpt from Interview 2 when I was inquiring about David's change agent behavior.

Table 5.2: Transcript excerpt from Interview 2 when Interviewer (AL) asks David (pseudonym) about his influence on his colleagues' teaching practices.

Speaker	Transcript
AL	Have you shared some of the things that you do in your classroom, some of the techniques you've been trying, with other people in your department or other colleagues you have, either locally or at other institutions?
David	I have done it locally with some of the new faculty who come in.
AL	And do you think they've perhaps taken up some of those techniques?
David	Yeah. I'm not sure if it's because of me or because they also came to the [New Faculty] workshop too.
AL	Right, I think I saw we had a couple come to the [New Faculty] workshop.
David	Yeah. So I don't want to take any credit.
AL	Do people come to you for teaching advice or questions?
David	Yeah, for some questions.
AL	What types of questions?
David	What types of questions?
AL	Like are they really specific to the course?
David	The most recent was asking about how I kept students engaged. I have about 90 percent of my students show up every day.
AL	Oh, wow.
David	One of my colleagues had 60 percent showing up and wanted to know what I was doing about that. She will come and sit in my class at some point.

David has continued to share his teaching techniques with the new faculty in his department and colleagues do come to him with teaching questions. He is hesitant to claim credit for these colleagues' teaching practices though because there is a confounding factor of them having also attended the NFW. He reports that his department encourages talking about teaching and when I asked him how confident he is in sharing the techniques he has tried he replied, "Not 100 percent. I'm still working on that. I feel definitely maybe 75 percent confident." David is confident in talking about teaching techniques at least with some of the other junior faculty in his department. It is impossible to determine the exact effect of the FOLC in this sharing, especially given that his departmental culture supports talking about teaching, but we can say the FOLC experience has contributed to his teaching development and thus what he is able to discus with colleagues.

Since completing his NFW-FOLC experience, David has also served as a guest speaker for one of the cohorts that followed his. He talked to this cohort about his experience with Peer Instruction. I asked him in Interview 2 about what motivated him to be a guest speaker. David explained,

> "Well, I thought it was a good idea. No, I did benefit a lot from having, at least I think for our FOLC cohort, the leader of it, the organizer was someone who already had experience with teaching and implementing these things, so it was very good to get a perspective of someone who had already experienced teaching and influencing these things. I didn't think twice about it...It was just good to be helpful, yeah, to new faculty."

David wanted to share his knowledge with other new faculty because he knew from his time in the FOLC that hearing from experienced practitioners was very helpful. His statement that he "didn't think twice" about speaking to another cohort, together with his recounting of the conversations he has had with local colleagues, demonstrate that he is motivated to help other new faculty and feels confident in doing so.

5.3 Conclusions and future work

Through the above analysis and discussion of David's two interviews we see that two years after his FOLC experience he is still trying new teaching techniques while continuing to use some strategies he implemented during the FOLC; he is talking to colleagues about his teaching practice (and feels pretty comfortable doing this); and he is continuing to reflect on his teaching and seeking to improve. All of these behaviors align with our NFW-FOLC learning objectives for participants and more specifically the long-term impacts we hope to achieve. The fact that we see David meeting our long-term goals provides additional support for the efficacy of the FOLC model. Of course, David is also situated in an environment which supports the use active learning techniques and discussion of teaching efforts. It is impossible to fully disentangle the effects of his local context, experience gained through additional semesters of teaching, and his time in the NFW-FOLC. However, his interviews highlight a few areas where there was a clear FOLC impact. For example, based on David's descriptions of Peer Instruction and the implementation help he acquired through the FOLC, it is obvious that the FOLC influenced his current use of clicker questions. He also mentioned how the FOLC experience "mainly colored" the way he views teaching.

This preliminary analysis will guide the analysis of the full set of longitudinal interviews in a number of ways. First, I will be particularly attuned to participants' retrospective views on the FOLC experience and how their responses compare to what they said in their first interview. We ask for this general, retrospective view at the start of the second interview and so the responses are perhaps the most spontaneous and un-primed for of the entire interview. Seeing what aspects of the experience are salient to participants two years later will inform us about the most impactful design elements of the FOLC. We saw with David for example that the diversity of perspectives in his cohort and the knowledge that he was not alone in his teaching challenges were particularly impactful for him. I will maintain this focus on participants' descriptions of the FOLC structural elements throughout their longitudinal interviews. For example, what do they say about their SoTL projects? We expect these projects to be an important mechanism for teaching FOLC members

to reflect on their teaching practice, but we will have to see if the effect of these projects persists beyond the FOLC. If it does not, that could indicate additional scaffolding and emphasis that needs to be added to the FOLC experience or a revision to our model. Additionally, I will look for how participants describe their current communication with their FOLC cohort and how they describe their local teaching resources. A question that David's interview raised was what is the role and importance of the community aspect of the FOLC after the cohort stops meeting regularly and if that depends on people's local support. An answer to this question will inform the post-experience support we provide for FOLC alumni (e.g. Should we host periodic videoconferences for the alumni to connect?).

David's interviews show that the NFW-FOLC can indeed continue to impact members after their year-long experience has finished and this initial analysis provides a clear path forward in analyzing the full set of longitudinal interviews.

Chapter 6

Adaptation of the FOLC model to a new context

Portions of this chapter are adapted from a manuscript in the final stages of preparation, to be submitted to the International Journal of STEM Education: Price, Lau, et al. 2020 [22].

So far in this dissertation we have presented and examined one implementation of the FOLC model, the NFW-FOLC. We have established the success of this model in supporting new physics and astronomy faculty as they incorporate research-based instructional strategies into their teaching and develop their reflective skills. This now leads us to consider, *To what degree is the FOLC model adaptable to different contexts?* It may not seem like a huge jump to organize a FOLC around a different population group, say experienced physics faculty or physics faculty at liberal arts colleges. It also may not be a stretch to apply this model to a group of faculty all teaching the same course (e.g. introductory, calculus-based physics; quantum mechanics; or electronics lab). However, we expect there are limits to the applicability of this model to support faculty's teaching practice. For example, arranging a FOLC around "successfully using your learning management system" may be too narrow and technical of a topic to sustain conversation. We also know from a number of efforts to import a research-based instructional strategy or material into a new environment from where it was originally designed that the adaptation is a non-trivial endeavor [118, 119].

In this chapter, we explore the question of adaptability by considering a FOLC centered on a shared curriculum. Specifically, we describe and present data from a FOLC designed to support faculty implementing the Next Generation Physical Science and Everyday Thinking (NGPET) curriculum [120]. We start by describing the curriculum. Next, we present the design of the

NGPET-FOLC. We then compare the design of the NGPET-FOLC to that of the NFW-FOLC, exploring two major differences in their designs. In order to determine if the FOLC model was successfully adapted by the NGPET-FOLC, we present outcomes from that FOLC and determine if the goals of the NGPET-FOLC are being met. Finally, we discuss the implications from this adaptation of the FOLC model as well as identify areas for future work in exploring the limits of the adaptability of the model.

6.1 NGPET curriculum

The Next Generation Physical Science and Everyday Thinking (NGPET) curriculum [120] is a highly interactive, inquiry-based physical science curriculum taught in university courses for prospective elementary teachers. The curriculum is also used for university general education science courses. NGPET is the current iteration of the Physics and Everyday Thinking (PET) curriculum [121], the Physical Science and Everyday Thinking (PSET) curriculum [122], and the Learning Physical Science (LEPS) curriculum [123]. NGPET is aligned with the Next Generation Science Standards [124]. The curriculum is comprised of five modules: Developing Models for Magnetism and Static Electricity; Interactions and Energy; Interactions and Forces; Waves, Sound, and Light; and Matter and Interactions.

The curriculum is semi-flexible: instructors have flexibility with respect to content and implementation format. The modular design allows instructors to customize the curriculum to their needs, choosing which topics they will cover. Each of the five modules are comprised of multiple units. Depending on the length of their course and the needs of their student population, an instructor has the freedom to choose which units to cover. For example, one instructor may choose to include the Interactions and Forces module, the unit on developing models for magnetism from the Developing Models for Magnetism and Static Electricity module, and the unit on potential energy and fields from the Interactions and Energy module, while another instructor with a longer term may choose to cover the complete Interactions and Energy module. Additionally, there are two implementation versions of NGPET: one for lecture-style courses and one for studio-style courses.

Instructors can choose the format which fits their situational constraints. Once an instructor chooses the topics they will cover and their implementation format, there is the expectation that they will adhere to the activity structure and design provided by the curriculum.

For instructors currently teaching a traditional lecture-based physical science course, adopting the Next Gen PET curriculum will require them to change their course content and their pedagogy. The content included in the curriculum deviates from popular physical science textbooks (e.g. Hewitt [125]) by including units on *developing models* of magnetism and static electricity, presenting energy before forces, and including engineering design activities and activities on teaching and learning. Rather than covering a litany of topics, NGPET prioritizes a few big ideas and conceptual understanding. In addition, it guides students to develop an understanding of the nature of science and of their own learning process. Pedagogically, the curriculum makes extensive use of active learning techniques. Students are positioned with the agency (and responsibility) to construct the main ideas presented in the curriculum through a process of developing and testing ideas [126–128]. The learning goals of the curriculum are achieved by adherence to five core pedagogical principles (each of which is drawn from research on learning) [126–128]:

- Learning builds on prior knowledge
- Learning is a complex process that requires scaffolding
- Learning is facilitated through interaction with tools
- Learning is facilitated through interactions with others
- Learning is facilitated through establishment of certain specific behavioral practices and expectations

In both the lecture format and studio format, it is expected that students will work with each other to draw on evidence gathered in class to reach the main ideas. The instructor takes on the role of facilitator. This requires a significant shift in an adopter's approach to teaching if they are used to instructor-centered, lecture-based practice. Given that the curriculum is a departure

from the style of teaching and learning instructors and students are used to, successful adoption requires buy-in from students.

6.2 The NGPET-FOLC

Given the large departure of this curriculum from status-quo instructional practices, the developers of NGPET hypothesized that adopters would benefit from a large amount of implementation support. In addition to extensive material-based support (e.g. instructor website, test bank of exam questions), they established a faculty online learning community for NGPET adopters (the NGPET-FOLC). This community is comprised of approximately fifty members, divided into five clusters. Each cluster has around ten members and is facilitated by two or three members who are more experienced with the curriculum. Demographic and institutional characteristics of the community are reported in Table 6.1. Approximately 85% of the FOLC members responded to a demographics survey. These respondents are split evenly between males and females and are predominantly white. They come from a range of career stages and two-thirds are affiliated with physics departments. We also see that 29% are affiliated with education departments and 29% are affiliated with natural/physical science departments (besides physics). Additionally, ten participants (24%) list affiliations with departments in *both* the sciences and in education; this makes sense given that NGPET is a physical science curriculum designed for prospective teachers. The majority (60%) of the overall community works at master's granting institutions, with 27% working at doctoral granting institutions, 6% at primarily undergraduate institutions, and 7% at two-year colleges.

Each NGPET-FOLC cluster meets regularly via videoconference (using Zoom) to discuss how their NGPET course is going, troubleshoot teaching challenges, and share resources. In these meetings, participants have the opportunity to discuss problems of practice and gather feedback from the group. These discussions may include encouragement to stick with the teaching changes one has made and ideas on concrete techniques to try to solve the implementation challenge at hand. In between meetings, members are connected on an online discussion platform (Slack). On

Table 6.1: Demographic characteristics of NGPET-FOLC participants. N=42 for gender, race/ethnicity, academic rank, and departmental affiliation data. (N=42 is 85% of the NGPET-FOLC population). N= 55 for institution type data.

Gender Identity	Female	50%
	Male	50%
	Cisgender	7%
Racial & Ethnic Identity	Asian, or Asian American	12%
	Black, African, or African American	<5%
	Hispanic, Latino or Spanish origin	<5%
	White	86%
Current Academic Rank	Full Professor	12%
	Associate Professor	38%
	Assistant Professor	21%
	Instructor/Adjunct	24%
	A rank not listed above	5%
Departmental affiliation	Physics/ Physics & Astronomy	67%
	Natural/physical sciences	29%
	Education/Science Education	29%
Institution Type	Two-year college	7%
	Primarily undergraduate institution	6%
	Master's granting college/university	60%
	Doctoral granting university	27%

this platform, they can communicate with their immediate cluster members as well as the full community. This platform offers an easy way to share curricular resources and also acts as a venue for soliciting timely feedback.

The NGPET-FOLC community is designed to continue for five years (faculty are expected to participate for this entire period). The community launched in the summer of 2017. Members first met in-person at a two-day workshop that introduced them to the curriculum and the FOLC

structure. In order to accommodate everyone, members were split between two workshops (i.e. the workshop was run twice). The clusters met biweekly online from September 2017 through May 2018. Community members were divided into clusters based on their implementation format (lecture-style or studio-style). The main focus of FOLC meetings during this first year was to assist members with all the issues that arise the first time one implements a curriculum. In year two (September 2018-May 2019), the clusters met only approximately once a month given members' increased familiarity with NGPET. In addition, members joined project groups in which they worked on developing materials for the course or exploring some area of interest regarding the course. For example, there was a group which worked on developing materials to teach the nature of science and a group which explored students' science identity development in the course [129]. The frequency of these project group meetings varied by group. Membership of the project groups was not identical to the cluster membership (i.e. Cluster 1 members were not all in the same project group). In year three (September 2019-May 2020), members were resorted into clusters based on their meeting-time availability. The new clusters are meeting approximately biweekly and meetings focus on promoting deeper pedagogical understanding.

One of the main objectives of the NGPET-FOLC is to support faculty in successfully implementing NGPET. This goal was the immediate and primary focus during the first two years of the FOLC. Now in year three, community members have sorted through many of the logistical difficulties associated with implementing a new curriculum. The FOLC continues to support members in implementing NGPET while simultaneously working toward long-term goals of the FOLC such as promoting reflective teaching practice and pedagogical sophistication in the range of courses members teach.

6.3 Comparison of NFW and NGPET FOLC designs

The NGPET-FOLC has broad structural similarity to the NFW-FOLC, but differs in a few major ways. Like the NFW-FOLC, the NGPET-FOLC is designed to support the teaching practices of geographically-dispersed physics instructors through a professional community which meets via

videoconference and is connected asynchronously on a discussion platform. Both communities provide the space for members to troubleshoot teaching challenges and more formally explore their teaching practice. The design principles of the NFW-FOLC (Refer to Table 3.1 in Chapter 3) are echoed in the NGPET-FOLC design. Table 6.2 summarizes and compares the design of both FOLCs.

Table 6.2: Comparison of the NFW-FOLC and the NGPET-FOLC.

	NFW-FOLC	**NGPET-FOLC**
Goal/Purpose of Community	Support participants in successfully implementing RBISs & sustaining use	Support participants in successfully implementing NGPET curriculum & sustaining use
	Support participants in developing skills as reflective practitioners	Support participants in implementing pedagogical techniques & practices used in NGPET in other courses
Participant Characteristics	Geographically dispersed (located at different institutions)	Geographically dispersed (located at different institutions)
	Teaching a variety of physics & astronomy courses	Teaching NGPET curriculum
	Physics/astronomy faculty	Come from variety of STEM departments
	New faculty who attended New Faculty Workshop	Mix of career stages
Facilitation	2 past participants	2 faculty members experienced with NGPET curriculum
Community Structure	1-year length	5-year length
	Cohorts of 10 members, formed following NFW twice a year	50 total community members divided into 5 clusters
		Cluster membership shifts year-to-year
	Little contact between cohorts	Some community-wide connection
Videoconferences	Biweekly Zoom meetings	Biweekly Zoom meetings
	Time split between guest speakers experienced with range of RBISs & group troubleshooting teaching challenges	Group troubleshoots implementation of NGPET curriculum
Asynchronous Platform	Slack for communicating & document sharing in between videoconferences	Slack for communicating & document sharing in between videoconferences
Projects	Completed individually	Completed in groups
	Scholarship of Teaching & Learning to assess individual practice	Developing supplemental curricular material & Assessing effect of curriculum

NFW-FOLC	NGPET-FOLC

The two FOLCs differ in two main ways: (1) the focus and motivation of the group and (2) the structure of the community.

6.3.1 Focus and motivation of the FOLC

The NFW-FOLC is centered on a specific population: new physics and astronomy faculty. Members are united by their common career status and desire to develop their teaching practice. In contrast, the NGPET-FOLC is centered on a shared curriculum. The members of this FOLC are in different career stages, but they all teach NGPET. This difference in focus can be understood in terms of a difference in joint enterprise and shared repertoire, to borrow terms from communities of practice (CoP) [18, 33, 92]. The joint enterprise of the NFW-FOLC is to support members in expanding their teaching skills and implementing research-based instructional strategies, as they navigate their positions as new faculty at their respective institutions. The joint enterprise of the NGPET-FOLC is to support members in implementing the NGPET curriculum and to help them develop their reflective skills. The shared repertoire of a CoP encompasses the resources needed to negotiate meaning in the community; these resources include shared tools, language, concepts, artifacts, and ways of interacting [33, 92]. The NGPET curriculum is a large piece of the shared repertoire of the NGPET-FOLC. In order to understand the teaching experiences members share and to help troubleshoot teaching challenges, members must have knowledge of the NGPET curriculum, including the physical materials, terminology and language it uses, and pedagogical concepts that underlie its design. The members of the NFW-FOLC have a shared understanding of the common undergraduate physics and astronomy curriculum (e.g. the topics and concepts taught), but they do not necessarily share the same tools, materials, or language for teaching these topics.

One way this difference manifests is in the content of the conversations had during FOLC meetings. The topics of conversation for the NGPET-FOLC clusters (at least during the first

two years of the program) often centered on logistics, course management, and pedagogy of the NGPET course. For example, there were conversations about what modules and units to cover, how to access some of the materials, how to handle certain issues with the equipment, how to get different groups of students to move at similar paces through the curriculum, and how to assess students in the course. Table 6.3 shows the beginning of a conversation held during an early NGPET FOLC meeting. This conversation is unique to the NGPET-FOLC context. Preceding this excerpt, one of the cluster leaders asks the group if anyone has a question or struggle they want to talk with the group about. Mary is finishing the magnetism unit with her class and she faced a few issues during the unit. One of these is that she found lesson five in the unit to be redundant.

Table 6.3: The first turn of talk in a curriculum-specific conversation in the NGPET-FOLC. Names are pseudonyms.

Turn	Speaker	Transcript
1	Mary	In lesson five they're kind of remaking their model. But, at least for my students, it seemed like that they came to a pretty good conclusion about models in four. And it seemed like five was maybe not needed.

In the next six turns of talk, Mary raises two other concerns with the magnetism unit (an equipment problem and a concern on the teaching and learning activity in the unit). One of the cluster leaders, Chris, coordinates which concern they will talk about first. They start with the concern about lesson five. The proceeding turns of talk are displayed in Table 6.4.

Table 6.4: Transcript of a NGPET-FOLC cluster's discussion of a lesson within the magnetism unit of the curriculum. These turns of talk come approximately two minutes after the excerpt shown in Table 6.3. All names are pseudonyms.

Turn	Speaker	Transcript
8	Chris	I found lesson five worked well for my class. This where they're taking the magnetism model and having to make some additional predictions, like, if you wanted to make the north end of nail, or whatever, the pointy end north, what are two different ways you could do that? So, it's taking the model they've used and applying it to some new situations. I felt like it went well, but right, you could choose to skip lessons, and certainly, if you feel like your class really has it and it's redundant, sometimes I choose to skip a slide in a lesson where I'm like, "They've got this, and this is a really redundant slide." That's actually some of my learning assistants and I have been talking about, sometimes they've got it and they feel like, "Why are you making me do this again?"
9	Chris	Nope, we're going to just skip that one. Moving right along. So, that's been one thing I've done.
10	Cassandra	If I can interject for one second?
11	Chris	Please.
12	Cassandra	I think that lesson five, the importance might depend on how you're planning to assess them. So, I think for me when I look at this magnetism unit and I look at the tests I've given in the past, which are very much out of the test bank so far. A lot of the, I don't know what percentage, my memory is that a lot of the questions are only really prepped for by lesson five. So, one through four, they're building the model and there will be some questions about like, what was that process like, how do they build a model. But a lot of them are going to be like, okay, you click this here, and here, and what happens. And there's definite questions in it about like, you rub the nail with this and then you bring this over here. So if you were gonna use those questions from the test bank, I think that makes lesson five important in my experience.
13	Chris	I would also say that lesson five is the lesson where they are essentially done building the model and then they are using it to predict things that they haven't seen yet. So, it sort of shows that they have accomplished something if they can explain this new behavior or predict this new behavior with their model. So that's a, I think that's a pretty important piece in terms of, maybe not the specific things that are listed in there, but in terms of the view of just taking all of science and making a little model of science in this class, I think it's important in that use.

Turn	Speaker	Transcript
14	Michael	It sounds like it's an expansion or application part of the whole module. I'm not teaching it currently, but it might be an assignment. I don't know. Or, depending on how things are structured, it could be something you keep in your back pocket if a group finishes early. Say, okay, wait for everyone to kind of get up to speed, and can work on that. Anyway, just a comment from outside.

Chris and Cassandra share their experiences of teaching the lesson and offer two perspectives on why it is useful to include, and maybe not so redundant as Mary fears. Michael, although not currently teaching the magnetism unit, is familiar enough with the curriculum to propose an alternate way to incorporate the lesson in the class.

This conversation is possible specifically and exclusively because all of the FOLC members are teaching the same curriculum and are familiar with its details. Chris and Cassandra, having taught the lesson before, understand how it fits in the overall trajectory of the magnetism unit. Cassandra alerts Mary to the fact that many of the test bank questions (a shared resource for NGPET instructors) depend on students having gone through lesson five. In Turn 13, Chris also links the lesson to one of the goals of the curriculum: understanding the nature of science. He explains how this lesson shows students the importance of model building in science, "they are using it [their model] to predict things that they haven't seen yet." Michael, even though he has not taught the unit yet, can contribute to this conversation because he understands the structure of the curriculum. In the studio-format of NGPET, students work through the activities in small groups, with periodic whole-class check-ins; one of the challenges of this format is keeping the groups moving at similar paces. We can see that Michael understands this challenge because he suggests that lesson five, "could be something you keep in your back pocket if a group finishes early." He offers the idea that lesson five could be used to prevent a group from getting too far ahead.

We do not see such specific conversations in the NFW-FOLC because a common curriculum is not part of the NFW-FOLC members' shared repertoire. Instead, conversations often center on a

range of research-based instructional techniques and how they can be applied into every members' different context. Some common topics of NFW-FOLC meetings include standards-based grading [130, 131], Just in Time Teaching (JiTT) [83], Think-Pair-Share (TPS) [2, 85, 132], white-boarding [105, 106], exam design and exam alternatives (e.g. oral exams, group exams), writing in labs, and teaching techniques for upper division courses (e.g. [133]). These conversations may include a guest speaker on the topic, or may just be a discussion among the cohort members based on their experiences. The conversations do not assume a common curriculum or common textbook. Note, the NGPET-FOLC clusters do not have outside guest speakers because the focus of each meeting is on implementing NGPET, and it is expected that the cluster leaders and members have sufficient collective knowledge and experience in this area to assist each other; also, the pedagogy is built into the curriculum so instructors have less choice about the techniques they will be using.

To illustrate the difference in the types of conversations that occur in the NFW-FOLC versus the NGPET-FOLC, I include an excerpt from a NFW-FOLC meeting that was centered on implementing Think-Pair-Share. TPS is an instructional technique where an instructor poses a multiple-choice conceptual question and students take a minute to think about the answer on their own and vote. If there is enough disagreement on the answer, the instructor asks students to turn to their neighbor and discuss, and then vote again on their (possibly revised) answer. The results of this second vote are discussed with the whole class. Two guest speakers were invited to this meeting to share their advice and experience using TPS. (Both guests also happened to be past NFW-FOLC participants). Members of this cohort were teaching a range of lower and upper division physics and astronomy courses. The meeting started with everyone sharing their experience with TPS. Next, the conversation was opened to questions for the guest speakers on various details of implementing TPS. About an hour into the conversation, one of the participants, Alexandru, raises a question about one of the answer choices provided in TPS questions. Table 6.5 includes the transcript of this portion of the conversation.

Table 6.5: Transcript of a NFW-FOLC cohort's discussion of the inclusion of a specific answer choice in Think-Pair-Share questions. All names are pseudonyms.

Turn	Speaker	Transcript
1	Alexandru	I wanted to ask you. Why do you give the option "I don't know" as part of the answers? How is that helping students? I don't use that because I thought about it, but I feel like it's an invitation to "yeah whatever" kind of attitude. So I would rather have them and I keep telling them over and over again that it's nothing wrong with being wrong. And I give them examples from history when the humankind consider the earth to be flat and the earth to be in the middle of the universe and stuff like that. So why is that kind of options important?
2	Kelsey	I only did that [included that option] because that's what they did in the [New Faculty] workshop. And I actually never had that option on my clicker questions for the clickers. So if anybody else has an answer, I don't have one.
3	Stephanie	I see Kathryn has a comment, Christine has a comment and I have a comment. Let's start with Kathryn.
4	Kathryn	I found that it gives them a way to answer when they really just don't have an idea. So they will take a random guess and they will put up A, when they have absolutely no clue. And it gives me good feedback on who's just totally lost on this question, not even to the point of "I can make a good guess and I can eliminate between two", but who is so lost?
5	Kathryn	And I think typically at a class of 25, I do five questions that day, I have maybe three "I don't knows" out of the whole class typically over the whole course of the day. I don't get very many of them, but when I do, they really just, they don't know where to begin. They need me to back up and cover some things as compared to, "Oh, I thought the answer was C, and I flipped my direction." Or something along that line. So I find it gives me really good feedback on who's just really lost.
6	Christine	I would say that for me it's the same thing. It's not so much for their option, but it's for me particularly because if I get a large percentage that means that I need to reframe the question. What if I get a lot of people who are like, "I don't know." And so I do this even with small whiteboards, right? Like if they just have no idea where to start, I just tell them to put a big question mark because again, it gives me a sense of like people really are clueless, then they're not understanding what I asked them to do. And so it's more about the feedback for me and less about that. I haven't really had the issue, like Kathryn said, I don't really actually get a whole lot of them when I do this.

Turn	Speaker	Transcript
7	Stephanie	I typically have one regularly in my class and some of it is because I would rather, if I just get them A through D, then if they're really, really, really clueless, they're just going to pick a number and click it because they get participation points and I would rather know when they're lost. I don't want to have a bunch of A's because they happens to be the first letter of the alphabet, but A is right. And so then I think that we are good and I just go through the explanation quickly because in personal class, click A and if 10% of them just randomly clicked A, then I'm not actually helping them.
8	Stephanie	And so I'd rather know I get a bit more of the, "I don't knows" and so maybe it's something to do with how I'm framing the question or maybe it has to do partly with student body because I'm also having more attendance problems than these other two people that I'm hearing [inaudible] But I think that it helps keep a pulse on the class for how long you want to continue talking about that question.

Rather than discussing the inclusion of a particular lesson like we saw in the NGPET-FOLC excerpt, in this NFW-FOLC discussion, members are considering the inclusion of a particular answer choice for TPS questions. TPS can be applied to many different courses so the discussion in Table 6.5 is more broadly applicable than the conversation in Table 6.4. Kathryn, Christine, and Stephanie (who have collectively implemented TPS across a range of courses, from introductory physics to advanced electromagnetism) describe the value in the "I don't know" answer choice. The members of the NFW-FOLC have shared knowledge of the TPS technique (for example, the common answer choices provided with the questions) but the conversation is not course-specific. There are still plenty of implementation details and knowledge shared in this excerpt, however the shared repertoire of the members (from which examples and concepts can be drawn) rests at their common experience with undergraduate physics and astronomy content rather than a specific curriculum.

6.3.2 Community structure of the FOLCs

The second major difference between the NFW-FOLC and the NGPET-FOLC is the structure of each community. A new cohort of the NFW-FOLC is formed following each iteration of the in-

person New Faculty Workshop. (There have been eleven cohorts since the start of the NFW-FOLC program). The cohort will meet for one year following the workshop. The facilitators of the NFW-FOLC cohorts are often past participants in the FOLC; other than (indirectly) through facilitators, there is little inter-cohort interaction for the active cohorts. After a cohort finishes (once the year is up), members are added to a Google group of NFW-FOLC alumnni. This platform allows past participants to continue sharing their teaching successes and challenges via asynchronous messages with previous FOLC members across the full range of cohorts. The activity on this platform is generally low, although at the start of a new semester there can be more activity. Members from a range of cohorts have also met up at some of the annual physics conferences (e.g. the American Physical Society March Meeting and the American Association of Physics Teachers summer meeting).

In contrast, the NGPET-FOLC is a community of approximately fifty members that is intended to last for five years. Rather than a cohort-model, this community divides its members into clusters. Like cohorts, clusters are groups of around ten members, including two or three facilitators. The difference is that membership of each cluster can shift from year to year over the five years of the NGPET-FOLC program. This means that participants interact with members from the whole community, not just the people that were in their cluster in year one. Even in year one, communication across clusters was encouraged and facilitated by a shared asynchronous platform (a structure that remains in place today). On the platform (first SharePoint and then Slack) participants could pose questions and share resources with both their cluster and the entire fifty-person community. Further, in year two members joined project groups, in addition to their clusters, which connected them with members from across the community in investigating some aspect of the course.

In the first year of the NGPET-FOLC, members were divided into four clusters. Six members did not continue on to year two for logistical reasons, but a fifth cluster was added with nine new members to the community. Since the beginning of year two, membership in the community has remained mostly stable, with only a handful of people leaving or joining.

The long-term nature of the NGPET-FOLC community and the opportunities to interact with members beyond one's small group mean that NGPET-FOLC members are connected to a much larger community during their FOLC experience than members of the NFW-FOLC. For the NFW-FOLC, members only interact with their cohort of ten people for their time in the FOLC. Once their year in the program is complete, they are connected in a rather passive way to the now seventy alumni (many of whom they have not met) via the Google group.

6.4 Outcomes from the NGPET-FOLC

We opened this chapter with the question, *To what degree is the FOLC model adaptable to different contexts?* In order to answer this question, we need to consider the success of the NGPET-FOLC in achieving its objectives. The NGPET-FOLC has a set of immediate and longer-term goals. The immediate goals were the main focus of the FOLC during its first two years. These goals are that participants will increase their:

- familiarity with the NGPET structure, content, & materials
- confidence in using the curriculum
- knowledge of pedagogical techniques
- reflection on their NGPET teaching
- use of pedagogical techniques in their NGPET implementation

These goals remain for the five-year lifetime of the NGPET-FOLC, but we expect to be able to begin to see evidence of the achievement of these goals as early as the end of year one of the FOLC. In contrast, the longer-term goals are those which we do not expect to see evidence of until later on in the lifetime of the FOLC. These longer-term goals are that FOLC members:

- See student learning gains in their NGPET course
- Persist in using the curriculum

- Apply the pedagogical techniques used in NGPET to their other courses
- Engage in reflection on their teaching practice in *all* of their courses

These goals shift to the forefront for the FOLC after members have implemented the curriculum a few times and worked through many of the logistical hurdles. Note, some of these goals (increasing knowledge of pedagogical techniques, applying pedagogical techniques and engaging in reflection across courses) directly overlap with the learning objectives the NFW-FOLC has for its members.

6.4.1 Methods

In order to assess our progress in achieving the NGPET-FOLC objectives, we surveyed the community at three time points: before the in-person, orientation workshop (summer 2017), after said workshop (summer 2017), and at the end of the second year of the FOLC (May 2019). Many questions were repeated on the pre- and post-workshop surveys in order to measure the effect of the workshop in introducing the curriculum and the FOLC to participants, as well as to get a more accurate baseline measure of participants' teaching knowledge and experience. Using both closed and open-ended questions, the workshop surveys asked about participants' concerns regarding implementing the curriculum, their feelings of preparedness to implement NGPET, their beliefs about teaching and learning, and their thoughts about participating in the FOLC. The workshop surveys were distributed to workshop attendees (including the cluster leaders) and there was approximately a 95% response rate on both surveys.

In May 2019, we surveyed participants again to ask about the impact of participating in the FOLC and members' current thinking regarding the curriculum, as well as to solicit feedback on programmatic aspects of the FOLC. (The complete survey is included in Appendix D). Some of the questions regarding participants' concerns and readiness to implement NGPET that were asked on the workshop surveys were repeated on this survey in order to measure change over time. In addition, new questions were added to assess the benefits of participating in the FOLC.

The survey included a mix of closed and open-ended questions. The survey was distributed to all current community members (including the cluster leaders). There was an 81% response rate. Note, an external evaluator at Horizon Research administered all surveys, processed the raw data, and conducted any statistical analysis included below [134]. Details about the design and analysis of specific questions will be included in the Results section when necessary to understand the data presented.

6.4.2 Results

One set of questions that was included on the post-workshop survey and the May 2019 survey asked about participants' feelings of preparedness to teach NGPET, both from a logistical and pedagogical standpoint. Results from the most recent administration of these questions, in May 2019, are in Table 6.6. These results show that after year two in the FOLC, participants feel at least "Somewhat prepared" in all five queried dimensions of implementing NGPET. FOLC members had implemented the curriculum at least once at the time this survey was administered. Combining the top two ratings ("Fairly well prepared" and "Very well prepared") we see that almost all participants (95+%) feel prepared to structure and teach the NGPET course, including handling logistics. Over 75% of respondents also feel fairly well or very well prepared to assess students in the course. This same set of questions was asked of participants immediately after the initial in-person workshop. At that time, participants were asked about their preparation to implement the Next Gen PET curriculum *before* the workshop (retrospective pre-workshop) and after the workshop. The percent of faculty reporting a sense of preparedness at the levels of fairly well or very well prepared increased at all three time points (see Table 6.7, reproduced from [134]), indicating positive growth. While this is perhaps not surprising, as participants had more and more experience with the curriculum at each time point, it confirms a trend we hope to see.

Feelings of preparedness to implement the curriculum can be attributed to a number of factors, starting with simply having taught the course one or more times. In order to evaluate how *participating in the FOLC* contributed to this sense of preparedness, in the May 2019 survey

Table 6.6: Responses to set of questions on sense of preparedness to teach NGPET, administered in May 2019 survey. Participants rated their preparedness on a four-point scale. N=39

Indicate your current level of preparedness to do each of the following:	Not at all prepared	Somewhat prepared	Fairly well prepared	Very well prepared
Structure your course using the Next Gen PET curriculum	0%	3%	26%	72%
Manage the equipment/logistics associated with implementing the Next Gen PET curriculum	0%	5%	44%	51%
Teach the Next Gen PET curriculum materials effectively	0%	5%	31%	64%
Assess student learning formatively in the context of the Next Gen PET curriculum	0%	23%	44%	33%
Assess student learning summatively in the context of the Next Gen PET curriculum	0%	18%	46%	36%

participants were also asked to what extent had participating in the FOLC prepared them to teach their NGPET courses. Results from this question are shown in Table 6.8. Between 77 and 90% of respondents report that the FOLC "Moderately" or "To a great extent" prepared them to teach NGPET effectively, handle logistics, and structure their courses. Fewer, but still over 60%, feel "Moderately" or "To a great extent" prepared by the FOLC to assess student learning. We also see that along the five dimensions queried, respondents feel the FOLC at least "Miminally" prepared them; no one indicated the FOLC prepared them "Not at all" to implement NGPET.

The questions on preparedness to implement NGPET speak to a number of the immediate goals of the FOLC. The responses to these questions tell us most directly about the goals that participants will increase their **familiarity with the NGPET structure, content, & materials**, and their **confidence in using the curriculum**. The high levels of preparedness respondents report regarding their ability to structure the NGPET course, handle logistics, and teach with the materials effectively, and the increase in the percent of participants indicating a fairly well or very

Table 6.7: Percent of participants reporting feeling "fairly well" or "very well" prepared for various aspects of implementing NGPET. Responses are reported for three time points: retrospective pre-workshop, post-workshop, and May 2019 follow-up. N=22 (the number of participants who answered this question at all 3 time points).

Percent of respondents indicating their current level of preparedness to do each of the following as Fairly well or Very well prepared:	Retrospective Pre-workshop	Post-workshop	May 2019 Follow-up
Structure your course using the Next Gen PET curriculum	30%	87%	100%
Manage the equipment/logistics associated with implementing the Next Gen PET curriculum	43%	78%	100%
Teach the Next Gen PET curriculum materials effectively	48%	87%	91%
Assess student learning formatively in the context of the Next Gen PET curriculum	26%	55%	74%
Assess student learning summatively in the context of the Next Gen PET curriculum	30%	73%	83%

well sense of preparedness since the initial in-person workshop, are indications participants are meeting the **familiarity goal**. Table 6.8 provides more robust evidence that the FOLC specifically is contributing to participants' familiarity with the materials. In addition, the sense of preparedness questions can be indications of **confidence in using the curriculum**. One way to interpret an increased sense of preparedness is as increased confidence. Combining responses on all 5 preparedness statements into a composite score and then testing how the composite scores compare across time points, we find that there is a significant increase in scores at the later times (HLM,$p<0.05$). The May 2019 survey composite scores were on average 1.61 standard deviations higher than the scores at the retrospective pre-workshop time point and on average 0.79 standard deviations higher than the scores at the post-workshop time point (HLM,$p<0.05$) [134]. We also see that the majority of respondents say the FOLC moderately or to a great extent prepared them in these areas.

Table 6.8: Responses to set of questions on *FOLC's* role in sense of preparedness to teach NGPET, administered in May 2019 survey. Participants rated their attribution to the FOLC on a four-point scale. N=39 for the whole table except the last row where N=38.

To what extent has participating in the FOLC prepared you to do each of the following:	Not at all	Minimally	Moderately	To a great extent
Structure your course using the Next Gen PET curriculum	0%	13%	44%	44%
Manage the equipment/logistics associated with implementing the Next Gen PET curriculum	0%	23%	44%	33%
Teach the Next Gen PET curriculum materials effectively	0%	10%	44%	46%
Assess student learning formatively in the context of the Next Gen PET curriculum	0%	31%	44%	26%
Assess student learning summatively in the context of the Next Gen PET curriculum	0%	37%	37%	26%

On the May 2019 survey we also asked participants about the impacts of participating in the FOLC. We provided a list of fifteen (potential) benefits and participants rated each statement based on the extent to which the benefit had occurred for them as a result of participating in the FOLC. We wrote the fifteen benefit statements based on the impacts identified through interviews with NFW-FOLC participants [19] and interviews conducted in summer 2018 with a selection of NGPET-FOLC members after their first year in the FOLC. The statements and results for this question are shown in Table 6.9. In the Table we group the benefit statements into five thematic categories. This grouping was done during our analysis; when participants took the survey, they saw the list of statements ungrouped and in a different order than in Table 6.9.

Table 6.9: Responses to the set of impact statements regarding participation in the FOLC. The statements are grouped into five themes. This grouping was done during our analysis phase. For the statements marked with a *, N=38; otherwise, N=39.

To what extent has each of the following occurred as a result of participating in the FOLC during the 2018-2019 academic year:	Not at all	Minimally	Moderately	To a great extent	Combined: Moderately or To a great extent
Teaching Practice & Pedagogy					
I have incorporated ideas from the FOLC into my teaching	3%	3%	56%	38%	95%
I have become more reflective about my teaching	5%	15%	56%	23%	79%
I have gained a deeper appreciation for the complex aspects to consider in diagnosing teaching challenges	5%	15%	56%	23%	79%
I have gained knowledge about pedagogical techniques *	3%	21%	55%	21%	76%
I have been introduced to new concepts (about teaching and learning) that are helpful for thinking about my ongoing teaching work	3%	23%	54%	21%	74%
Affect					
I have become more excited about my teaching	5%	15%	56%	23%	79%
I am more motivated to try new teaching techniques in my other classes *	3%	26%	42%	29%	71%
I have gained confidence in my teaching	5%	26%	56%	13%	69%
Student Impact					
I have seen increased student learning	10%	26%	44%	21%	64%
Time & Efficiency					
I have developed my skills as a teacher more efficiently than I would have without the FOLC	5%	13%	59%	23%	82%

To what extent has each of the following occurred as a result of participating in the FOLC during the 2018-2019 academic year:	Not at all	Minimally	Moderately	To a great extent	Combined: Moderately or To a great extent
I have saved time in preparing and implementing my course	8%	23%	36%	33%	69%
Community					
I have gained a community which supports my teaching practices	3%	8%	28%	62%	90%
I have learned that others face similar teaching challenges	3%	10%	33%	54%	87%
I have learned how other institutions/departments compare to my own	3%	10%	36%	51%	87%
I have received encouragement and moral support regarding my teaching*	3%	13%	26%	58%	84%

For all of the benefits related to teaching practice and pedagogy, at least 74% of respondents said that they have experienced those impacts moderately or to a great extent because of their FOLC participation. These benefits include gaining knowledge of pedagogical *techniques* as well as pedagogical *concepts*, and putting these ideas into action through their teaching and reflection on their practice. Of particular note, we see that 95% of respondents said they have incorporated ideas from the FOLC into their teaching to a moderate or great extent. On the May 2019 survey, we also asked participants in an open-ended format to describe the most significant impact(s) of participating in the FOLC. Illustrating the impact of gaining implementation ideas from the FOLC, one respondent shared, "The biggest impact has been the sharing of ideas, and being able to pick out the ones that fit best into the context of my institution for implementation." Another participant said the most significant impact for them is, "Seeing and experiencing the implementation of new teaching methods that are vastly different than what I've done before. This has opened the possibilities of the classroom like never before for me." This participant has

expanded their pedagogical toolkit in learning about active learning teaching techniques that are "vastly different" from what they are used to doing. Yet another participant specifically noted how one of the most significant impacts is, "being more reflective in my practices as I work with my colleagues and others in the FOLC." Reflecting on one's teaching practice is one of the main skills we hope to instill in FOLC participants.

The benefits participants report to their teaching practice and pedagogy indicate that the FOLC is meeting a number of its goals. This data suggest we are meeting the immediate-term goals on **increasing participants' knowledge of pedagogical techniques, reflection on their teaching practice in the NGPET course, and use of pedagogical techniques in the NGPET course**. Consider, 76% of respondents directly indicate that they have indeed increased their knowledge of pedagogical techniques to a moderate or great extent because of the FOLC. Moreover, the teaching practice and pedagogy items do not specify if they are referring to the NGPET course exclusively, so they also speak to our longer-term goals for participants of **applying the pedagogical techniques used in NGPET to their other courses** and **engaging in reflection on their teaching practice in all their courses**. For example, 79% of respondents said that they have gained a deeper appreciation for the complex aspects to consider in diagnosing teaching challenges, moderately or to a great extent due to their participation in the FOLC. This indicates that they have gained pedagogical knowledge and reflection skills, which can be applied across their teaching practice.

Next looking at the benefits categorized under the theme of Affect, over two-thirds of respondents report that the FOLC moderately or to a great extent contributed to increased motivation, excitement, and confidence in their teaching. In the open-ended question on the most significant impacts of FOLC participation, one participant shared, "The [FOLC] meetings really motivate me to do better, and to be accountable for my teaching and students." This participant demonstrates that motivation is an important aspect in growing and improving one's teaching practice. These set of benefits directly relate to the immediate-term NGPET-FOLC goal that participants will **increase their confidence** in using the curriculum and the longer-term goal that participants

will **apply the pedagogical techniques used in NGPET to their other courses**. It is particularly encouraging to see that 71% of respondents say that moderately or to a great extent because of their FOLC participation they are motivated to try new teaching techniques in their non-NGPET courses. Even at the end of year two, there are indicators that the NGPET-FOLC will have an impact beyond participants' NGPET course.

One of the fifteen benefit statements relates to the impact of the NGPET-FOLC on participants' students. Of the survey respondents, 64% said that they have seen increased student learning moderately or to a great extent due to their participation in the FOLC. Of course, it is hard to disentangle the impact of the FOLC from the impact of the curriculum on student learning as the instructors' experiences of teaching the curriculum and participating in the FOLC are intertwined. Nevertheless, the fact that the majority of respondents are reporting seeing student learning gains shows that we are making progress on the long-term goal of **achieving student learning gains in the NGPET course**. We have also heard of (unexpected) learning opportunities for students due to their instructor's participation in the FOLC. One survey respondent said that, "One of the most useful aspects of FOLC was to let my students know that I was discussing issues about how the course was being presented so that provided them with a greater understanding of the teaching process and the students appreciated that." Recall, many of the students taking the NGPET course are prospective elementary teachers and they have more to learn than the content contained in the NGPET curriculum; they are also learning about the practice of teaching.

Turning our attention now to the Time and Efficiency benefits reported in Table 6.9, we see that for 69% of respondents, participating in the FOLC moderately or to a great extent contributed to their saving time in preparing and implementing their NGPET course. Even more respondents, 82%, report that moderately or to a great extent they have developed their teaching skills more efficiently than they would have without the FOLC. These are both very encouraging findings because participating in the FOLC takes time, and this could be a significant deterrent to faculty involvement. Faculty commonly cite lack of time as preventing them from implementing research-based teaching techniques [7, 135]. It is therefore important that any program to support faculty in

implementing these techniques respect the time of faculty who are often overworked and balancing multiple responsibilities. Hopefully the benefits to faculty from participating in a FOLC motivate and justify the investment of time, or even save time overall. This appears to be the case for many NGPET-FOLC members. In responding to the open-ended question on the most significant impacts of participating in the FOLC, one participant said that, "having a network of people makes it very efficient to get started [on a new teaching prep]." Implementing a new course can be an immense undertaking, but this participant recognized the FOLC as alleviating that burden. Another response to the significant impact question perhaps offers one reason why the FOLC helps some participants save time in their teaching work; this respondent said, "[The FOLC] enabled me to anticipate difficulties that students and instructors have with the curriculum, enabling me to be more prepared in my own teaching." The implementation experiences shared in the FOLC helped this member feel more prepared in teaching their course. These Time and Efficiency statements do not directly relate to the NGPET-FOLC goals for participants as they are more indicative of the process by which the goals are being achieved. Still, it is important feedback for the NGPET-FOLC designers that the program is not an onerous commitment for many participants.

Finally, a set of the benefit statements in Table 6.9 are related to community formation. There cannot be a FOLC without a sense of community established between members, and it is through community that the NGPET-FOLC is designed to achieve its outcomes. Participating in a professional community provides opportunities for members to discuss problems of practice, gather feedback, share information and resources, provide encouragement, and explore concepts related to their domain of practice. The results in Table 6.9 strongly indicate that many NGPET-FOLC members feel they are part of a community. On all the statements related to community, over 80% of respondents said they have experienced the benefits moderately or to a great extent due to their participation in the FOLC. Particularly important, 90% of respondents said that moderately or to a great extent they have gained a community which supports their teaching due to their participation in the FOLC.

Results from another survey question show that not only is a community established, but

participants highly value the FOLC community. In an open-ended question on the May 2019 survey, we asked participants what they found most valuable about their participation in the FOLC. We reviewed the 33 responses to this question, coding for the main topic(s) of the response. Coding categories were semi-emergent, but also influenced by themes seen in responses to the questions about the impact of participating in the FOLC. Almost all of the responses cited sharing knowledge/implementation support and/or the community they formed with their FOLC members as the most valuable part of the FOLC experience. Often, the value of sharing knowledge and the community were intertwined. For example, one FOLC member said, "It is nice to talk with people who have approached the same problems from different perspectives, and so have developed solutions I might not have thought of myself." For this member, the implementation help and knowledge they gained was particularly valuable because it came from people who are teaching Next Gen PET, but have different experiences and ideas than their own. Another participant echoed this idea, sharing, "Sometimes it is just nice to talk with other people about how your class is going and it is really helpful when the other people understand what you're trying to accomplish and why you are teaching in a certain way." Participants valued the opportunity to connect with instructors who had similar pedagogical alignments and were invested in implementing Next Gen PET.

In order to determine if participating in the FOLC is impacting members' teaching in their non-NGPET courses, we included a question on the May 2019 survey that asked "Has participating in the FOLC impacted mostly your teaching of the Next Gen PET course, mostly the other courses you teach, or a mix of both?" Participants marked their response on a five-point scale ranging from "Mostly my Next Gen PET course" to "Mostly other courses." The results from this question are displayed in Table 6.10. The "spread" of impact to other courses is related to two of the long-term outcomes we hope FOLC participants achieve: **applying the pedagogical techniques used in NGPET to their other courses** and **engaging in reflection on their teaching practice in these other courses**. The results from the question asked on the May 2019 survey provide early indications of participants meeting these goals. Unsurprisingly, the majority (59%) reported

impacts primarily on their Next Gen PET course, but encouragingly 41% indicated the FOLC had some impact on their teaching of other courses as well. We do not expect to see much transfer to other courses at the end of year two of the FOLC, especially since the focus of the first two years was heavily on implementing the NGPET course, so these results are promising for the potential impact participating in the FOLC will have on members' teaching overall at the end of the five years. Even at the two-year mark, 21% of respondents said that participating in the FOLC has impacted "A roughly equal mix" of their NGPET and non-NGPET courses. In the future, we plan to collect more information about the types of courses members' are applying their learning to and what exactly they are transferring.

Table 6.10: Responses to a question on the spread of impact of the NGPET-FOLC to other courses. N=39

	1 Mostly my Next Gen PET course	2	3 A roughly equal mix	4	5 Mostly other courses
Has participating in the FOLC impacted mostly your teaching of the Next Gen PET course, mostly the other courses you teach, or a mix of both?	59%	15%	21%	3%	3%

The survey results presented in this section all indicate that the NGPET-FOLC is meeting its goals for participants. As a summary of the information presented above, Table 6.11 compiles the survey items that provide support for each FOLC outcome. While no survey item directly relates to the goal that **participants persist in using the curriculum**, we can say that current FOLC members are continuing to use NGPET. (There have been a handful of members who dropped out because they were no longer teaching NGPET, often due to course assignment changes, but those who are in the FOLC are using the curriculum). The results show that the NGPET-FOLC is "working." By this we mean that a functioning community is established (and this is the mechanism by which the FOLC is designed to meet its outcomes) and the FOLC is achieving the goals it set

out for participants to achieve. At this time, we have ample evidence that participants are meeting the immediate-term goals and there is encouraging early evidence that long-term goals will be met.

Table 6.11: Summary of the survey results that show the FOLC outcomes are being met. Note, no survey item directly relates to the "Persistence in using the curriculum" outcome, but continuing participation in the FOLC is evidence of members still teaching the curriculum.

NGPET-FOLC Goals for Participants	Survey items whose results indicate goal is being met
Immediate-Term Goals	
Increased familiarity with the NGPET structure, content, & materials	Preparedness to teach NGPET questions (Table 6.6 & Table 6.8)
Increased confidence in using the curriculum	Preparedness to teach NGPET questions (Table 6.6 & Table 6.8)
	Affect Impacts (Table 6.9)
Increased knowledge of pedagogical techniques	Teaching Practice & Pedagogy Impacts (Table 6.9)
Increased reflection on their NGPET teaching	Teaching Practice & Pedagogy Impacts (Table 6.9)
Increased use of pedagogical techniques in their NGPET implementation	Teaching Practice & Pedagogy Impacts (Table 6.9)
Longer-Term Goals	
See student learning gains in their NGPET course	Student Impacts (Table 6.9)
Persist in using the curriculum	N/A (no survey item directly relates to this outcome; continuing participation in FOLC is evidence of members still teaching NGPET)
Apply the pedagogical techniques used in NGPET to their other courses	Teaching Practice & Pedagogy Impacts (Table 6.9)
	Affect Impacts (Table 6.9)
	Spread of impact of the NGPET-FOLC to other courses question (Table 6.10)
Engage in reflection on their teaching practice in *all* of their courses	Teaching Practice & Pedagogy Impacts (Table 6.9)
	Spread of impact of the NGPET-FOLC to other courses question (Table 6.10)

6.5 Discussion and implications for the FOLC model

The NGPET-FOLC is meeting its goals for participants, providing proof of principle that the FOLC model can work in multiple contexts. While the learning goals of the NFW-FOLC and NGPET-FOLCs are not identical, they are each achieving their respective goals. Additionally, they are achieving the goals they have in common, namely increasing participants' knowledge of pedagogical techniques and participants applying pedagogical techniques and engaging in reflection across their courses. Even with the differences between each FOLC implementation, they are able to achieve similar goals. In this section, we discuss what we can learn from this adaptation of the FOLC model and identify areas for future inquiry.

6.5.1 Key characteristics and principles of a FOLC

Preserving the main structural components and principles of the NFW-FOLC, the NGPET team successfully adapted the model to a community focused on a shared curriculum and designed to last multiple years. Referring back to Table 6.2 we see that both the NFW-FOLC and NGPET-FOLC are facilitated communities of geographically-dispersed faculty members that meet regularly on Zoom to troubleshoot teaching challenges and to grow and discuss their pedagogical knowledge (NFW-FOLC Design Principles 1 & 2). These Zoom meetings are timely (occurring throughout the academic term as members are teaching) and both groups operate with a participant structure defined by mutuality, expecting and valuing the contributions of all participants (NFW-FOLC Design Principle 4). In addition, they use Slack to connect between meetings and share resources. Both groups engage in some form of teaching project in order to promote reflection (NFW-FOLC Design Principle 5), although the details and focus of these projects differ. The NFW-FOLC and NGPET-FOLC both aim to establish a supportive community among members and to ensure that members can be vulnerable within their group (NFW-FOLC Design Principles 6 & 3, respectively).

While acknowledging these similarities, we also recognize that the common design principles are enacted in different ways in the two FOLCs due to the two main differences between the

groups. These differences can be summarized as the focus of each community and each community's structure. In contrast to the NFW-FOLC, the NGPET-FOLC has a narrow topical focus (at least in its first two years) and the community has a longer duration (multi-year) with a larger total membership that is split into smaller groups whose membership shifts year-to-year. The (initial) focus of the NGPET-FOLC on supporting members in implementing the NGPET curriculum is reflected in the content of their Zoom meetings and their projects. This is to say that NFW-FOLC Design Principles 1, 2, and 5 "look" different in practice in the NGPET-FOLC. Similarly, NFW-FOLC Design Principles 3 and 6 look slightly different in the NGPET-FOLC because when we talk about "community" there we have to consider a participant's smaller cluster as well as their connection to the larger, 50-person community overall.

Both FOLCs are meeting their goals even with these differences. We can thus conclude that the design principles (at least in essence) and major programmatic elements (i.e. Zoom videoconferences, Slack asynchronous platform, and projects) of the NFW-FOLC work for the NGPET-FOLC. What, then, are the implications for the FOLC model in general? In terms of the focus of a FOLC, it seems that the model works for both cohort-based (e.g. new faculty) and topic-based (e.g. implementing a certain curriculum) groups[1] . For the NGPET-FOLC, it did not matter that members were at different career stages and came from a range of STEM departments; the shared curriculum provided the connection between NGPET-FOLC members and the community of instructors implementing the same curriculum was what many members reported valuing. In the NFW-FOLC, we see an opposite yet similar result: for the vast majority of participants, it did not matter that members were teaching a variety of courses; the shared career stage of being new and relatively inexperienced physics and astronomy faculty members was what provided the (highly-valued) connection between NFW-FOLC members. It seems, then, that what is important for FOLC design and functioning is that the group connects participants around a shared purpose that is highly valued by each member; the shared purpose though could be related to a particular topic or identity of the community members.

[1] This is true for FLCs as well [71].

Additionally, we can conclude that a FOLC cohort (or cluster) of approximately 10 members works well. This is large enough to sustain conversations and provide multiple perspectives without being so large that some community members are never heard from. This small-group model also works for a larger overall community, as is the case in the NGPET-FOLC. Shifting membership in the small groups from year-to-year in a multi-year community also does not appear to have a large effect on the sense of community established (more on this in Section 6.5.3 below). It is still unclear, however, what the value of a multi-year versus one-year FOLC is. Many NFW-FOLC participants indicate interest in having periodic meetings after their FOLC ends with other alumni on Zoom. In addition, a number of the NFW-FOLC facilitators decided to become a facilitator to extend their FOLC experience past their year as a participant. This feedback indicates that participants see value in a FOLC that extends beyond one year. After all, more time together provides more opportunities for learning. On the other hand, we see from the NFW-FOLC that a lot can be accomplished in only one year, and we suspect there may be a saturation point past which a FOLC's conversations are no longer very generative for participants. The NGPET-FOLC does not seem to have reached a saturation point after two years, perhaps because adopting the curriculum is a large endeavor for instructors to undertake, let alone implementing their new knowledge and skills in other courses they teach. In Sections 6.5.2 and 6.5.3 which follow, we will pose specific questions to be addressed in future work regarding the ideal length of a FOLC.

From the interviews with NFW-FOLC participants and the open-ended questions on the NGPET-FOLC survey, we can suggest two more important elements to FOLC design. First, FOLC members value the variety of perspectives they hear in the FOLC due to *membership from a range of institutions*. Second, they also appreciate the opportunities provided by the FOLC to *share ideas and troubleshoot teaching challenges with a community of peers*. Both the activity of problem solving and discussion and the undertaking of this activity with a group of people who understand each others' contexts are important for FOLC design. At its most basic, then, a FOLC is a community of practice of faculty members from different institutions that communicate online in pursuit of their shared purpose. This common goal is worked toward collectively and

collaboratively, guided by the facilitation of a more experienced community member. Below we explore two areas of future work which will expand our knowledge on the essential characteristics of a FOLC.

6.5.2 Capacity to implement pedagogical techniques & knowledge across teaching practice

One of the major differences between the NGPET-FOLC and the NFW-FOLC is the focus and motivation of each community. The NGPET-FOLC is focused on implementing a specific curriculum whereas NFW-FOLC members are connected by their shared status as new faculty interested in improving their teaching. Given this difference in focus, one might expect that most of the impacts on NGPET-FOLC participants' teaching will be related specifically to their NGPET course. After all, the immediate-term goals for NGPET-FOLC participants are concerned with implementation of NGPET. Additionally, the pedagogy is built into the curriculum so members are focused on employing the teaching strategies specified by NGPET rather than choosing which techniques to use. In contrast, the NFW-FOLC supports members in using their choice of research-based instructional strategies (RBISs) in a variety of undergraduate physics and astronomy courses. In the NFW-FOLC, participants learn about RBISs generally while simultaneously discussing how to implement them in their unique contexts. These discussions provide a broader view of the potential of the active-learning pedagogical strategies than would a conversation on the implementation of these strategies in just one context. Both FOLCs ultimately want their participants to develop reflective teaching habits and to persist in their use of RBISs across their teaching practice (the range of courses they teach), but they approach these goals from different directions. The NGPET-FOLC starts with a focus on a specific curriculum and only later turns to transferring these skills; the NFW-FOLC starts generally, considering how to apply a range of RBISs in wide spread of physics and astronomy courses. This leads us to ask, *what are the consequences of a FOLC taking a "general-to-specific" versus a "specific-to-general" approach in supporting members' implementations of RBISs?*

Above, we demonstrated the differences in shared repertoire that the two FOLCs have and how a shared curriculum does afford NGPET-FOLC members the opportunity to discuss extremely specific issues. One NGPET-FOLC member shared, "I have benefited from having a community of people using the same curriculum that I am using because it has given me a place to trouble shoot issues I am having with the materials/equipment. It has also allowed me to hear how other students are doing so I don't have unreasonable expectations for my own students." This participant is expressing the value in a shared curriculum: members can provide logistical support and realistic expectations for student performance (an important element of implementing a new curriculum that deviates from traditional instruction). Our survey data shows that NGPET-FOLC members are being supported in their NGPET implementation, and they are also beginning to transfer some of their learning to other courses they teach. Anecdotally, we are hearing from the cluster leaders that conversations this year (year three) are broadening to members' non-NGPET courses. It is possible then for this transfer of knowledge to other contexts to occur even when the FOLC is initially focused on a specific course, but our evidence shows that this transfer started at earliest after year one of the FOLC, and not intentionally until year three. This suggests that if a FOLC is hoping to support participants in implementing RBISs across their teaching practice, but they want to start with a focus on a specific curriculum or course, they should consider adopting the multi-year model of the NGPET-FOLC in order to give time for transfer to other courses to occur. Alternatively, it may be possible to both support implementation of a specific curriculum and transfer of practices to other courses in a one-year time frame if explicit focus is placed on the latter as the former is ongoing. An area of future work with the NGPET-FOLC will be to identify the specific elements or impacts participants transfer to their other courses and how explicitly this transfer was supported. This will provide much more detail about the consequences (bad and good) of taking a "specific-to-general" approach in supporting members' implementations of RBISs. In other future work, it will be important to investigate the question of the necessary length of a FOLC, specifically if the goals of a "specific-to-general" approach can be successfully accomplished in one year, or if longer is needed.

6.5.3 Strength of community formed

The NFW-FOLC and NGPET-FOLC also differ in the structure of their communities. The NGPET-FOLC members are connected to a much larger community during their time in the FOLC and the community is in place for a longer time. There are a number of potential consequences of this difference. On the one hand, a large community provides more perspectives and more members to draw ideas and support from. On the other hand, it may be harder to feel a part of a larger community and to trust all the members. The NGPET-FOLC mitigated these challenges by providing multiple opportunities for people to connect (i.e. through FOLC meetings, the Slack workspace, and the project groups). The multi-year design of the FOLC also seems important for people to get to know everyone in the large community; one plan for future work is to conduct social network analysis on the community to see how connected different members are, especially with the members who are not in their cluster. We do have evidence (presented in the Results section) that FOLC members do indeed feel they are part of a community, but we did not ask them to define who makes up that community.

The NGPET-FOLC members were redistributed into clusters this year, resulting in new groupings of participants. While this was much easier logistically, it potentially could have disrupted the sense of community members felt towards the FOLC. Anecdotally, we have heard from cluster leaders that the new groups have melded seamlessly. This is encouraging and perhaps an indication that members already felt connected to the members who were not part of their original clusters. Another area of future inquiry will be to see if and how participants' sense of community shifts this year. It will be particularly informative to learn from members what benefits they have drawn from having new cluster members (e.g. Did the new membership reinvigorate FOLC discussions?).

The community structure of both the NFW-FOLC and the NGPET-FOLC work in the sense that community is established in both groups and both groups are achieving their objectives. With the future work laid out above, we will be able to determine the crucial aspects of a larger community (e.g. Is it necessary to shift around sub-group membership? and Is it important that

the community meet for multiple years in order for members to establish connections outside their sub-group?). Identifying the benefits of the larger community will likewise inform future NFW-FOLC design, such as the structure and support that should be provided to connect current cohorts and alumni.

Chapter 7

A Tool for classifying learning opportunities in faculty members' conversations about teaching

This chapter represents a manuscript in the final stages of preparation: Lau, et al. 2020 [23] and is expanded from an earlier conference proceedings paper [24].

7.1 Introduction & motivation

Having presented two different implementations of the FOLC model and explored the adaptability of the model, I now turn to a tool for analyzing FOLC meetings. As the previous chapters have demonstrated, FOLCs can be effective at supporting faculty in trying and persisting in using research-based teaching strategies and materials. That said, not all FOLC cohorts unfold in identical ways and their norms and conversational patterns can be quite distinct. Some groups focus on very practical implementation details whereas other cohorts engage in discussion of why certain problems are occurring and connect particular problems to more general phenomena. While both types of discussions can be appropriate and valuable, they offer different learning opportunities. In order to best support faculty members' teaching development, we need to be able to describe the learning possible for faculty members in a given FOLC cohort and even more so, explain the variation in FOLC enactment across groups and within a group over time. A mechanism for describing both what occurs in a FOLC and why it is happening is useful in developing best practices for running FOLCs.

In this chapter I present a taxonomy for describing the learning opportunities in FOLC

meetings. This tool provides a systematic approach to making sense of the complex, dynamic, and abundant social interaction which occurs during the hour-long FOLC meetings. I first describe the theoretical commitments underlying the taxonomy, specifically our choice to focus on capturing the opportunities to learn for the members of the FOLC group, collectively. I then detail the development process of the taxonomy, present the taxonomy itself, and introduce the elements of the taxonomy, with illustrative examples provided for each construct. Finally, I discuss the utility of the taxonomy and demonstrate the types of claims the tool can help build along with a discussion of the affordances and limitations of the tool and the contexts beyond a FOLC in which I see the taxonomy being useful. The taxonomy has both analytic and practical uses.

7.2 Theoretical framing

7.2.1 Opportunities to learn and a sociocultural perspective on learning

The taxonomy presented in this chapter is built to describe the opportunities to learn (OTLs) in FOLC conversations. With this focus on OTLs, we are attending to the process of learning (rather than the outcomes only) and this allows us to make claims about how the environment and social structures of the FOLC contribute to learning of the collective group.

Our definition of OTLs is grounded in a sociocultural view of learning. Rather than viewing learning as a purely cognitive, individual process, a sociocultural perspective considers the interactions of the environment (i.e. context, other people, tools) and history (i.e. one's prior knowledge) in the process of learning [17, 25–27, 30]. In this perspective, learning can be defined as changing participation in a community of practice (CoP), or changing the practices of a CoP [17, 26, 34, 136]. As Gee explains, "The central ideas [of a CoP] are that **people learn new practices through participation with others**, that they are networked with others and with various tools and technologies in ways that allow them to accomplish more than they could by themselves, and that **knowledge is stored as much in the network and the practices of the group as it is in any one person's head**" [25, p. 92, emphasis added]. FOLCs are one example of a CoP, with a

joint enterprise of improving their teaching practice and a shared repertoire (i.e. ways of communicating, tools, artifacts) for accomplishing this goal [17, 18, 32]. Viewing learning as influenced and mediated by the environment, tools, and culture, if one changes how they interact with those elements, that is a change in practice, and thus learning has occurred.

7.2.1.1 Group learning

With this taxonomy, we consider the opportunities to learn available to the *FOLC group* [70, 136]. Our unit of analysis is a FOLC conversation[1] and this allows us to make claims about the OTLs for the *collective* participants in the conversation, rather than the *individual* members of the conversation. One can view a conversation as representing a collective zone of proximal development (ZPD) for the group engaging in the conversation [30, 70]; this means that the conversation (which is scaffolded by all participants, but especially by the facilitators) represents the resources and concepts available to the group and their ideas about what is possible (to learn and do). It is through participation in a community that OTLs arise so we focus our analysis on the conversations of a FOLC group.

The learning of a group occurs when there is a "change in its practices" [34, p.174]. The practices of a group include the conceptual resources it draws on, the ways it approaches solving problems, and its discourse. Consider an example by Greeno and Gresalfi of a class learning: "A classroom's practices change as information and concepts are added to its common ground, supporting changes in the content of its discourse...the practices of the classroom, specifically in terms of the ways participants can make sense of new information, change. Opportunities to learn for a classroom include resources and practices that can support the extension and transformation of those practices" [34, p. 175]. New ideas provide new ways to understand concepts and phenomena, and enacting a new way of understanding constitutes a new practice for a community. We can draw a parallel from this classroom example to FOLC conversations; as faculty discuss their teaching with a FOLC group, different ways of thinking about a pedagogical issue are introduced and a

[1] An hour-long FOLC meeting is comprised of a number of conversations.

range of concepts are brought into the conversation. When these resources are new to the group, its collective ZPD expands as its practices and sense of what is possible (in terms of teaching) grow.

7.2.1.2 Defining opportunity

When we talk about OTLs, we are using "opportunity" in a literal sense: an OTL describes the potential for learning to occur. OTLs are "affordances for changing participation and practice" [34, p. 172], where affordances describe the resources and practices of a community, and the ability of members to use the resources and interact with the practices [34, 137, 138]. The taxonomy we present describes the affordances of FOLC conversations for changing how the group acts and thinks about different challenges they face.

7.2.1.3 Operationalizing opportunity to learn

We operationalize OTL by considering what causes a change in participation. Following Horn and colleagues' definition, we describe an OTL provided by a FOLC conversation by considering the conceptual resources employed in the conversation and how the conversation prepares participants for their future work [70, 136, 139]. Conceptual resources include ways of representing one's practice (e.g. replays and rehearsals), ways of interpreting those representations, different problem framings, and epistemic stances [69, 70, 140, 141]. These resources are what a group uses to understand a problem and to imagine possible solutions.

For the purpose of our taxonomy, we describe both pedagogical and non-pedagogical OTLs in FOLC conversations. We define pedagogical as a conversation attending to students' learning and the effects of teaching practices on their learning. In a FOLC, OTLs extend beyond the pedagogical to include other learning opportunities (e.g. the opportunity to get to know fellow cohort members) which affect the ways the community functions.

7.3 Development process

7.3.1 Development context

The taxonomy was mainly developed in the context of the Next Generation Physical Science and Everyday Thinking (NGPET) FOLCs [120]. As described in the previous chapter, these FOLC groups support instructors who are implementing the NGPET curriculum. NGPET is a physical science curriculum for future elementary teachers, but it is also used in general education university science courses. The curriculum employs a guided-inquiry pedagogy, allowing students to construct the main ideas in each unit through experimentation and modeling. Instructors can choose their implementation format based on their classroom constraints (either lecture or studio-style course). Instructors also choose the topics to cover from five modules: Developing Models for Magnetism and Static Electricity; Interactions and Energy; Interactions and Forces; Waves, Sound, and Light; and Matter and Interactions.

There are five NGPET-FOLC groups, each consisting of approximately ten members who are teaching the curriculum, including two to three facilitators who are experienced NGPET practitioners. From monitoring a number of FOLC meetings across various groups, we know the content and norms of their conversations are not identical. Each group's meetings are focused on implementation of the NGPET curriculum and challenges members are facing, but the types of issues they focus on and the depth of their conversations vary. We created the taxonomy to help describe and explain this difference.

7.3.2 Taxonomy origins

The taxonomy I present in this chapter is adapted from an existing framework for classifying opportunities to learn about teaching [136]. Horn, Garner, Kane, and Brasel constructed a taxonomy to describe how different forms of interaction afford different types of learning in the context of in-person, middle school mathematics teacher workgroups. More specifically, their taxonomy describes how collegial conversations range in the nature and depth of support they provide for

teachers' learning [136]. The framework defines six categories of workgroup meetings based on the pedagogical concepts developed, the degree of mobilization for future teaching work, and the nature of the discourse in the meeting. We used this framework as a starting point for analyzing NGPET-FOLC meetings.

Horn et al.'s taxonomy characterizes OTLs by considering both the *content* of a conversation as well as *how* participants engage in the conversation [136]. They see the richest learning opportunities as occurring when a conversation involves the teachers developing a pedagogical concept while mobilizing them for their future teaching work. Our taxonomy preserves the overall organization of Horn et al.'s taxonomy, but the outcome of applying that organization to FOLC meetings has resulted in a taxonomy which differs substantially from theirs.

7.3.3 Tool development process

We began by applying Horn et al.'s taxonomy [136] to one NGPET-FOLC meeting in order to see how well the taxonomy fit the FOLC context. This initial test alerted us to a number of changes that would be required to adapt the taxonomy to our context. For example, the meeting categories which comprehensively describe the types of mathematics teacher workgroup meetings in Horn's data corpus did not do the same for FOLC meetings. While some of their categories applied to the FOLC context, a number did not. It was clear we would need to define additional meeting categories to capture the full scope of FOLC meetings. We also wanted to describe *how* participants engage in a conversation in more detail than Horn et al.'s taxonomy provides. We turned to the work of Scott, Mortimer, and Aguiar [142] for constructs that would add the desired level of detail.

We went on to apply the taxonomy to three additional NGPET-FOLC meetings, iteratively refining the tool with each application. One member of the research team (ACL) would divide a meeting based on shifts in conversational purpose [143]. Then three to four researchers independently coded each meeting segment along the dimensions of the taxonomy (describing both the content of the conversation and how the conversation unfolded). (Each time the researchers were

working from a codebook which represented our current understanding of the taxonomy). The team of coders would then compare their coding for each segment until full agreement was reached. Reaching consensus entailed adding elements to taxonomy, clarifying existing definitions, and looking for similar segment examples. Through these coding comparisons, we specified code definitions and identified touchstone examples for each code in the taxonomy. As our taxonomy developed, we re-coded meeting segments as necessary to reflect any definition changes we had made.

We purposefully chose the four NGPET-FOLC meetings used in developing the taxonomy to come from two cohorts with different norms in order to capture a range of what occurs in the NGPET-FOLCs. This work resulted in the first full version of the taxonomy for classifying OTLs in FOLC meetings. Through this cycle of coding and comparison, we developed our definitions for how to describe the content of a conversation (encoded in concept development codes and meeting segment category codes) and for how to describe the discursive nature of a conversation (encoded in communicative approach codes).

7.3.3.1 Tool refinement

We wanted to test the applicability of the first full version of the taxonomy to other FOLC groups, as we wanted the tool to be useful beyond the specific NGPET-FOLCs. Recall from earlier chapters that the New Faculty Workshop FOLC (NFW-FOLC) connects new physics and astronomy faculty for the year following their attendance at the in-person Workshop for New Physics and Astronomy Faculty [13, 19]. The Workshop introduces faculty to research-based instructional strategies and the FOLC supports the faculty members as they implement the techniques in their classrooms. The structure of the NFW-FOLCs is similar to that of the NGPET-FOLC, with the main difference being that members of the NFW-FOLCs are not using the same curriculum. We applied the taxonomy to two NFW-FOLC meetings following the same process as described above: individual coding followed by comparison and discussion until consensus was reached. The taxonomy largely applied to the context of the NFW-FOLC, but we found that we needed to refine meeting category and communicative approach definitions to account for the slightly different

conversations that occur in the NFW-FOLC.

At this point, the taxonomy had changed significantly since the beginning of the development process. Therefore, we returned to the first two NGPET-FOLC meetings we had coded to re-code based on the current taxonomy version. With this last round of coding, we finalized the taxonomy elements and their definitions.

7.4 Taxonomy

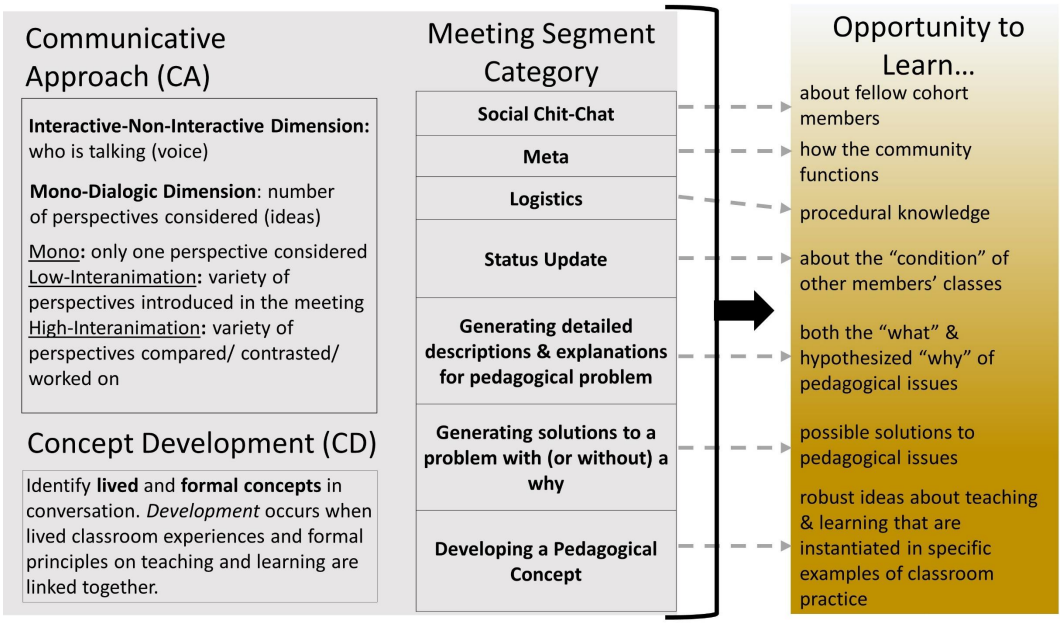

Figure 7.1: Overview of the taxonomy for describing learning opportunities in FOLC meetings. A meeting segment is coded for communicative approach (CA), concept development (CD), and meeting segment category in order to describe the learning opportunity in that segment.

The taxonomy is organized around three major constructs: communicative approach, concept development, and meeting segment category. Communicative approach (CA) describes how people engage in a conversation while concept development (CD) and meeting segment category describe what people are talking about. Figure 7.1 provides an overview of the taxonomy. A FOLC meeting can be divided into conversational segments based on when the purpose of the conversation shifts [143]. Segments can last less than a minute to over twenty minutes. The taxonomy is meant to be applied to each segment (i.e. each segment can be coded for CA, CD, and meeting segment

category). Together, these three elements indicate the OTL provided by a meeting segment. Once the taxonomy is applied to each segment of a whole meeting, one is left with a detailed description of the OTLs provided in the hour-long meeting. Below we describe each of the major elements of the taxonomy and provide examples for each code.

7.4.1 Communicative approach

An important aspect of the social interaction in FOLC meetings is how members are communicating with each other. The communicative approaches used are consequential for the learning opportunities provided by a conversation. In order to describe how people are engaging in FOLC meetings, we adapted Scott, Mortimer, and Aguiar's classification scheme for describing classroom talk [142, 144]. This scheme defines communicative approach along two dimensions: classifying who is talking (the "Interactive-Non-interactive" Dimension) and classifying how ideas are discussed (the "Mono-Dialogic" Dimension).

7.4.1.1 Interactive-Non-Interactive dimension

Interactive talk means there is substantive engagement in the content of the conversation by more than one person. This can range from a person asking clarifying questions about an idea someone else shared to (multiple) people adding ideas, solutions, or reflections on the topic being discussed. In contrast, **non-interactive** talk describes conversations in which only one person is substantively contributing. Other people can talk during this conversation, but their contributions stay at the surface level, limited to simple phrases of agreement or acknowledgement (e.g. "I agree," "umm hum") or a facilitator directing the conversation (e.g. "Sue, go ahead").

7.4.1.2 Mono-Dialogic dimension

This dimension describes *how* ideas are discussed and taken up; it has nothing to do with the number of voices in the conversation. **Mono** conversations only consider one perspective on an idea, or involve the sharing of facts. **Dialogic** conversations involve the consideration of multiple

perspectives on an idea.

Dialogic discourse can be further described based on how the multiple perspectives are introduced into the conversation; this is known as the interanimation of ideas [142, 145]. Dialogic discourse involves **low level interanimation** of ideas when, "different ideas are made available on the social plane [of the FOLC meeting]" [142, p. 611]. Dialogic discourse involves **high level interanimation** of ideas when, "different ideas are explored and worked on by comparing, contrasting, developing" [142, p. 611]. With low level interanimation, ideas are simply introduced to the conversation, while with high level interanimation, those ideas are directly brought together through comparison and/or development.

Table 7.1: Examples of mono discourse, dialogic discourse with low level interanimation of ideas, and dialogic discourse with high level interanimation of ideas.

How ideas are discussed	**Example**
Mono	A. Somebody shares how they enforce attendance in their class, "I do X." This is not followed-up on; conversation moves on to a new topic.
	B. Sharing facts. Someone says, "My institution has a policy which prohibits us from including attendance in our grades."
	C. Somebody shares how they enforce attendance in their class, "I do X." Other people ask clarifying questions about the policy, e.g. "How do you implement X?"
Dialogic Discourse with Low Level Interanimation of ideas	D. Multiple people share how they enforce attendance in their class. This is done in a round-robin format: "I do X," "I do Y." People do not directly engage in what others have shared.
	E. One person shares how they used to enforce attendance and how they currently enforce attendance (two different practices). They do not directly compare these practices.
Dialogic Discourse with High Level Interanimation of ideas	F. Multiple people share how they enforce attendance in their classes and these ideas are directly compared, contrasted, and/or engaged with. Person A shares, "I do X." Person B responds, "I've tried X before and it didn't work for my class because of Z. Instead, I find that practice Y is a more effective strategy."
	G. One person shares, "I used to do X to enforce attendance and I thought it was perfect for my small class size. However, this semester I also have a small class and X has not worked. Instead, I now think Y is a better strategy to handle attendance in small classes because _____."

The distinction between mono discourse, dialogic discourse with low level interanimation of ideas, and dialogic discourse with high level interanimation of ideas is most easily understood through an example. In Table 7.1 we use the example of a discussion on how people implement attendance policies in their classes. The examples also demonstrate how the Mono-Dialogic dimension of communicative approach is independent of the Interactive-Non-Interactive dimension of talk; it is possible for one person to produce dialogic talk.

Together, the two dimensions describing how people are talking combine to form six options for the communicative approach (CA) of a meeting segment (see Table 7.2). These communicative approaches help describe the OTL provided by a meeting segment. As the examples in Table 7.1 show, CA tells us how many perspectives are considered regarding the topic of conversation. Every conversation during a FOLC meeting provides an OTL, regardless of the CA used, but CA helps us describe the depth and scope of that OTL. Following the examples in Table 7.1, CA can tell us how many ideas about enforcing attendance were shared during a conversation.

Table 7.2: The six communicative approaches. The examples noted in parentheses refer to the examples listed in Table 7.1.

	Interactive	Non-Interactive
Mono	**Interactive/Mono** (Example C)	**Non-Interactive/Mono** (Examples A & B)
Dialogic-Low Level Interanimation	**Interactive/Dialogic-Low Interanimation** (Example D)	**Non-Interactive/Dialogic-Low Interanimation** (Example E)
Dialogic-High Level Interanimation	**Interactive/Dialogic-High Interanimation** (Example F)	**Non-Interactive/Dialogic-High Interanimation** (Example G)

CA also helps us from a practical, meeting-facilitation perspective. If multiple ideas are shared, are they taken up by the cohort, or are they simply left to waft? The interactive-non-interactive dimension helps answer this question. Ideally, the majority of a FOLC meeting will be interactive, including the voices of multiple (and hopefully all) participants. CA is one metric to

see if we are achieving this goal.

7.4.2 Concept development

To begin to describe *what* a conversation is about, we consider what pedagogical concepts are present in the talk. We look for formal concepts and lived concepts; both are conceptual resources utilized in conversation. **Formal (pedagogical) concepts** are theories, abstractions, principles, or generalizations about teaching and learning (see Table 7.3 for examples) [136]. **Lived concepts** are experiences in the world, for example replays of things that have occurred in one's classroom or rehearsals of techniques one will try (examples in Table 7.3) [69, 136].

Table 7.3: Examples of Formal and Lived Concepts.

Formal Pedagogical Concepts: *theories, abstractions, principles, or generalizations about teaching and learning*	Ex 1: "Students are more comfortable asking a TA or LA for help because they are less intimidating than the professor."
	Ex 2: "Students need to have agency over their learning."
Lived Concepts: *experiences in the world, for example replays and rehearsals of classroom experiences*	Ex 1: "Students had a really hard time with Activity 5 yesterday."
	Ex 2: "I am not going to give unit tests this term. I will only give module exams."

We are particularly interested in when the FOLC group develops pedagogical concepts because we want their conversations to reach this level of discussion. We draw our definition of concept development from Horn [136], who in turn is applying a Vygotskian perspective [146]. According to this perspective, as summarized by Horn, concept development occurs when conversation "bring[s] the general and the particular together—by surfacing the formal dimensions of lived concepts or illustrating lived examples of formal concepts" [136, p. 43]. Concept development means formal and lived concepts are linked in the course of a conversation. When we identify concept development in a conversation, the concept may not be new to all participants and is generally not new to the larger education community. The linking of concepts may be done by multiple participants

or by an individual. We take the stance that even if the linking is done by an individual, because the development is done out loud, in the meeting, it is available to the whole group. Additionally, concept development does not require everyone to come to agreement about the ideas shared; the important thing is that the ideas and connections are made available to the group members through the conversation.

In all of the conversations we analyzed, lived and formal concepts are present, but these concepts are not always joined in a way that would constitute concept development. In order to decide if a concept was developed, we employ the "engaged newcomer" heuristic [136]. In reviewing a conversation, we ask ourselves, "would an engaged newcomer to the conversation have made a connection between these lived concepts and these formal concepts?" This heuristic prevents us from inferring too much from the conversation, based on our background knowledge of the topic being discussed or the speaker doing the linking. We only say there was concept development if we think it is reasonable that an engaged newcomer to the conversation would have picked up on the developed concept.

It is perhaps easiest to understand what concept development means by seeing examples of what it looks like:

Example One

In Table 7.4 we include a transcript of a five minute excerpt from a ten minute conversation in one of the NGPET-FOLC clusters. The conversation was opened by Courtney, one of the cluster leaders, asking the group, "So how do you guys give tests? How many tests do you give? When do you give your first test?" For the next five minutes, group members share their lived concepts (i.e. lived experiences): the number of exams they give, if they give a final, when their first exam comes about, and how far in advance they schedule exams. Then the conversation reaches what is shown in Table 7.4. Yin, agreeing with what others have shared, says that at the start of the term she only gives an estimate of when the exams will be (her lived concept, LC). She then asks for people's thoughts on giving two midterms during her course (she is on the quarter-system). Courtney is interested in this question and prompts Yin to share more about what she has done in the course.

Yin says that the first time she taught the course she gave frequent quizzes and she didn't do this the second time she taught the course (an LC). She then states a formal concept (FC) that more frequent quizzing keeps students more engaged with the material. She also posits that a difference in the class population could account for the difference in engagement; we don't label this as a FC though because the underlying concept (that no two classes are identical and there is some natural variation in how they respond to the course) is too implicit for an engaged newcomer to learn from.

Table 7.4: Transcript of the last five minutes of a ten minute NGPET-FOLC conversation about assessment practices. All names are pseudonyms. We mark formal concepts in Red and lived concepts in Blue.

Turn	Speaker	Transcript
1	Yin	No, I was wondering, don't have a schedule. I totally understand that. I only gave an estimate date of exam, but would it also be two midterms? Does that sound typical or reasonable?
2	Courtney	I mean, I think so. Actually, that's what I was interested in. What do you do?
3	Yin	I do notice what makes a difference is the first time I taught it I gave frequent quizzes. Really short quiz, a five minute quiz throughout, four quizzes throughout the quarter. The second time I teach it, I taught it and did not give quiz, only the midterm. I felt maybe having the quiz is keeping students a little bit more engaged, or could it be I just happened to have a different group of population the second time. I don't know. Maybe the third time I'll know the answer.
4	Carter	Yeah. I give just the one summative test at the end of each unit. And I do have the sense that the students have a false sense of their own understanding based on the homework and things. So when they get to the quiz, there are some students who don't perform as well as they think they were going to, or they feel somehow surprised. So I'm wondering if giving earlier, shorter, low stakes quizzes, but where they can really see when they're by themselves without being able to talk to their neighbor, or look in their book, or whatever, here's what you know and are able to do. The first time they find that out is four weeks in, when they're taking the exam at the end of the energy unit.

Turn	Speaker	Transcript
5	Wallace	So in my introductory physics class, last semester, I moved to giving five midterm tests and a final and the first test at the end of the second week for exactly this reason. Last year, I've been trying to hammer on at students about metacognition and thinking about their own learning because, as you said, if you ask them before a test how they think they're going to do and compare with how they actually do, it's very few of them have a good idea of their own understanding. And I've only done it one semester, but it seemed to work pretty well. I think they were lower stakes, shorter tests, but they were able to ... A lot of them did pretty badly on the first test, but that in itself made them take more seriously what I was trying to tell them about the various adjust your study habits, and think about how you do things like read the textbook, and so on.
6	Wallace	So I was thinking about testing more frequently as well in this class. And I think this is, since I'm teaching future teachers, they're obviously a good population ... They should be more receptive to things like metacognition, and [crosstalk] this should tie into what they learn in their education classes. So that means I'm going to be testing them probably twice per unit.
7	Carter	Okay.
8	Wallace	So I have yet to figure out the details of that, but that's what I'm thinking of.
9	Carter	In these courses, and actually PET courses where I think for most of us they're studio style, right? And there are longer periods of class meeting. It seems fairly reasonable to have a class meeting where part of the class is spent on doing curriculum, but then a part of it is spent on testing. So that if you decide to give more tests during the term, you don't have to waste more classes. Whereas with their typical 50 minute introductory course, if you want to give five midterms, I would imagine it'd be hard to recoup, even if the tests are shorter than they otherwise would be, it might be difficult to recoup the time on that particular day to do any more lessons. I don't know, but that's appealing.
10	Courtney	Yeah.

Carter then adds in his LC, that he only gives end-of-unit tests. He makes a generalization about students in the course, noting that they do not have a good sense of their own learning (an FC). He supports this claim with an LC that students are often disappointed in how they perform on the exams, thinking they will do better than how they actually perform. He offers the conjecture that "earlier, shorter, low stakes quizzes" will help students better gauge their own understanding

(another FC).

Wallace builds on what Carter has shared, saying he instituted frequent tests the last time he taught his introductory physics course (an LC). He explains this choice with the FC of metacognition; like Carter, he discovered that students have a hard time judging their own learning, based on their poor predictions of how they will perform on a test (LC). He says that the frequent, lower-stakes tests seemed to help students adjust their study habits after the first test where they did not perform well (LC). He then rehearses his plan for his NGPET course, saying he will try the frequent testing in that course as well (LC). Re-emphasizing the formal concept of metacognition, he says this should resonate with the NGPET students because they are future teachers and should be familiar with the concept. Wallace thinks he will be testing two times per unit in the NGEPT course, but he is still working out details (LC). Carter ends the conversation, saying that in a studio-style NGPET course, there is enough class time to have frequent tests (LC). The group then shifts to a new topic of discussion.

We say there is concept development in this conversation because Yin, Carter, and Wallace directly connect their classroom experiences around the frequency of testing to the formal concepts of students' metacognition and engagement. From this conversation, the group has the opportunity to learn the concept that regular, low-stakes testing helps students understand their own learning and stay engaged in the course.

Example Two

In the above example, we saw an NGPET-FOLC cluster engage in a conversation which did not depend on their shared curriculum. We now provide an additional example of concept development, this time with a conversation that shows the unique OTLs provided by a shared curriculum. The conversation is from the same cluster, but in a different meeting.

The cluster members are taking turns sharing updates from their NGPET classes. Wallace tells the group that his class is almost finished with the magnetism unit of the curriculum. In this unit, students are guided through an iterative process of prediction, experimentation, and revision as they construct a model for how magnetism works. Wallace describes how his students have

trouble making predictions based on their working model, and the group discusses how to help students with the model building process. The conversation then shifts to a second issue Wallace has been facing. This new conversation, which lasts 4 minutes, in shown in Table 7.5.

Table 7.5: Transcript of a four-minute NGPET-FOLC conversation about students googling answers. All names are pseudonyms. We mark formal concepts in Red and lived concepts in Blue.

Turn	Speaker	Transcript
1	Wallace	The other issue I have, which is ... I think this mainly arises because we meet only twice a week for such a short time, so the module gets drawn out over a few weeks, is some students go away and google how magnetism works, and so suddenly they'll be talking about domains. Okay, so this is kind of skewing the process.
2	Courtney	Yeah, but I've found that in my experience anyway, if they go away and they come back with domains that they usually don't have any idea how they actually work.
3	Wallace	No, yeah, that's true.
4	Courtney	They try to use domains to explain whatever, and they can't, and so the rest of the class is like, "Well, never mind that. We'll just forget ... "
5	Wallace	I think that is true. They google the answer, but they're not really quite understanding what's going on still. I'm not too worried about that. It was just funny when they suddenly start pulling out these words.
6	Carter	Kind of seems like it's evidence about the students' epistemology, like I feel like they don't have very sophisticated views about what it means to understand something.
7	Courtney	Oh, they don't.
8	Carter	Because science context, what it means to understand something, and so for them understanding means like knowing the term or being familiar with the term when we're trying to give them an experience that's so much different view of what it means to understand something, and there's a tension there.
9	Courtney	Yeah, they want to memorize. "I must memorize."
10	Carter	I had a student after the quiz, he was in my office complaining, different student than the other one that I mentioned earlier, he's going about how he understands everything in this class, because after all this class is like baby physics, and he learned it all in high school, but he just can't explain it the way that I want him to. He went on and on and on and on. I tried to provide some, "Have you thought about maybe writing an outline of the key bullet points that you wanna hit in your explanation, and only then start ... "

Turn	Speaker	Transcript
11	Carter	I just tried everything I could to get him to reflect on maybe "I don't fully understand it. My struggles are evidence that I don't fully understand it." Every time I tried to hand it back to him, he just kept handing it back to me. Like, "No, this is so easy, and I just ... yeah, I can't explain it the way you want." Oh God, just leave.
12	Courtney	Right.
13	Yin	What is domain? I'm sorry I don't think I fully understand. What kind of question that they google?
14	Wallace	Oh, this is they're googling ... they're basically trying to google how ferromagnetism and iron gets magnetized, so they come across the idea of magnetic domain, certain small regions that are polarized in the magnet.
15	Wallace	They generally don't really understand what that means. They just start using these words because it's something they've seen.
16	Carter	Yin, have you taught the magnetism unit?
17	Yin	No, but I am very much looking forward to it.
18	Carter	Yeah, it's so awesome. I would encourage you ... you gotta find a way
19	Wallace	Despite these problems, I think it is really good, and I think the students are getting a lot out of it.

Wallace shares his experience (LC) that students will google how magnetism works, and he is concerned that this is "skewing the process" built into the curriculum. The magnetism unit takes several weeks for the class to work through and students are supposed to be constructing their model of magnetism based on evidence collected in class, rather than searching for the answer on the internet. Courtney responds to his concern with her own LC, that students do not actually understand what they google. They may read about the domain model of magnetism, but they can't actually explain it, so it is ignored by the class. Wallace agrees with Courtney's comment that students do not understand what they google, and this seems to assuage his concern.

Carter offers an explanation for this situation with the formal concept of epistemology. He suggests that for students, "understanding means like knowing the term," whereas in science, understanding entails something deeper than being familiar with terminology. Courtney agrees with this interpretation, saying her students want to memorize terms. Carter shares a LC which

demonstrates the explanation he offered: he recounts a recent experience with a student who thought he understood the material even though he couldn't explain it.

Yin asks for clarification on the situation, not understanding what it is that students google. Wallace explains what his students are doing (LC) and synthesizes what Courtney and Carter said about the situation, that students use the terms they have read about without understanding them (FC). The conversation ends with encouragement for Yin to try the unit in her course; Wallace shares his lived experience that students are getting things out of the unit despite the minor challenges he has described.

This conversation is grounded in the group's collective understanding of the magnetism unit and the pedagogy built into NGPET. In another type of class, for example a traditional intro physics class, it would not necessarily be a problem if students google how magnetism works. However, in the NGPET course this behavior (potentially) interrupts the guided-inquiry structure of the curriculum. Courtney is able to share her experience with the exact problem Wallace describes and with Carter's contribution of the formal concept of epistemology, we say there is a concept developed in this conversation: that some students do not yet have a sophisticated understanding of what it means to know something in science, and this may underlie their googling behavior.

7.4.3 Meeting segment categories

The second piece of describing *what* a conversation is about is applying a meeting segment category. We identified eight different meeting segment categories that collectively describe the range of conversations we have observed in FOLC meetings. These categories and their definitions are shown in Table 7.6. Note, if we determine that a pedagogical concept was developed during our concept development (CD) analysis, then that meeting segment is automatically labeled as "Developing a Pedagogical Concept." Concept development does not occur in all the other meeting segment types.

Table 7.6: The eight meeting segment categories and their definitions.

Meeting Segment Category	**Definition**
Social Chit-Chat	People talk about their family, themselves, life outside of work; this can include talk about work in the broad scope (e.g. sharing where they are employed) as long as the talk is not tied to FOLC activities or teaching work in detail
Meta	Discussing the operation of the FOLC (e.g. How to use the Slack Workspace; What the agenda of the meeting is)
Logistics	Discussing "how to do something" in one's teaching work, but the issue is not pedagogically motivated (e.g. how to upload homework to a learning management system; equipment issues)
Status Update	Updating people on how one's class is going (e.g. where you are in the curriculum, what units you plan to cover, how many students are in the class, how a lesson went); a report on your teaching "condition" with **no underlying reason** for it **presented**; can also entail report of one's experience with a teaching strategy/an update on something you tried in the past
Generating detailed descriptions and explanations for pedagogical problem	When people are reporting in depth on a clearly articulated pedagogical issue, i.e. there is a description of what has happened and some statement or conjecture about **why** it is happening or why they care about the "what"
Generating solutions to a problem *without a why*	Describing in detail what one did in class to address a particular pedagogical issue. The issue itself may be implicit. These are conversations where people are reporting how they run some activity or deal with some issue in the classroom, "how to's" that are pedagogically motivated (e.g. how they use student assistants; how they use a particular teaching strategy; how they run an activity). **No explanation** is proposed for the problem or solution. The 'problem' can be the underlying pedagogical problem that drove the need for the solution, or it can refer to problems or rationale associated with implementing the solution.
Generating solutions to a problem *with a why*	Same as above, except an **explanation** is proposed for the problem or solution. A "why" is provided; either: "Why this is a problem/ why we care about it" or a conjecture as to "why this problem is occurring" or "Why I use the solution I do"
Developing a Pedagogical Concept	The group collectively addresses a pedagogical issue by making links between lived and formal concepts, developing a more general pedagogical concept that applies to the situation at hand. (The developed concept is new to the group's collective knowledge, but not new to the broader education community).

7.4.4 Nature of hierarchy in the taxonomy

The taxonomy is meant to provide a structure for describing the range of conversations we observe in a FOLC. However, it would be *incorrect* to say that the meeting categories are ordered *in terms of increasing OTL*. There are two reasons for this:

First, in some ways it does not make sense to compare learning opportunities given that they can be so different in nature. For example, during Social Chit-Chat segments, participants have the opportunity to learn about their fellow cohort members and in Developing a Pedagogical Concept segment, participants have the opportunity to learn some formal concept about teaching and learning which is grounded in lived classroom experience. Is this "better" or "more" of an OTL than learning about your fellow members? These OTLs are very different in nature, one being non-pedagogical and one is pedagogical. Even when comparing two pedagogical OTLs, it is not clear how to assign value to the different OTLs. In Generating Solutions conversations, participants have the opportunity to learn about various solutions to a pedagogical issue. This is not necessarily "less" of an OTL than when the conversation extends to develop a pedagogical concept and rises to a Developing Pedagogical Concept segment type. Afterall, if one is facing a problem in their classroom, it may be much more useful to get timely advice on how to solve the challenge, rather than to consider the broader pedagogical implications of the situation.

Second, the communicative approach in a conversation can affect the nature of the OTL for a given meeting segment. The broad topic/characterization of the OTL corresponding to each meeting segment type shown in Figure 7.1 holds regardless of the CA used in the conversation, but the "width" of the OTL can shift with the way ideas are presented. Consider a conversation in which someone asks about a lab equipment issue which is distracting students from the main point of the lab activity. This person asks for ideas about how to solve this problem. If there is only one idea proposed, the communicative approach for how ideas are presented is "mono." If instead there is a diversity of ideas presented (e.g. "I do X," "I do Y") that is low interanimation of ideas. If participants in the conversation directly compare and contrast the different solutions proposed,

we would say that is high interanimation of ideas. Whichever way the conversation unfolds, we would say there was an opportunity to learn solutions to this pedagogical issue; however, more opportunities for learning are supplied by the multiple perspectives present in dialogic conversation. The effect of communicative approach on the OTL for a given meeting segment means we cannot say certain meeting segment types offer "more" OTL than another segment type. For example, a Generating Detailed Description segment in which multiple explanations for a pedagogical challenge are compared (high interanimation) does not necessarily offer "less" of a learning opportunity than a Generating Solutions segment where only one idea is presented for solving a pedagogical issue (mono).

The taxonomy helps us describe how OTLs may differ from each other, but it does not assign value to different OTLs. That is, the taxonomy does not tell one about "better" OTLs or "more" or "less" OTLs. We hold that all OTLs described by the taxonomy are valuable. The taxonomy does allow one to see when an OTL is "wider," i.e. providing multiple perspectives or ideas.

All this said, we *can* apply a hierarchy to the *meeting segment types* based on the kinds of conversations we value. This value judgment is influenced by the goals of the FOLC (or another professional development group whose conversations the taxonomy is applied to). The taxonomy user assesses alignment between meeting segment type and their program's goals, and assigns value accordingly. This means that for some faculty development group, they may most highly value their conversations that generate solutions to teaching challenges that members face and may not care as much about developing the pedagogical concept knowledge of members. This group would then place "Developing a Pedagogical Concept" closer to the bottom of their meeting segment types. Doing this would not mean the OTL provided by those segments are "less" or "worse" than the OTLs provided by Generating Solutions segments, but just that the group cares more about generating the latter OTL type.

In Figure 7.1 we have ordered the meeting segment types in terms of proximity to developing a pedagogical concept. In the NGPET-FOLC we ultimately want members to reach the stage of developing pedagogical concepts in their conversations, connecting their lived teaching experi-

ences to the deeper issues and factors at play. For the NGPET-FOLC then, we place Developing Pedagogical Concepts segments at the top of our hierarchy.

When coding a conversation for meeting segment type, we apply the highest level category that fits, "highest" according to the chosen hierarchy of categories. A conversation often starts as one meeting segment type and then evolves into another type before the purpose of the discussion shifts enough to count as a new segment. For example, a participant may begin with a Status Update of their class, recounting the curricular units they plan to cover. Another participant may then raise the challenge of how to choose what units to cover in the class. The group then might discuss different solutions to this challenge, offering how they choose the topics they will cover and comparing options. By the end then, the conversation has evolved into a Generating Solutions segment and that would be the meeting segment type we would apply to the segment overall. This analytic choice allows us to flatten some of the information contained in a meeting segment while capturing essential distinctions between conversations.

7.4.5 Combining the taxonomy elements

The communicative approach, concept development, and meeting segment type coding of a conversation combine to describe the type of OTL provided by that segment. As described in the preceding section, we broadly characterize the OTL based on the meeting segment type, but the mono-dialogic dimension to communicative approach provides further detail on the OTL. If we consider the theoretically possible combinations of taxonomy codes (based on our constructed definitions and methodological choices), we see that the Developing a Pedagogical Concept segments must be paired with a high interantimation communicative approach, but that the CA can include one or multiple voices (non-interactive or interactive). All the other meeting segment types can (theoretically) appear with any combination of CA codes.

We can also consider the combinations we have seen empirically, based on our coding of six FOLC meetings using the taxonomy. For example, in this data sample, we have seen Meta meeting segments paired with every CA combination except non-interactive, high interimation.

For Generating Solutions with a Why segments, we have seen every CA except non-interactive, low interanimation. We can't make generalizable claims from the connections we have observed, but it does permit us to make context-dependent claims. Regarding Meta segments in our FOLC meetings, we can hypothesize that the group only develops ideas on how it will collectively function when multiple voices are included in the conversation. Of course, we could test this hypothesis by applying the taxonomy to more meetings and looking for the communicative approaches used during Meta segments and the learning opportunities provided by those segments.

All the combinations we have seen empirically of meeting segment types with different communicative approaches confirm that both elements of the taxonomy are capturing important information. If we only coded for meeting segment types, we would be missing an informative level of detail regarding the OTLs provided by conversations; communicative approach coding adds to our understanding of the OTL.

7.5 Applications of the tool

Having presented the entire taxonomy, we now present how the taxonomy can be used. We start by describing the analytic approach for applying the tool to a teacher workgroup conversation. We then demonstrate how we compactly represent the taxonomy coding for an entire meeting. We provide examples of the taxonomy-in-use and the claims the tool allows one to make.

7.5.1 Analytic approach

Starting with a transcript of a workgroup meeting, we segment the meeting based on shifts in conversational purpose [143]. As Schegloff explains, "A great deal of talk-in-interaction – perhaps most of it – is better examined **with respect to action than with respect to topicality, more for what it is doing than for what it is about**" [143, emphasis added]. When we determine the purpose of a segment, we are considering what the function of the segment is, i.e. "what it is doing."

Having segmented a meeting, we code each segment according to this three-step process:

(1) Code segment for communicative approach. If the CA includes high interanimation, proceed to step two. If not, proceed to step three.

(2) List the lived and formal concepts apparent in the high interanimation segments. (While all segments can have lived and formal concepts stated, concept development can only occur if the communicative approach of the segment involves high interanimation of these ideas). Consider how (and if) these concepts are connected. If they are clearly linked together, articulate the concept that is developed in the conversation. If you cannot identify a connection between the LCs and FCs, mark the segment as "no concept development."

(3) Select a meeting category that fits the segment. If in step 2 you do identify that a concept was developed, the meeting category for the segment is Developing a Pedagogical Concept. (Note, you likely will have an idea of the segment type as you proceed through the first two steps, but we don't make an official assignment until we have done the CA and CD analysis).

An exception to this process is if the meeting segment type is Social Chit-Chat. These segments are easy to identify (and at least for our FOLC, most frequently occur at the beginning and end of a meeting). As you read over a segment, if you immediately identify it as Social Chit-Chat, you can proceed directly to step 3 and label it as such. We do not bother coding the communicative approach for this segment type because it is not consequential for the main purpose of the FOLC meetings. (However, if one places Social Chit-Chat higher in their hierarchy of meeting segment types, they can revisit this decision). The analytic approach for applying the taxonomy to a meeting segment is summarized in Figure 7.2.

Once one has followed steps 1-3 for a given segment, they proceed to the next segment of the meeting and go through steps 1-3 again. We work through the segments in sequential order. This is important because later parts of a meeting may refer to an earlier conversation in the meeting and if one doesn't analyze the segments sequentially, they may miss essential context for understanding a segment. This point also raises the special case of segments that are discontinuous in time. Sometimes a conversation clearly refers back to an earlier conversation in a meeting, and in these cases if we determine the purpose of the two conversations to be the same, we count the two conversations as one segment and code them identically. Determining if the later conversation is a follow-up on the original conversation and if they have the same purpose is a judgement call based on the context of the conversation, the history of the group and previous meetings, and the

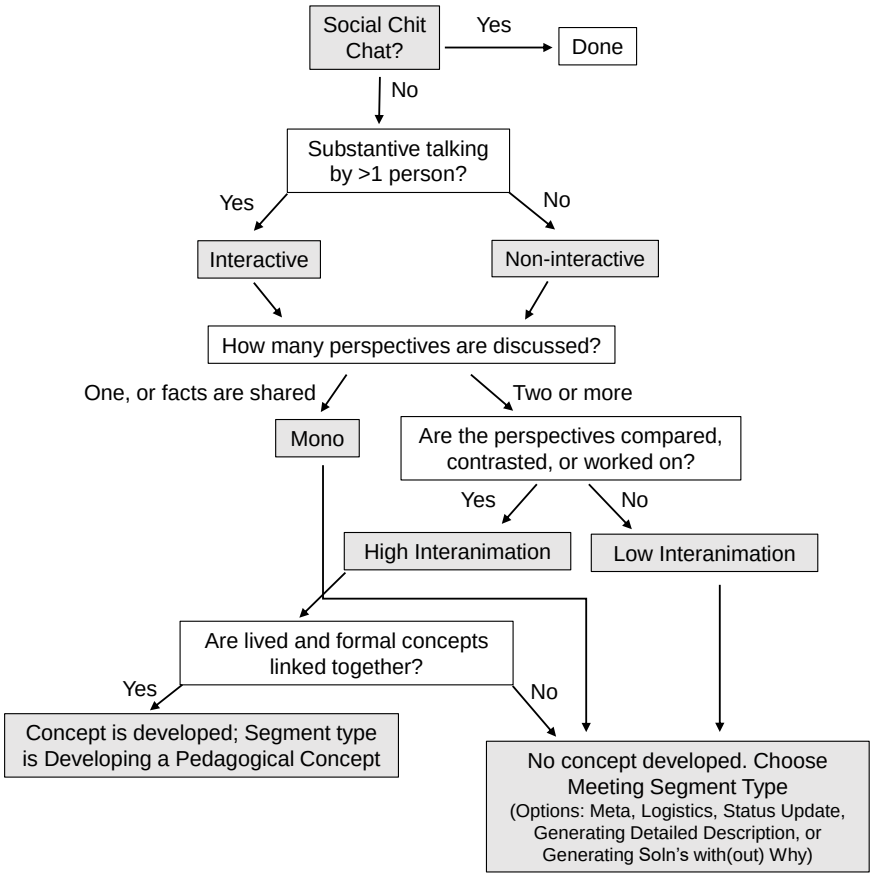

Figure 7.2: Flow chart representing the analytic process of applying the taxonomy to a meeting segment.

dynamics between participants; we also look for discursive markers to aid in this decision. For example, sometimes a participant will actually say, "Following up on the previous discussion about _____."

There are two general rules we apply when deciding how to code a meeting segment. First, as we have already touched on, we always consider the context and framing of a conversation. The same thing said in different contexts could be coded differently (particularly when we are determining if something is a lived or formal concept). This emphasis on context is grounded in our sociocultural approach to learning. Second, we use what Horn calls the "engaged newcomer" heuristic [136]. This heuristic causes one to consider a newcomer to the FOLC meeting. The newcomer is similar to the other FOLC members (e.g. they also teach the NGPET curriculum),

but they are a novice to the topic of the FOLC (e.g. they are teaching NGPET for the first time). When making coding decisions, we put ourselves in the place of this newcomer to the conversation, asking how they would interpret a conversation and what they would understand or learn through the conversation. This heuristic prevents us from over-interpreting a conversation and drawing conclusions that a new member would be unlikely to make in-the-moment of the conversation.

7.5.2 Timeline representation

Once we have applied the taxonomy to each segment in a meeting, we construct a "timeline image" of the meeting in order to draw inferences and interpret the coding results. This timeline representation shows in a condensed form how each segment in a meeting was coded along the different taxonomy constructs. One example is shown in Figure 7.3–Timeline **A**. Reading the timeline from left to right shows how the codes were assigned to each segment during the meeting. Reading the timeline vertically shows how a particular segment was coded along all the taxonomy dimensions.

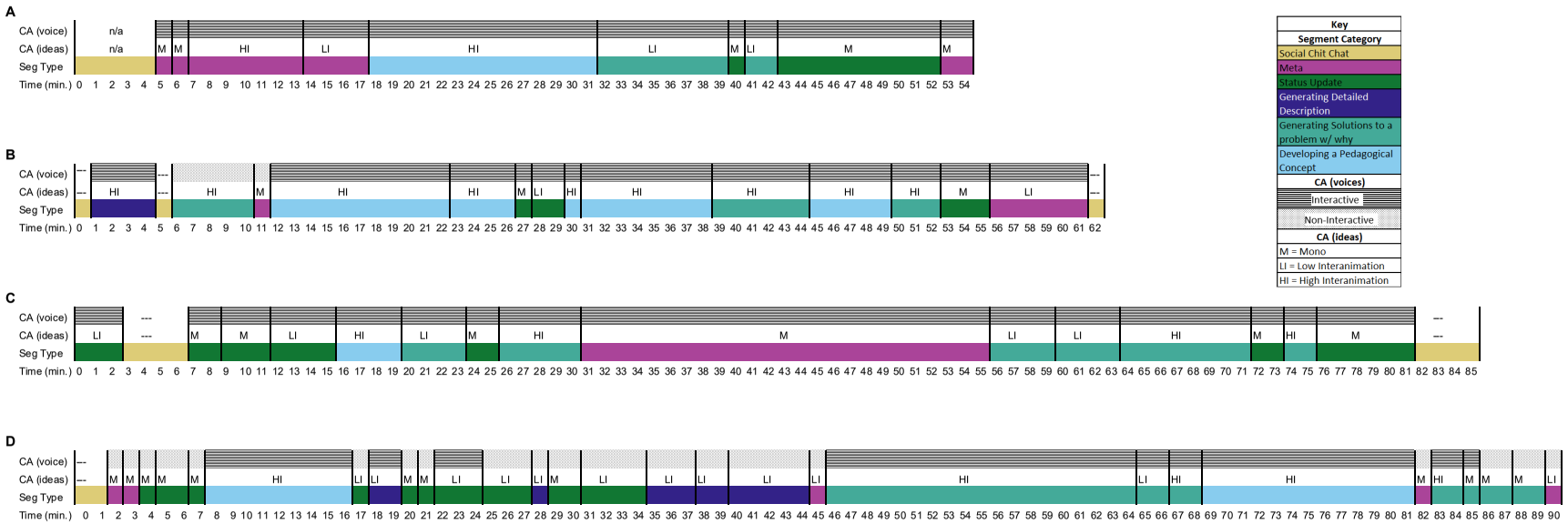

Figure 7.3: **A:** A timeline representation of a FOLC meeting coded with the taxonomy. The vertical black lines divide the meeting into segments. The bottom line tracks the time in the meeting. Reading the timeline from left to right shows how the codes were assigned to each segment during the meeting. Reading the timeline vertically shows how a particular segment was coded along all the taxonomy dimensions. **B:** Timeline representation of another NGPET-FOLC meeting coded with the taxonomy. **C:** Timeline of a second meeting from the same NGPET-FOLC group represented in Timeline B. **D:** Timeline representation of a NFW-FOLC meeting coded with the taxonomy.

7.5.3 Examples of the taxonomy in use

We will now explore the types of inferences and information we can draw from a timeline representation of a meeting coded with the taxonomy. Figure 7.3–Timeline **B**, shows the timeline for a meeting from one of the NGPET-FOLC clusters. What claims can we make about this meeting? Looking at the top row of the timeline, it appears that there were a number of voices heard in this meeting; all but two segments are coded as interactive (ignoring the Social Chit Chat segments where we do not attend to CA). Next reviewing the CA (ideas) row, we can see that the majority of the meeting segments included the presentation of multiple perspectives (LI or HI), and furthermore, most of the segments involved participants comparing and contrasting the perspectives introduced (HI segments). Finally, the Segment Type row tells us that the meeting started and ended with Social Chit Chat, and in the middle most of the conversations involved Generating Solutions or Developing a Pedagogical Concept. Note, however, "most of the conversations" is not the same as "most of the time." Because we code a segment based on the highest-level code that fits, we cannot make claims about the time spent in different modes. It would be incorrect to say that half of the meeting time shown in Figure 7.3–Timeline **B**, was spent on Developing a Pedagogical Concept; while a concept was developed in each of the five Developing a Pedagogical Concept segments, the conversations likely started as a Status Update or Generating Solutions and evolved to develop that concept. That is, in a ten minute segment coded as Developing a Pedagogical Concept, it may be that the first eight minutes were spent on Generating Solutions to some problem and only in the last two minutes were formal and lived concepts clearly linked together, resulting in concept development. Regardless, this timeline indicates a productive FOLC meeting to us because there is concept development that occurs and the conversations involve multiple voices and ideas.

The timeline also indicates areas to explore further. For example, the only non-interactive portion of the meeting happened in minutes 6-11. We may want to revisit those meeting segments to see who was talking and what the facilitators were doing during those segments. It is also interesting

that from minutes 6-10, the one person talking introduced multiple ideas and compared them (HI). This indicates that the person who was speaking may have a lot of resources to draw on and they may have a big influence on the direction of conversations. Thus, the timeline representation has analytic value to researchers wanting to explore the group dynamics and learning opportunities in FOLC meetings, but also practical use to the meeting facilitators who want to learn how to encourage different types of discussions. This timeline represents just one meeting of a NGPET-FOLC group. The taxonomy can be applied to many more of this group's meetings though, allowing us to see trends over time.

Figure 7.3–Timeline **C**, includes a timeline of a second meeting from this same FOLC group. From this new timeline, we can see that the group again has a meeting where the majority of the conversations (actually all of them) are interactive. We see differences in the meeting segment types between the two meetings though. Timeline **C** shows more Status Update conversations and fewer Developing Pedagogical Concept segments than the meeting represented in Timeline **B**. This is consequential for the types of learning opportunities provided by the meeting and it seems the meeting represented in Timeline **C** was more focused on practical applications than higher-level, theoretical discussions. We want our FOLCs to discuss practical issues, so it is good we see this, but we would also want to investigate the framing of this meeting by the facilitators to see if that was consequential for the meeting segment types that ensued. To develop robust claims about the OTLs provided in this group's meetings and their conversational patterns, we could apply the taxonomy to meetings that occurred over a span of time, for example near the beginning, middle, and end of their first year of meeting.

The taxonomy also allows us to compare different FOLC groups. Figure 7.3–Timeline **D**, shows the timeline of one meeting from a New Faculty Workshop (NFW) FOLC group. Recall, the structure of the NGPET and NFW-FOLCs are very similar but the NFW-FOLC members do not share a common curriculum; rather, they are connected by their shared status as new faculty. Right away, one difference we see is in the top row of the timeline; the NFW-FOLC meeting has many more non-interactive conversations than the two meetings we examined above from a NPGET-

FOLC group. This may indicate that the two FOLC groups have different conversational norms. We also see more Generating Detailed Description meeting segments than in the NGPET-FOLC meetings. One hypothesis we could draw from this evidence is that the lack of shared curriculum makes it so the NFW-FOLC participants have to spend more of their meetings explaining and exploring the teaching challenges they face in their individual classes. Of course, revisiting the transcript and the content of those Generating Detailed Description segments would allow us to test this hypothesis.

This timeline though also indicates a level of similarity between this NFW-FOLC group and the NGPET-FOLC group. Both meetings, despite their differences, provide similar types of OTLs. In both meetings, participants can learn about the status of their fellow members' classes, identify possible solutions to a pedagogical challenge, and develop a pedagogical concept, connecting formal and lived concepts about teaching. The kinds of pedagogical challenges and concepts may differ, but we see both groups have the opportunity to learn about their context-specific challenges in similar ways (i.e. sharing solutions and developing concepts).

7.5.4 Facilitator perspectives on the tool

In order to include the voices of the FOLC facilitators in our research process, we conducted interviews with a sample of the facilitators in which we gathered their perspectives on the taxonomy [81]. The purpose of these interviews was to ask facilitators about the inferences they would be able to make from the timeline figures and to see how useful this information is to them. We interviewed four of the current ten facilitators and chose our sample purposefully to 1) overlap with the interests of other research projects within the NGPET project, 2) hear from facilitators of different NGPET-FOLC clusters, and 3) talk to those with distinct approaches to facilitating. Before each facilitator's interview, we sent them a five-page document to review which provided an overview of the taxonomy: our motivation for making it; the purpose of the tool as we see it; the definitions of all the taxonomy elements; and one timeline (that shown in Figure 7.3–Timeline **B**). We opened the interviews by asking the facilitators for any clarifying questions they had about

the taxonomy. This ensured that we established a shared understanding of the definitions, structure, and overall purpose of the taxonomy. Next, we asked them about the timeline figure in their pre-interview materials. Specifically, we asked about the information the representation provides about a meeting and asked them to postulate what was occurring in the meeting based on what the timeline shows. We asked them how the representation could inform their practice if they were the facilitator of the meeting shown, and if the representation was lacking aspects of a meeting that they find important. We then presented a second timeline (that presented in Figure 7.3–Timeline **A**) and asked about the differences they saw and the inferences they could make in comparing the meetings.

The feedback from the four facilitators alerted us to both affordances and constraints of the taxonomy and the timeline representation. We will describe the affordances they highlighted here and in the discussion we will present some limitations to the tool. Overall, all four interviewees thought the timeline representation of meetings coded with the taxonomy provided useful information. One facilitator talked about how the first thing he would look for in the timeline was the line that tells us about CA voices–if segments were interactive or non-interactive. As a facilitator, he wants to be attuned to how many voices are heard. This facilitator also said they would be interested in seeing trends between groups, over time, and between codes. As we have shown above, the taxonomy affords these types of comparisons. Another facilitator expressed that the timeline could serve as a tool to provide facilitators with a suite of "good" meeting examples, where the meetings could be "good" along different dimensions of the taxonomy. Echoing the ideas of these two facilitators, another facilitator we interviewed recognized that the taxonomy could help one identify features which accompany the different types of conversations, and that this could be a great professional development activity. He suggested that facilitators and participants could look at meetings coded with the taxonomy and identify connections together. He thought this would be useful training for the facilitators of the meetings, but also for the participants because they often do not know what causes a conversation to be productive.

In interpreting the timelines, one facilitator wondered about the transitions between meeting

segment types and what drives that. For example, he noticed that in one of the timelines Generating Solutions segments seemed to precede Developing a Pedagogical Concept segments, but in the other timeline we provided there was the opposite pattern. The timeline pinpoints areas of a meeting to explore further and would allow us to examine this facilitator's question.

Finally, the facilitator who suggested using the taxonomy for a professional development activity also said that this tool may be able to identify conditions that lead to concept development in conversations. He said this could be very powerful information for professional development programs because in his experience it is often hard to get to a concept development stage in professional development workshops. This speaks to the broader impact of the taxonomy; it has the potential to inform the practices of different forms of professional development. It is interesting to consider what "lessons learned" from applying the taxonomy to FOLC meetings (e.g. conditions that lead to certain meeting segment types) would apply to shorter-form (single or multi-day) workshops.

7.6 Discussion

The taxonomy presented here provides a structure for describing the learning opportunities in different workgroup conversations, capturing information on the nature and content of the discourse. This tool focuses our attention on only four of the myriad social dynamics contained in a one-hour meeting: the way ideas are presented, the voices heard, the concepts participants draw on and develop, and the broad scale purpose of a conversation. We focus on these four elements because they are consequential for the OTLs provided in a conversation.

By design, applying the taxonomy reduces our data into a manageable corpus, but this also means that it does not pick up on all aspects of a conversation one may be interested in. Our conversations with facilitators surfaced a few limitations of the taxonomy. First, while we do mark if a conversation was interactive or not, that is a binary distinction. We do not capture the names of the people talking or the number of people talking (during interactive segments). Facilitators may be interested in this information, especially if they want formative feedback on their facilitation

practice and which voices are being privileged in conversation. If one is interested in this level of detail, they have to return to the transcript and separately capture this information. However, recall from our Theoretical Framework section that our unit of analysis is a conversation and we view this conversation as a collective zone of proximal development for the group engaged in the conversation. Thus, we take the OTLs created by a conversation as available to all participants in the conversation; that is, the taxonomy positions us to make claims about the group's OTLs rather than an individual's learning.

The taxonomy also does not count the *number* of different ideas raised during interanimation segments and *which* of these ideas is taken up. If a segment is coded as low or high interanimation, that only tells you that there were at least two ideas presented. (Of course, returning to the transcript will allow you to count up the ideas, but we do not carry this information over to the timeline representation of the coding, or in the coding itself). This level of detail may be of interest if one was focused on only a handful of meetings, but for our purpose of describing a large range of these workgroup meetings it is too fine-grain-sized to capture.

One of the facilitators we talked to mentioned how there are really two forms of Social Chit-Chat that occur in their meetings: social talk and professional talk (e.g. Who else is going to this conference?). The former (social talk) contributes to the sense of community we aim to develop in the FOLC groups. The latter helps participants establish a professional network. These are both valuable forms of social capital but the taxonomy does not allow one to distinguish between them. The taxonomy certainly provides evidence of community formation (for example, through the Social Chit-Chat and Meta segments) but it better positions us to make *specific* claims about the types of pedagogical OTLs provided in conversation than specifics about the social connections a meeting affords.

One of the facilitators talked about how some FOLC meetings seem like a chore to people and the facilitators have to work hard to keep conversation going. In contrast, there are other meetings where the conversation flows organically and the discussion seems genuinely useful to people. The facilitator wants to be able to "see" the difference in these meetings. The difference certainly seems

consequential for the quality and usefulness of the OTLs created in the meeting. The facilitator hypothesized that indicators of these different meeting types would include how many times the facilitator has to interject, if there is a"round-robin" pattern of sharing out (a technique they use to fill the time), and if the meeting ends early. As explained above, the taxonomy does not capture who is talking, so it would not immediately identify where the facilitator talks in the meeting. Also, a round-robin conversational routine could be represented in multiple ways by the taxonomy coding. For example, we could imagine a round-robin of individual status updates, so a bunch of short, non-interactive status update segments. However, people could also go in a round-robin sharing how they have handled a pedagogical problem, and that would be coded as one long, interactive generating solutions segment. All this to say, the taxonomy may not offer the precision needed to distinguish between different conversational patterns, particularly those that are used in different types of conversations.

Lastly, as described with the examples of the taxonomy in use, but worth repeating here, the taxonomy does not tell one about the time spent in different meeting segment types. Because of our methodological choice to code a segment based on the highest-level meeting segment category that applies, it is misleading to talk in terms of time. As we discovered in our conversations with facilitators, it is natural to want to compare meetings based on time spent in different modes, but in reality the tool only permits us to talk about frequency (counts) and patterns of codes that co-occur. This adds a level of care one must take in interpreting (and not over-interpreting) a meeting coded with the taxonomy, but going with the highest-level meeting segment type keeps the information contained in a workgroup meeting at a manageable scale. Additionally, the user assigns value to the meeting segment types and an important result to capture is the highest-valued type a conversation reaches.

7.7 Conclusions

In this chapter I have presented a taxonomy for characterizing opportunities to learn in professional teacher workgroup meetings, specifically Faculty Online Learning Communities. I

have established what types of questions the taxonomy is well-positioned to answer, and those it is not so attuned to. It allows one to talk about group-level OTLs, track change over time, compare different teacher workgroups, and identify patterns between meeting segment types and communicative approaches. It does not capture some of the fine-grained detail on conversational dynamics (e.g. names of speakers) or speak to an individual's learning.

While we developed the taxonomy to provide a systematic way of analyzing FOLC meetings, we also see this tool being useful for in-person professional development programs such as Faculty Learning Communities (FLCs). Afterall, FOLCs are based on the FLC model and they both focus on building a long-term professional development community which provides OTLs around teaching. The tool is also potentially useful for analyzing the activity during one-time workshops. We expect that our communicative approach categories and attention to lived and formal concepts would translate to this environment, but the meeting segment types would likely need to be adapted. For example, in one-time or short-term faculty professional development we would not expect to see many "Meta" conversations, navigating how the community functions, because the community formation is limited. Our development of this tool occurred in the context of higher education science courses, adapting a taxonomy developed based on middle school mathematics teacher workgroups [136]. It is likely easiest to apply our taxonomy to other teacher workgroups at the higher education level, but the way we describe the communicative approach in conversations should translate to the K12 teacher workgroup context. Again, the compatibility of our meeting segment categories to this different context may be low, especially given that we had to change many of Horn's meeting segment categories and add new ones during our development process.

The taxonomy is a powerful analytic resource for researchers to explore the social dynamics and affordances for OTLs that are provided by the increasingly prevalent professional development spaces to support faculty's teaching practice. It also has practical utility for identifying facilitation moves that accompany different types of conversations and OTLs and for training meeting facilitators based on this information. This will be a major focus of our future work with the taxonomy.

Chapter 8

Conclusions and future work

In this dissertation, we have engaged in extensive model-building work directed at supporting change in faculty teaching practices. We presented the faculty online learning community (FOLC) model of professional development for educational change. At its most basic, a FOLC is a community of practice of faculty members from different institutions that communicate online in pursuit of their shared purpose. This common goal is worked toward collectively and collaboratively, guided by the facilitation of more experienced community members. Many change efforts in science education expect faculty to adopt research-based instructional strategies (RBISs) and to serve as the catalyst for wide-spread educational transformation, yet they fail to sufficiently support faculty through this change. We explored the FOLC model as a supplement to these change efforts, examining how a model grounded in a sociocultural approach to learning and structured around a community of peers can facilitate change in teaching practice. We did this through studying two implementations of the FOLC model, one supporting new physics and astronomy faculty and another supporting STEM faculty implementing a physical science curriculum. We investigated both the mechanisms supporting these faculty members' pedagogical development and the impacts of these mechanisms as perceived by the faculty.

In Chapter 3 we introduced the general FOLC model and how it is motivated by and builds on existing change models. We presented our first implementation of the model, the New Faculty Workshop-FOLC to support new physics and astronomy faculty as they implement RBISs and develop their reflective practice. The design principles of the NFW-FOLC include: providing ongoing

opportunities for learning about RBISs; providing ongoing feedback and support to help through implementation difficulties; encouraging a sense of safety and a willingness to be vulnerable within the group; enacting a structure that encourages and values the expertise of all participants; encouraging completion of a Scholarship of Teaching and Learning (SoTL) project; and fostering a supportive community. In Chapter 4, we went on to demonstrate through interview and survey results that the NFW-FOLC is meeting its learning objectives for participants by the mechanisms in its design (specifically the community of peers). We presented faculty participants' self-reports of their motivations for joining the NFW-FOLC and the impacts of participating in the program. Common motivations for joining included a desire to expand one's professional community; to receive implementation help with teaching techniques; and to learn more about teaching strategies. These motivations indicate that NFW-FOLC participants believe they need more support to implement changes than is provided by a single workshop and they value and see a need for this support to be in the form of a community. Common impacts were consistent with our learning objectives, such as gaining more teaching knowledge, implementing RBISs, and increasing reflection on teaching. Participants also are learning things beyond our written objectives, such as gaining professional knowledge about how different departments and institutions function. Survey data additionally indicated that FOLC members do feel a sense of community with their cohort; trust, commonalities in interests and goals, and the capability of the group to help them problem solve all aid this sense of community. Community is an important mechanism for change and also outcome for participants. In Chapter 5, we provided a preliminary study of the longitudinal impact of NFW-FOLC participation. Through the case of one participant, we showed proof-of-concept that FOLC participation can have an impact on teaching practice after a FOLC cohort has officially ended. Together these three chapters demonstrate the efficacy of a program to support new physics and astronomy faculty in their teaching. More generally, they contribute evidence supporting the FOLC model of professional development for educational change overall.

In Chapter 6, we tested the applicability of the FOLC model by exploring a second implementation, this time to support adopters of the Next Generation Physical Science and Everyday

Thinking curriculum (the NGPET-FOLC). We compared the NFW-FOLC and the NGPET-FOLC; in design, the two FOLCs differ in their focus and community structure. Nonetheless, we showed that they each are achieving their respective learning objectives for participants, including the ones they share in common. From comparing the two FOLC implementations, we concluded that the model works for both cohort-based and topic-based groups. What is important for FOLC design and functioning is that the group connects participants around a shared purpose that is highly valued by each member; the shared purpose can be related to a particular topic or identity of the community members. NGPET-FOLC and NFW-FOLC members both value the variety of perspectives they hear in the FOLC due to membership from a range of institutions and they appreciate the opportunities to troubleshoot teaching challenges with a community of peers. Future work will need to examine when a multi-year FOLC is preferable to a one-year model, and the details of what participants transfer to their teaching generally when they are involved in a topic-based FOLC (the "specific-to-general" approach).

In Chapter 7, we presented a taxonomy for analyzing the learning opportunities in FOLC meetings. A FOLC, as a dynamic social system, can be challenging to study. The taxonomy provides a structure and methodical approach to describing what occurs in a FOLC meeting and for investigating why those things are happening. We discussed how the tool has analytic and practical applications, as well as its potential to enhance the study of other professional development environments.

We have demonstrated the efficacy of the FOLC model in supporting the teaching development of new physics and astronomy faculty and faculty implementing a specific curriculum. Of course, there are some structural limitations inherent in the model. First, participation in a FOLC is voluntary and this may affect participation levels. FOLC meetings and the asynchronous communication platform require active participation from the faculty members in order for them to be useful. To incentivize NFW-FOLC participation, faculty members' department chairs complete an endorsement letter at the beginning of the program acknowledging that they support the faculty member participating in the FOLC; at the end of the year, we also provide letters documenting

their participation for their promotion packets. Generally speaking, the onus is on FOLC facilitators/program managers to make the value of active participation in the FOLC apparent for members. Second, participation requires members to have access to a stable internet connection and a web-cam. These resources are usually available when working on-campus, but they may be less accessible if a faculty member is joining a FOLC meeting from their home. Third, because FOLC members are located across multiple time zones, finding a meeting time that works for everyone can be challenging. We have found that a time that works for most members is late in the afternoon, Eastern time (e.g. 5pm EST, 4pm Central, 3pm MT, 2pm Pacific). However, this time is particularly challenging for faculty members with young children and families. This challenge could be mitigated by establishing FOLC groups based on the time zone of participants, or based on the time people would like to meet. Finally, FOLC groups are designed to have facilitators who ideally understand the FOLC model and have some experience with the topic of the FOLC. Finding facilitators has been relatively easy following the first implementation of a FOLC cohort because we can draw from past participants. If one wants to start a new FOLC, though, they will need to find and train facilitators. This could include themselves, if they have the necessary experience, or they may need to reach out to their wider professional network to find suitable facilitators.

Future research should continue to explore how far we can extend the FOLC model. For example, can it be a useful mechanism for supporting underrepresented populations in the physics professoriate? Traditionally physics faculty have been overwhelmingly male and white [102, 147] and recent efforts have sought to increase the diversity of physics faculty (see, for example, the efforts of the NSF INCLUDES program, in particular the APS IGEN network [148],and the APLU Aspire program [149]). It is reasonable to expect that faculty from underrepresented groups in a discipline will face unique challenges due to culture and bias. A FOLC may serve as a useful model for helping these new hires persist and succeed in their jobs by providing an opportunity to establish a sense of belonging among a community of peers which can support their teaching, research activities (e.g. getting grants, establishing a research group), and navigating a new department and institutional context. There are already in-person faculty learning communities (FLCs) for female faculty at a

given institution [74], but FLCs may be of limited use for providing disciplinary-specific support given that there are often only a handful of faculty members from underrepresented groups in a given physics department. A program sponsored by the American Association of Physics Teachers (AAPT), the eAlliance, is currently trying to address this issue by facilitating the establishment of mutual mentoring groups (which meet online) for women faculty in physics and astronomy [150]. The FOLC model is a more structured and scaffolded approach that could compliment the efforts of the eAlliances. Disciplinary societies (e.g. AAPT, American Physical Society, and American Astronomical Society) should explore hosting a FOLC to serve in this capacity.

It is also useful to consider what lessons from the FOLC model can be applied to our undergraduate science classrooms. While the needs of faculty and students certainly differ, the idea of learning through participation in a community of practice applies both when faculty are the ones learning and when students are the learners. It is perhaps easiest to consider what transfer could look like when focusing on a topic-based FOLC such as the NGPET-FOLC. Could a similar model support *students* in the NGPET course? As discussed in Chapter 2, many active-learning strategies incorporate group work and opportunities for collaborative knowledge generation, but something like the FOLC could help extend these commitments online, both for completely online courses and those that have in-person and online elements. Videoconference technology is widely available and many learning management systems already offer the functionality to create online discussion groups. From what we have seen with the two FOLC implementations, if a structured online community was formed for a given class, it would probably work best to split the class into smaller groups (approximately 10 members each) and there should be a variety of perspectives represented within a group (which could come from including students with a range of majors or class years, or simply ensuring that students are not grouped with the peers they work with in class). Ideally these groups would be facilitated by a more experienced peer such as a learning assistant. Our work also suggests that these groups should have a clear shared purpose that students care about. This could mean that groups select a focus (based on options given by the professor) or the focus reflects a major theme or goal of the class. This is a generative area for future work.

There is ample knowledge of effective teaching strategies and materials in STEM education generally and physics education more specifically. These research-based techniques and curricula are of little use, however, if they do not gain widespread and sustained use in our undergraduate science classrooms. Faculty have the incredible power to impact the science education students experience and they are motivated to implement new teaching techniques. They deserve adequate support as they make these changes and develop their teaching practice. Recognizing that faculty members can learn from each others' experiences, the FOLC model provides a structured community of support for educational change. This model additionally has the potential to support science faculty in their roles beyond teaching and can even serve to inform the communities we establish in our classrooms.

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Appendix A

NFW-FOLC Post-Experience Interview Protocol

This appendix includes the protocol for the post-experience interviews conducted with NFW-FOLC participants soon after the completion of their FOLC experience.

Interview Protocol –Cohort 4 Post FOLC Interview

Note: This is intended to be a semi-structured interview using this protocol as a guide. The interviewer should make a point to ask about the main questions but is free to follow up as feels appropriate.

GENERAL QUESTIONS

1. Introduce yourself, explain the purpose of the interview, ask if the interviewee has any questions about the process, remind them it is confidential and recorded, get verbal consent, etc.
2. Give me a little background about yourself? (i.e. what type of school, teaching experience, etc.)
3. Tell me about the FOLC. How did it is go?
   (This is intended to be a general question to get their perceptions without being guided by our questions; just get them talking about the FOLC and see what they say.)
4. Why did you sign up for the FOLC?
5. How different is it from what you expected? Explain.
6. What did you find most helpful or enjoyable regarding the FOLC?
7. What would you like to see improved or changed about the FOLC?
8. Do you feel your time spent on the FOLC is worthwhile? Explain.
9. How has what you do in the classroom changed since attending the NFW? (probe for how much of those changes were impacted by the NFW vs. the FOLC?)
    a. What techniques are you using now that you didn't before?
10. Has the way you view teaching changed since attending the NFW? (Probe for NFW vs FOLC impacts)
11. How confident are you in your ability to gauge your students' learning?
    a. Did that change as a result of the NFW and/or the FOLC?
    b. How did you evaluate your teaching previous to NFW? How do you evaluate it now?
12. What was [facilitator's] role in the group? Do you think they did a good job in that role? What could they have done to improve the function of the FOLC?

COMMUNITY

13. Does the FOLC feel like a community? Why or why not?
14. Did you feel a sense of responsibility towards the group? Do you think others feel a sense of responsibility towards you?
15. Have you talked with anyone outside of the FOLC about being part of the FOLC? How have you described the experience to them (or, how would you describe the experience to an outsider if you were going to)?

16. Have you had any interactions with members of the FOLC outside the online meetings or social cast? If so, what are they (e.g., professional vs. social) and using what medium (e.g., in person, email)?

ONLINE MEETINGS

17. Did you miss any of the online meetings? Why?
18. Was there a meeting or part of a meeting that you particularly liked? Please elaborate on what and why.
19. Was there a meeting or part of a meeting you particularly disliked? Please elaborate on what and why.
20. Please comment on the balance between guest speakers and general discussion time. Would you prefer a different balance?
21. How frequently do you participate in the discussions compared to others?
    a. Do you find it easy to participate in the discussion when you want to?
    b. Do you feel comfortable participating in the discussions?
22. Do you have any suggestions for how to improve the online meeting experience?

ASYNCHRONOUS COMMUNICATION (SOCIALCAST)

23. What do you think of the Socialcast platform?
24. Have you had any difficulties using Socialcast?
25. How helpful is reading posts made by others? Explain. (Perhaps ask them to tell a story about a particularly helpful discussion or post.)
26. Under what circumstances do you generally respond to others on Socialcast? (e.g. what kinds of questions, facilitator's prompts, time of day, around certain activities in your life)
27. Under what circumstances do you generally initiate a thread on Socialcast? (e.g. time of day, topics?, etc.)
28. Do you feel that you post more frequently, or less frequently compared to others? If they report they post infrequently, ask them why that is.
    a. (if not covered) How often do you post?
29. When you have posted on Socialcast, have others responded? Have you found these responses to be helpful? Explain. (Perhaps ask them to tell a story of very useful or not so useful experiences.)
30. Do you have any suggestions for how to improve the Socialcast experience?

PROJECTS

31. Tell me about the projects in the second half of the FOLC
    a. What was your project?

b. What was the process by which the projects happened?

32. Did you find them valuable?
33. Did you have the support you needed for the project? What other support might have helped you?
34. How could that experience be improved?

CHANGE AGENT

35. Have you talked to anyone about the things that you have learned in the FOLC?
    a. Has your participation in the FOLC impacted anyone around you?
    b. Follow-up: Have you shared any techniques? Given a seminar, brown bag….?.

OVERALL CONCLUDING QUESTIONS

36. If a participant in the next New Faculty Workshop contacted you to ask whether they should be part of a FOLC, what would you tell them?
37. Do you have any other feedback or suggestions that can help us improve the FOLC experience?

Appendix B

Codebook for NFW-FOLC interviews

This appendix includes our coding scheme for the NFW-FOLC post-interviews. Specifically, the first table includes the codes for describing participants' motivations for joining the FOLC. The second table includes the codes for describing the impact of participating in the FOLC.

Table B.1: Coding scheme for "motivation for joining" the NFW-FOLC. There are four main codes (bolded). The main code "Expanding Professional Community" has four sub-codes (italicized). Participants can be co-coded with multiple main codes and/or sub-codes.

MOTIVATION	DEFINITION
To be a Better Teacher	Participant says they joined the FOLC because they wanted to be a better teacher (or some synonym for this). Implies that they want to learn, so if participant says they joined to "learn something new" that fits under this code.
Expand Professional Community	Participant describes wanting to talk with others about teaching, connect with other faculty, and/or continue the conversations started at the in-person NFW. Participants who specified the type of connection they wanted fit into one (or multiple) of the following sub-categories:
Connect with other new faculty	Participant joined to meet other early career faculty members/ to have peer group.
Connect with faculty outside their department for broader perspective	Participant joined to meet faculty members outside their local department and institution.
Connect with other faculty who care about teaching	Participant wanted to join a community of people who were interested in teaching and cared about improving it.

MOTIVATION	DEFINITION
Connect with other faculty due to lack of sufficient local support	Participant expressed wanting a community that their local environment did not provide. This could be that their department is traditional in their teaching/ too small/ faculty are all tenured except for them. Note, these same participants often mentioned feeling supported by their local department in *other* ways.
Learn More about Teaching Strategies	Participant describes wanting to learn new things about teaching. This code captures participant's desire to increase their teaching knowledge. They don't specify who they want to learn from, or if they do specify, they are NOT talking about learning from group's experiences (that would be Implementation Help, see below).
Implementation Help	Participant wanted help implementing research-based instructional strategies. Participant described a desire to get feedback *from the FOLC community* as they implemented new teaching techniques; they wanted to increase the usability of knowledge they gained at the NFW. They may describe wanting to "bounce ideas off people" in order to improve their implementation of a teaching technique.

Table B.2: Coding scheme for "impacts of participating" in the NFW-FOLC. This scheme includes impacts of the FOLC on participants' teaching, beliefs, practices, attitudes, etc. Impact is anything that had an effect, either during the FOLC or more long term. Impact can describe an internal change or behavior change. For all impacts EXCEPT "Resource," they are an effect housed within you. There are seven main codes (bolded). The main code "Knowledge" has three sub-codes (italicized). Participants can be co-coded with multiple main codes and/or sub-codes.

IMPACT	DEFINITION
Implementation Change	FOLC influenced implementation change they made in their teaching. Includes different types of implementation of research-based instructional strategies: Try new thing (or plan to); persist in trying something; or trying something more robustly (something they did pre-NFW and now are modifying). Does not have to be too specific to count as this code: they don't have to reference a particular technique.
Increased Reflection	FOLC caused them to reflect on their teaching practices, what goes on in their classroom, and how to assess changes they have made.

IMPACT	DEFINITION
Gained Confidence	FOLC increased their confidence in some aspect of teaching (e.g. gauging student learning; trying a new teaching strategy).
Gained Knowledge	This code covers anything they learn from the FOLC experience, and includes increasing retention of knowledge learned at NFW. This code can be further specified by one (or multiple) of the following sub-categories:
Teaching Knowledge	Knowledge gained about teaching methods, techniques, and resources; feedback; bouncing around teaching ideas; implementation help received; learning about difficulties students encounter in physics class; learning how to evaluate their teaching; what they learned from their SoTL project; reinforcing info learned at NFW.
Professional Knowledge	Learned what different types of institutions are like; learning about politics at other institutions; "professional context"- learning about other people in academia; administrative things- how other departments/colleges do x, tenure process at other institutions, etc.; perspectives from people at different schools; "how to be a faculty member" info
Awareness they are not alone	Learned they are not alone: everyone experiences similar issues & are having similar struggles; learning problems they are having are common, no matter who your students are, there are common struggles; knowing that other young faculty don't know all the answers either; seeing that others are struggling too.
Students Benefited	Faculty report students saying the activity/teaching strategy they tried (because of the FOLC) helped them (students) or faculty specifically says FOLC experience helped their students.
Saved Time	FOLC saved them time in improving their teaching, made it more efficient.

IMPACT	DEFINITION
Gained Resource	Faculty report getting some (non-material) resource because they were part of the FOLC. Getting the resource is an effect. Unlike all the other impacts, Resource is housed external to you. (The only exception to this is when they talk about gaining outside-their-department perspectives; that is co-coded as Resource and Knowledge. This is the only exception where Resource can be internal to you.) Benefits of the FOLC fit under this code (commonly indicated by "I liked _____" or "_____was nice"); the most helpful/useful thing about the FOLC can count under this code, depending how talk about it. Common types of resources mentioned included a community of support, accountability, and access to experts.

Appendix C

NFW-FOLC Longitudinal Interview Protocol

This appendix includes the protocol for the longitudinal interviews conducted with NFW-FOLC participants approximately two years after the completion of their FOLC experience.

Longitudinal Interview Protocol

Note: This is intended to be a semi-structured interview using this protocol as a guide. The interviewer should make a point to ask about the main questions but is free to follow up as feels appropriate. Sub-bullets are meant to be follow-ups/probes if the participants don't naturally talk about them, but you don't have to ask all the sub-bulleted questions directly.

GENERAL QUESTIONS

1. Introduce yourself, explain the purpose of the interview, ask if the interviewee has any questions about the process, remind them it is confidential and recorded, get verbal consent, etc.
2. Since finishing the FOLC:
    a. Have there been significant changes in what you teach or your teaching load?
    b. The institution you are at?
3. Overall, how did you feel about your FOLC experience?
4. How has your FOLC experience impacted you?

(This is intended to be a general question to get their perceptions without being guided by our questions; just get them talking about their experience and see what they say.)

TEACHING

5. How would you describe your teaching?
6. Has what you do in the classroom changed since starting the FOLC?
    a. What techniques are you using now that you didn't before?
    b. Clarify what changes happened during the FOLC and after the FOLC.
    c. To what extent did the FOLC impact these changes? (vs. NFW for example or other experiences)
7. How have you changed as a teacher in general?
    a. Have your beliefs about teaching and/or your teaching philosophy changed?
    b. What lead to these changes?

REFLECTION

8. How do you evaluate your teaching?
9. How did you evaluate your teaching previous to NFW? Did that change as a result of the NFW and/or the FOLC?
    a. Probe about when changes happened if not mentioned.
10. How confident are you in your ability to gauge your students' learning?
11. What tends to prompt changes in your teaching and why?

a. Probe how they make these decisions- due to things they learned at FOLC?

COMMUNITY

12. Do you feel like you have a teaching community (a community that supports your teaching work)? (If yes, who makes it up?)
13. Do you have a department that is supportive of your teaching efforts?
14. How has your department viewed your participation in the FOLC?
    a. Was your department supportive of your participation in the FOLC? (get them to elaborate on the basis for their answer)
15. Have you kept in contact with any of your fellow FOLC members and/or facilitators?
    a. Who?
    b. By what means? (email, Social Cast, in-person, etc.)
    c. Can you give a specific example of some interaction you have had with a FOLC member after the end of your FOLC?
    d. Why? What motivated the continued contact?

If they say "No, they haven't kept in contact" ask why. Is it okay with them that they haven't kept up with people, or would they have liked to but other things got in the way?

ASYNCHRONOUS COMMUNICATION (SOCIALCAST)

16. Have you used the Social Cast Alumni Group?
    a. If yes, give an example.
    b. If no, why not?
17. Are there things we can do to make it easier to keep in touch with your FOLC members after the FOLC officially ends?

PROJECTS--

18. Have you continued/ followed-up on the project you completed during the second half of your FOLC?

CHANGE AGENT

19. In the time since completing the FOLC, have you shared any techniques, ideas, materials, etc. you learned in the FOLC with others (in your department)?
    a. Probe for formal and informal sharing (ie seminar, brown bag talk, hallway conversations, etc)
    b. Has anyone changed their teaching as a result of conversations with you?
20. Do people in your department or at your college go to you for teaching advice? Has this changed since participating in the FOLC?
21. Have other people in your department attended the NFW and/or participated in the FOLC?

a. If yes, did they attend due to your encouragement/past participation?

OVERALL CONCLUDING QUESTIONS

22. Do you feel your time spent on the FOLC was worthwhile? Explain.
23. What was the most valuable aspect of the FOLC experience for you?
24. What advice do you have for the FOLC organizers?

Appendix D

NGPET May 2019 Survey

This appendix includes the survey questions administered to the NGPET community in May 2019.

NGP FOLC Feedback 2018–19

1. To what extent has each of the following occurred as a result of participating in the FOLC during the 2018-19 academic year: [not at all, minimally, moderately, to a great extent]
    a. I have become more reflective about my teaching.
    b. I have gained confidence in my teaching.
    c. I have gained knowledge about pedagogical techniques.
    d. I have learned that others face similar teaching challenges.
    e. I have learned how other institutions/departments compare to my own.
    f. I have developed my skills as a teacher more efficiently than I would have without the FOLC.
    g. I have saved time in preparing and implementing my course.
    h. I have seen increased student learning.
    i. I have incorporated ideas from the FOLC into my teaching.
    j. I have gained a community which supports my teaching practices.
    k. I have received encouragement and moral support regarding my teaching.
    l. I have become more excited about my teaching.
    m. I am more motivated to try new teaching techniques in my other classes.
    n. I have been introduced to new concepts (about teaching and learning) that are helpful for thinking about my ongoing teaching work.
    o. I have gained a deeper appreciation for the complex aspects to consider in diagnosing teaching challenges.
    p. Other; please specify*

2. Please briefly describe the most significant impact(s) of participating in the FOLC. Please feel free to include impacts that are not listed in Question 1. [text box]

3. Has participating in the FOLC impacted mostly your teaching of the Next Gen PET course, mostly the other courses you teach, or a mix of both?

Mostly my Next Gen PET course		A roughly equal mix		Mostly other courses
□	□	□	□	□

Please use the space below to elaborate if you wish:

4. How would you describe the balance of attention to practical issues (e.g., pacing, equipment) and pedagogical issues (e.g. student learning, promoting student engagement) in the FOLC?

Too much attention to practical issues		The right balance between practical and pedagogical issues		Too much attention to pedagogical issues
□	□	□	□	□

5. What did you find most valuable about your involvement in the FOLC? [text box]

Cluster Feedback

6. How often have you participated in cluster meetings during the 2018-19 academic year? (Most clusters scheduled one meeting per month this year; cluster 5 met more often.)

Never		About half the time		Every time
□	□	□	□	□

7. What do you like most about cluster meetings? [text box] [skip if Q6 = never]

8. What could be better about cluster meetings? [text box] [skip if Q6 = never]

9. Did you participate in a project group?
   - ○ Yes
   - ○ No
   - ○ Sort of/not sure

Project Group Feedback

10. What interested you in the project you are involved in? Select all that apply [Display only if Q9=Yes]

    - ❑ I am interested in the topic for my teaching.
    - ❑ The topic ties in with other interests I have (research, previous work, etc).
    - ❑ I wanted to work with other people who were involved.
    - ❑ Other; please specify*

11. How satisfied are you with the project you are involved in? [Display only if Q9=Yes]

    Not Satisfied Minimally Satisfied Moderately Satisfied Very Satisfied

12. What do you like about being involved in the project? [Display only if Q9=Yes]

13. What could the Next Gen PET FOLC do to improve being involved in the project? [Display only if Q9=Yes]

14. To what extent did each of the following limit your involvement in a project group? [not at all, minimally, moderately, to a great extent]
    a. lack of time
    b. lack of interest
    c. scheduling difficulties
    d. uncertainty about expectations or what to do
    e. Other; please specify*

15. What could the Next Gen PET FOLC do to make it more likely for you to be involved in a project group? [Display only if Q9= No or sort of/not sure]

Other Ideas About Future NGP FOLC Activities

16. What other Next Gen PET FOLC activities would you like to participate in? Check all that apply.
    - ❑ Q&A with guest experts - one-time sessions either on video or 'live' on slack
    - ❑ Scheduled discussions with someone external to the FOLC on specific topics open to all FOLC members
    - ❑ Community-wide webinars
    - ❑ Video club - a group that meets regularly to share and reflect on videos of our teaching
    - ❑ "Taking it up a notch" groups that meet regularly to focus on improving a particular aspect of our teaching (eg, whole class discussions, managing groups, etc)
    - ❑ A group that meets regularly to share and reflect on student work
    - ❑ A working group to develop "implementer's perspective" guides for the curriculum
    - ❑ Peer feedback from the FOLC, possibly for use in teaching portfolio or tenure materials
    - ❑ Other; please specify*
    - ❑ None of the above

17. Please share any ideas for additional FOLC activities.

Your Thoughts About the Next Gen PET Curriculum

18. Please respond to each of the following statements in terms of <u>your present thinking</u> about the Next Gen PET curriculum. Select one on each row. [0, Irrelevant;1, Not true of me now; 4, Somewhat true of me now; 7, Very true of me now]
    a. I am concerned about how to organize my course using the Next Gen PET curriculum.
    b. I am concerned about not having enough time to organize myself each day to use the Next Gen PET curriculum.
    c. I am concerned about being able to acquire and manage the materials and equipment the Next Gen PET curriculum requires.
    d. I am concerned about my ability to implement the teaching strategies in the Next Gen PET curriculum.
    e. I am concerned about students' attitudes towards the Next Gen PET curriculum.

f. I am concerned about students' abilities to engage in the inquiry-oriented activities included in the Next Gen PET curriculum.
g. I am concerned about how the Next Gen PET curriculum affects students' learning.
h. I would like to help other faculty in their use of the Next Gen PET curriculum.
i. I would like to develop working relationships with other faculty using the Next Gen PET curriculum.
j. I would like to coordinate my effort with others to maximize the effects of the Next Gen PET curriculum.
k. I would like to know what other faculty are doing with the Next Gen PET curriculum.
l. I now know of some other approaches that might work better than the Next Gen PET curriculum.
m. I would like to revise the instructional approach of the Next Gen PET curriculum.
n. I would like to modify my use of the Next Gen PET curriculum based on the experiences of my students.
o. I would like to determine how to supplement or enhance the Next Gen PET curriculum.

19. Please indicate your current level of preparedness to do each of the following: [Not At All Prepared, Somewhat Prepared, Fairly Well Prepared, Very Well Prepared]
    a. Structure your course using the Next Gen PET curriculum
    b. Manage the equipment/logistics associated with implementing the Next Gen PET curriculum
    c. Teach the Next Gen PET curriculum materials effectively
    d. Assess student learning *formatively* in the context of the Next Gen PET curriculum
    e. Assess student learning *summatively* in the context of the Next Gen PET curriculum

20. To what extent has ***participating in the FOLC*** prepared you to do each of the following: [not at all, minimally, moderately, to a great extent]
    a. Structure your course using the Next Gen PET curriculum
    b. Manage the equipment/logistics associated with implementing the Next Gen PET curriculum
    c. Teach the Next Gen PET curriculum materials effectively
    d. Assess student learning *formatively* in the context of the Next Gen PET curriculum

e. Assess student learning *summatively* in the context of the Next Gen PET curriculum