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The Implementation and Outcomes of Lesson Study in Community College Mathematics

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TEACHERS COLLEGE, COLUMBIA UNIVERSITY

The Community College Research Center (CCRC), Teachers College, Columbia University, has been a leader in the field of community college research and reform for 25 years. Our work provides a foundation for innovations in policy and practice that help give every community college student the best chance of success.



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Inside This Report

In this report, we describe a project undertaken by the Community College Research Center (CCRC), Education Northwest (EdNW), and three community colleges in Oregon to adapt lesson study for use among faculty teaching a precollege (developmental) quantitative literacy course. Lesson study is a collaborative professional development approach that has been implemented among K-12 mathematics teachers with promising results for both teachers and students. There has been limited research on its application in higher education. We report findings from a mixed-method study of the adapted model's implementation among faculty in the community colleges and report limited findings on student learning and progression in developmental mathematics.

In the adapted lesson study model, a team of faculty members works to collaboratively design, teach, and reflect on the effects of a lesson, defined as a one- to two-hour period of instruction focused on a specific topic or goal. During lesson study, team members engage in iterative cycles of inquiry and action. Each cycle consists of four stages intended to be completed in a single semester/term: (1) study and plan a lesson; (2) teach the lesson, collect observational data, and debrief the teaching; (3) revise the lesson, reteach with a different set of students, and collect observational data; and (4) reflect on the cycle results, document professional learning, and disseminate the findings to colleagues.

The project activities unfolded across two phases. In the model development phase, faculty leaders were trained to implement lesson study over three cycles, during which the project team and faculty leaders collaborated on adapting the model for use in the community college context. Then, in the pilot study phase in fall 2019, the adapted model was implemented by faculty teams from the three colleges. A total of 22 math faculty participated in the project. Across the development and pilot phases of the project, the research team used a mixed-method study design to examine how lesson study was adapted for community colleges, how community college faculty implemented the model, and how the model affected faculty and students. Data sources included interviews with participating faculty and college administrators, a survey of all mathematics faculty at the three colleges, observations of lesson study activities, an assessment of student learning, and administrative data that included information about students' course enrollments and grades. This report includes the following project findings:

- **Lesson study is different from typical opportunities for professional development in community colleges.** While lesson study shares some similarities with other collaborative and intensive professional development models such as faculty inquiry groups, it makes use of a highly structured approach to improving discipline-specific teaching practices. Protocols used in lesson study are distinctive in how they prompt faculty teams to observe and closely examine specific instructional strategies and their impact on student learning.
- **Faculty implemented lesson study with fidelity.** Using a fidelity rubric developed in consultation with faculty leaders during the model development phase, the research team scored each faculty team during the pilot phase on

18 indicators of strong lesson study implementation. All four teams met the characteristics for either strong or moderate implementation for all 18 indicators.

- **Participating faculty were overwhelmingly satisfied with their lesson study experiences.** The lesson study protocols invited the faculty team to identify collaboration norms, directed the team’s attention to long- and short-term learning goals, required the team to make collective decisions about detailed instructional plans, and provided the team with opportunities to closely observe student learning. These elements of the model fostered rich and detailed conversations about teaching and learning, which participants found valuable.
- **Faculty who participated in lesson study adopted new teaching practices.** Analysis of observation notes and lesson plans from the model development and pilot phases shows that revised lessons included more open-ended, cognitively demanding tasks and new strategies to increase mathematical communication among students.
- **To sustain lesson study, community colleges must provide continued support.** Lesson study requires significant administrative coordination and a skilled facilitator. One of the three colleges continued lesson study beyond the project period using funds from the department dean to provide faculty facilitators with released time from teaching and pay part-time faculty for their participation. Others intended to implement “light-touch” versions of lesson study that preserve important features of the model but require less time.
- **Due to limitations of the research design, we were largely unable to estimate the effects of lesson study on student outcomes.** Students in some course sections taught by faculty who participated in lesson study performed better on some items in a researcher-designed assessment of student learning, as compared to students taught by nonparticipating faculty. We found no positive relationship between lesson study and students’ course grades or progression into college-level math. It may not be reasonable to expect substantial differences in student learning or academic outcomes after only one cycle of lesson study. What is more, we were unable to carry out a quasi-experimental estimate of the direct impact of even one cycle of lesson study on student outcomes because we did not have baseline data on students’ prior academic achievement.

Introduction

Effective instruction is central to a range of ongoing reform efforts in higher education, including those that aim to increase online course offerings, address persistent student equity gaps, and improve the student experience by means of broad structural change (through, for example, guided pathways and developmental education redesign initiatives). However, much of this reform work does not sufficiently support faculty in strengthening their teaching practice through professional development. Professional development for higher education faculty typically takes the form of attendance at one-time workshops or conference sessions and is rarely hands-on. It often focuses on relatively decontextualized topics—such as using technology in the classroom or addressing common student learning disabilities—which may not address the specific instructional needs that faculty have within their particular disciplines. Moreover, part-time faculty, who make up two thirds of the instructional staff at community colleges, have less access than full-time faculty to the limited professional development opportunities that do exist.

High-quality teaching is crucial for students taking developmental mathematics courses in community colleges, many of whom have been poorly served in their prior educational experiences. Succeeding in developmental mathematics can play a critical role in preparing these students for college-level coursework and getting them on a path toward college persistence, program completion, and, ultimately, upward mobility. Reform efforts are underway to redesign developmental course sequences at community colleges to better engage students and help them to succeed. Most of these efforts focus on restructuring coursework, redesigning curricula, or enhancing student supports. However, as with reform efforts in higher education more generally, few developmental mathematics reforms explicitly attend to student learning through improved pedagogy, which could be facilitated through professional development for faculty (Edgecombe et al., 2013).

High-quality teaching is crucial for students taking developmental mathematics courses in community colleges, many of whom have been poorly served in their prior educational experiences.

Lesson study, a collaborative professional development model that focuses on improving instruction, has the potential to help faculty members make changes in their teaching practice that may improve student learning and success. In lesson study, small teams of faculty work in iterative “cycles” to collaboratively plan a lesson, observe the lesson’s implementation in a class with students, collect and analyze observational data on how students interact with the lesson materials, and revise the lesson based on their findings. Lesson study has been implemented among elementary and secondary mathematics teachers with promising results, but there has been limited application in higher education. In this report, we describe a collaborative project undertaken by the Community College Research Center (CCRC), Education Northwest (EdNW), and three community colleges in Oregon to adapt lesson study for use in the community college context. We report on findings from a mixed-method study of the adapted model’s implementation and its effects on student learning and progression in developmental mathematics.

We found that, although lesson study is different from the typical professional development opportunities available in community colleges, faculty were able to implement lesson study successfully. Participants largely enjoyed their lesson study experience, particularly its focus on improving mathematics pedagogy and the opportunities it provided for intensive and productive collaboration. Faculty adopted new teaching practices as a result of their participation in lesson study. Owing to study design and time limitations, we were not able to rigorously evaluate lesson study's impact on student outcomes. Based on a descriptive analysis, we were able to detect only a limited positive relationship between faculty participation in lesson study and student learning and no positive relationship between faculty participation in lesson study and students' grades or other academic progression milestones during the pilot study. However, drawing on our qualitative analysis, we present a theory of change for lesson study and offer suggestions for future research that could assess the impacts of lesson study on student learning and outcomes in community colleges.

Rationale for Lesson Study in Community Colleges

Within the field of professional development for educators, evidence from K-12 contexts points to a well-documented set of characteristics that produce changes in educator practice and improvements in student learning outcomes. These characteristics include professional learning opportunities that: are content-focused and of sustained duration, incorporate active learning for teachers, support collaboration among educators, use models of best practice, provide coaching and expert support, and offer time for feedback and reflection (Cohen & Hill, 1998; Garet et al., 2001; Kennedy, 1998). According to Darling-Hammond et al. (2017), effective professional learning incorporates most or all these features.

In community colleges (and other higher education institutions), there are relatively few examples of professional learning opportunities with these characteristics. This is in part because the structure and culture of higher education have not typically fostered extended or intensive opportunities for professional development related to pedagogy (Furco & Moely, 2012; McHenry et al., 2010). Long-held professional norms around faculty autonomy and limited instructional guidance serve as barriers to meaningful or sustained professional development in teaching. Faculty are not typically provided with opportunities to learn about evidence-based teaching practices and their application in the classroom. Moreover, faculty have an array of responsibilities that extend beyond teaching and therefore engage in many professional development activities that are not focused on pedagogy, including learning about institutional policies and structures, improving skills related to scholarship and research, and strengthening disciplinary expertise (Taylor & Colet, 2010).

Evidence About Lesson Study

Lesson study shows promise as an effective professional development approach for improving instruction. Although it originated in Japan, where conceptions and expectations of teaching and teachers are very different from those in the United States, it has been implemented

successfully in K-12 settings in the United States with research showing positive impacts on student learning. A 2014 literature review of 643 studies of professional development in mathematics found that lesson study was one of only two approaches with rigorous evidence of effectiveness in improving student outcomes (Gersten et al., 2014). A randomized controlled trial of lesson study among elementary school teachers showed a significant positive impact on students' knowledge of fractions (Lewis & Perry, 2015). In a study of lesson study involving high school geometry teachers, Barrett et al. (2013) found that students whose teachers participated in lesson study performed significantly better on benchmark exams than students whose teachers did not.

These findings are not surprising, because lesson study aligns with the previously discussed research-based characteristics of high-quality professional development for educators. For example, lesson study groups teachers who teach common subject areas together, which has been found to increase collaboration and trust among teachers and build the capacity of teachers to learn together (e.g., Byrum et al., 2002; Garet et al., 2001; Wilms, 2003). The model uses active, hands-on approaches to teacher learning, with teachers planning lessons together, trying new teaching strategies, collecting data on their work, and reflecting on the results. The model also focuses on content-related topics, such as curriculum, content knowledge, and how students learn specific content, which has been found to be more effective in increasing teachers' professional learning than focusing on general pedagogical approaches (e.g., Cohen & Hill, 1998; Kennedy, 1998). In many ways, lesson study produces a structured professional learning community, or PLC, an example of a collaborative professional development model that incorporates several of the characteristics of effective professional development in K-12 settings that support student learning gains (Darling-Hammond et al., 2017).

Although not rigorously studied, the use of lesson study in higher education has been documented (Cerbin, 2011; Cerbin & Kopp, 2006; Demir et al., 2012). A recent systematic review of lesson study among higher education faculty (Hervas, 2021) found five positive outcomes for faculty who participated in lesson study across 21 studies (listed here from most to least often reported): a shift in faculty practice from teaching to learning, a consequent shift to more interesting and/or meaningful teaching and learning experiences, increased collaboration and collegiality, other changes in faculty knowledge and practice, and an increase in continuing to engage in inquiry-based professional development and research. Significantly, however, all but one of the studies were limited to seven or fewer participants, and the results focused on impacts on faculty, not on outcomes for students.

Lesson Study in the Developmental Math Context

Many developmental mathematics courses at community colleges have undergone extensive structural and curricular redesign, but faculty may not have received support in instructional practice for these new courses. This is particularly concerning given the documented challenges associated with implementing effective instruction in reformed developmental mathematics contexts (Bickerstaff & Cormier, 2015; Cox, 2018). For example, many community colleges have created quantitative literacy pathways, designed to shorten the developmental math sequence for non-STEM (science, technology, engineering, and math) students and prepare them for liberal arts math, a

college-level, transferable course. This newly redesigned developmental math pathway requires that faculty accustomed to teaching algebra develop a new body of pedagogical content knowledge that emphasizes mathematical reasoning about everyday mathematics concepts. Additionally, a significant proportion of developmental course sections in community colleges are taught by part-time or adjunct faculty, who are less likely to access on-campus supports and resources (Center for Community College Student Engagement, 2014). Thus, there is a need to identify models for instruction-focused professional learning that can be tested for usability in community colleges and for their promise in improving instruction and outcomes, particularly among those community college students who may be academically underprepared.

Given its relatively strong research base in K-12 settings, lesson study appears well-suited for the community college developmental mathematics context. The model provides a clear structure for strengthening instruction and systematically examining student learning, which is necessary for the development and monitoring of specific instructional interventions. Once trained in lesson study, faculty can continue to deepen their expertise with the model through repeated implementation without the need for additional training. In this way, the initial training investment potentially pays high dividends in terms of faculty learning in the future. Furthermore, with its focus on collecting classroom-level data, lesson study is aligned with faculty inquiry models such as scholarship of teaching and learning (Boyer, 1990) and classroom assessment (Angelo & Cross, 1993), which have long histories in higher education. Finally, lesson study does not require faculty to enact wholesale course redesign—for example, to revise course goals, curricula, or assessments—unless they choose to; therefore, it may be perceived as a feasible approach in an environment that prioritizes faculty autonomy.

Project Description

CCRC partnered with EdNW and three community colleges in Oregon to implement lesson study in a precollege quantitative literacy course (Math 098). As part of a larger, statewide effort to redesign developmental education that began in 2014, community college math faculty developed Math 098, and nearly all community colleges in the state began to implement it in the 2014–15 academic year (Hodara & Petrokubi, 2017). In parallel, Oregon's community colleges implemented other reforms to developmental education, including the integration of reading and writing skills into a combined course and the development of multiple measures for placement in developmental education courses.

Math 098 provides Oregon community college students with an alternative, shorter math pathway to prepare for college-level math (Higher Education Coordinating Commission, 2015). The course is designed for students whose degree or certificate goals do not require trigonometry or calculus and who are pursuing programs in liberal arts or other non-STEM fields. The course covers applied number sense, applied algebraic reasoning and modeling, graphical sense, measurement, and statistical reasoning. One of the three colleges also offers an additional prerequisite course (Math 058) in the non-STEM

pathway, which prepares students for Math 098. Faculty at that college conducted lesson study in both Math 058 and Math 098.

Table 1.

Partner College Characteristics

	URBANICITY	FALL ENROLLMENT, DEGREE-SEEKING HEADCOUNT	FULL-TIME STUDENTS	PELL GRANT RECIPIENTS	BLACK & HISPANIC STUDENTS	GRADUATION RATE, 150% (3-YEAR)
Clackamas Community College	Suburban	5,187	43%	44%	15%	13%
Lane Community College	Rural	6,607	53%	50%	15%	19%
Portland Community College	Urban	24,404	42%	43%	17%	21%

Source. Academic year 2018–19, Integrated Postsecondary Education Data System (IPEDS).

The project activities unfolded across two phases: (1) model development and (2) a pilot cycle and study. During the model development phase, lasting from spring 2018 to summer 2019, each community college identified a leadership team comprising about four full-time and part-time mathematics faculty members with an interest in refining instruction in Math 098. EdNW facilitators provided these teams with initial training on lesson study, and then the leadership teams conducted three cycles of lesson study facilitated by EdNW staff. After each cycle, faculty provided feedback on their experiences to EdNW, which informed the refinement of the adapted model and the development of facilitation materials. The leadership teams from the three colleges convened all together three times during this phase to deepen their understanding of research-based instructional practices, share what they were learning about instruction as a result of participation in lesson study, build consensus on the components of the adapted model, provide feedback on draft facilitation materials, and discuss strategies for sustaining lesson study at their colleges. (For more information about project activities, see Bickerstaff et al., 2019.)

In fall 2019, between one and three members of each leadership team volunteered to serve as facilitators of a pilot lesson study cycle with colleagues from their department who had not yet been involved in lesson study. Four teams at the three colleges participated in this pilot of the adapted lesson study model. The teams used lesson study materials developed by EdNW, but EdNW facilitators did not participate in the pilot implementation.

A total of 22 math faculty participated in the project. Compared to the broader population of faculty teaching developmental mathematics at the three colleges, faculty who volunteered to participate in lesson study were different from their colleagues in that they were more likely to be female, less likely to be White, less likely to have a doctorate, and slightly younger with less college teaching experience (as described in Table 2). These differences may be attributable to the fact that lesson study was focused on Math 098, a new quantitative literacy course that faculty largely self-selected to teach.

Table 2.
Characteristics of Faculty Participants and Nonparticipants

FACULTY CHARACTERISTICS	LESSON STUDY PARTICIPANTS	OTHER DEVELOPMENTAL EDUCATION MATH FACULTY
Employment status		
Full-time faculty	36%	36%
Part-time or adjunct faculty	64%	60%
Other	-	4%
Gender		
Male	23%	40%
Female	64%	52%
Other/no response	14%	8%
Age (years)	47.5	49.9
College teaching experience (years)	24.9	26.6
Highest degree		
Doctorate or professional	5%	12%
Master's	82%	86%
Bachelor's	14%	2%
Race/ethnicity		
White	73%	82%
Black	-	-
Asian	9%	6%
Hispanic	5%	-
Middle Eastern	-	2%
Other/no response	18%	16%
N	22	50

Across the model development and pilot phases of the project, the research team used a mixed-method study design to address four research questions related to the adaptation and implementation of lesson study and the influence of the model on instructors and students (see Table 3).

Table 3.**Research Questions and Data Sources**

RESEARCH QUESTIONS	DATA SOURCES
Adaptation and implementation	
1. How can lesson study be adapted for implementation in a community college context and what are the adapted model's core components?	<ul style="list-style-type: none"> • Observations of training activities, convenings, and lesson study cycles • Interviews with EdNW facilitators and faculty leadership teams
2. Does lesson study influence instructors' beliefs, curricular materials, and teaching practices?	<ul style="list-style-type: none"> • Observations of lesson study cycles across both project phases • Review of lesson plans • Faculty survey • Interviews with faculty
3. Can lesson study be feasibly implemented in higher education?	<ul style="list-style-type: none"> • Interviews with faculty and college administrators
Student outcomes	
4. What is the relationship between faculty participation in lesson study and student learning outcomes?	<ul style="list-style-type: none"> • Assessment of student learning • Student-level administrative data

To address the first three research questions focused on adaptation and implementation, we collected several forms of qualitative data. To capture the perspectives of faculty participants and to understand the feasibility of implementing lesson study, we conducted interviews with members of the leadership teams at the beginning and end of the project period and interviews with other stakeholders in the interim, including college administrators and faculty who participated in the pilot study. We conducted a survey of all math faculty at all three colleges in fall 2018 and fall 2019. The research team observed and took field notes at training and adaptation activities as well as at the lesson study cycles during the model development and pilot study phases. For each lesson study cycle, the research team collected two versions of the lesson plan; in cases where the team was working from a preexisting lesson, researchers also documented a third baseline version of the lesson plan. Through our implementation research, we sought to understand faculty experiences with lesson study, the ways in which the approach is different from other typical professional development opportunities, and faculty satisfaction with their experiences. We also identified lessons that could be useful for other postsecondary institutions interested in implementing lesson study. This research also informed adaptations to the lesson study model during the model development phase.

To document the effects of lesson study on students, the research team and members of the faculty leadership teams codeveloped an assessment of learning on percentages, a key concept in the quantitative literacy pathway, which we administered in 2018 and 2019, before and after the lesson study pilot implementation. Additionally, we collected and analyzed student-level administrative data from each college that included information on students' course enrollments and course grades. These data sources and our analytic approaches are discussed in further detail in the findings sections below and in the Appendices (available in a [separate document](#)).

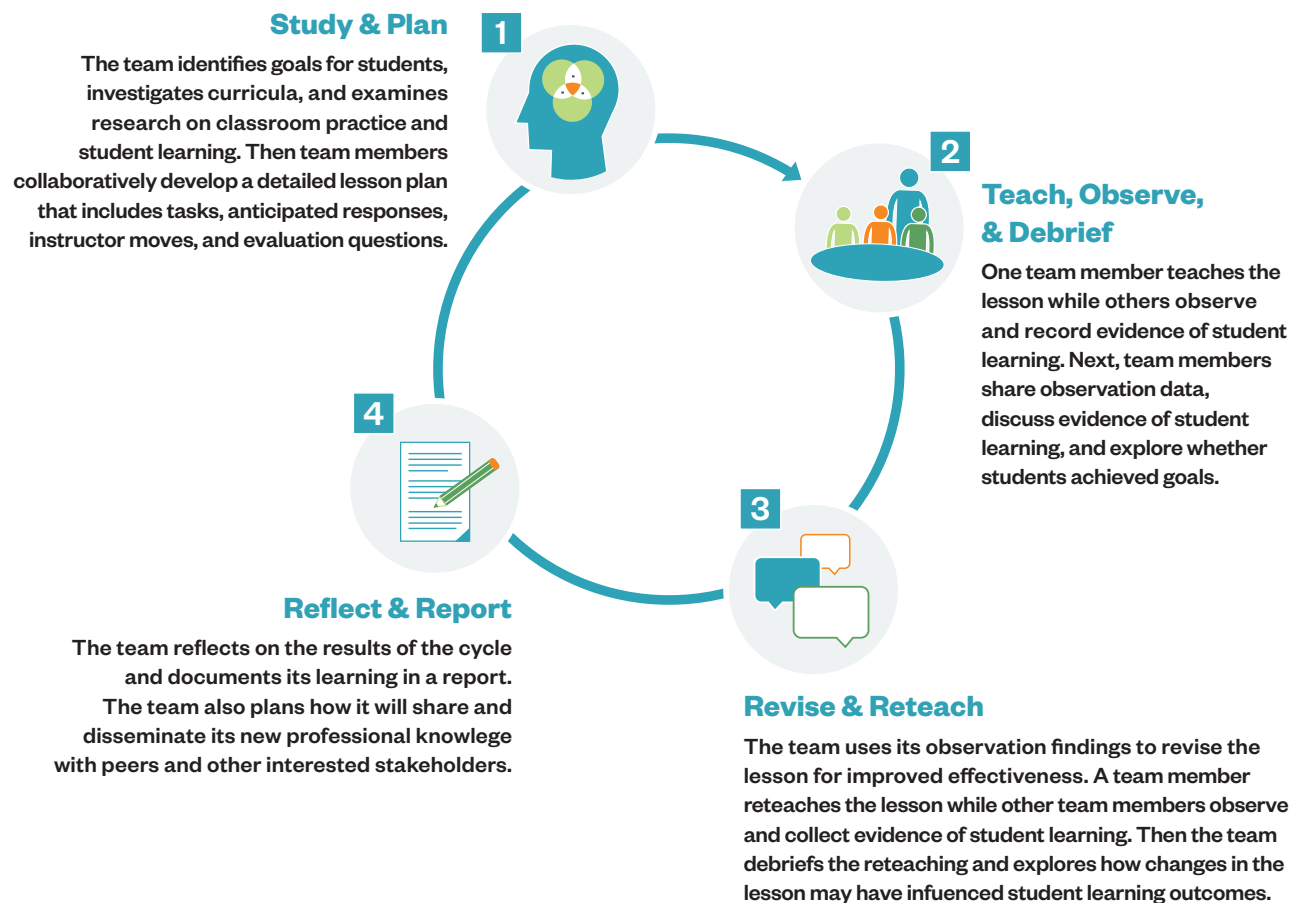
Model Development: Adapting Lesson Study for Community College Faculty

Overview of the Adapted Lesson Study Model

The model of lesson study that was refined during the model development phase and used in the pilot phase of this project is adapted from the version of lesson study described in *Leading Lesson Study: A Practical Guide for Teachers and Facilitators* (Stepanek et al., 2007). In the adapted model, teams of four to five faculty members work in iterative inquiry cycles to collaboratively design, teach, and reflect on the effects of a lesson—which, in the community college context, is defined as a one- to two-hour period of instruction focused on a specific topic or goal. Each team is guided by a self-selected research theme that is intended to establish the direction for at least one year of lesson study work. Typically, the research theme connects to a fundamental purpose of the course, defines a problem of practice that faculty participants care deeply about, and relates to long-term goals for students. For example, one team in this project selected the research theme: “How do we build students’ confidence in their mathematical reasoning and willingness to persevere in problem-solving?”

During lesson study, team members engage in a cycle of inquiry and action. Each cycle consists of four stages intended to be completed in a single semester/term (see Figure 1). First, the team sets its research theme, examines the course curriculum, identifies a topic that is challenging to teach or a lesson they want to improve, and develops a detailed plan tied to a set of learning goals for a class period. Second, one team member teaches the lesson while others observe students and record evidence of learning; together, the team debriefs the experience. Third, the team draws on observation data to revise the lesson plan, and a team member reteaches the revised lesson to a different set of students. Finally, the team reflects on the cycle results, documents its learning, and disseminates the findings to peers and other stakeholders.

Figure 1.
Lesson Study Cycle Stages



Each of these stages is guided by a set of structured protocols that encourage faculty members to investigate evidence-based practices, draw connections between instructional decisions and the research theme, and consider what students do and do not understand. The full cycle, including meetings, classroom observations, and preparatory work, takes up to 20 hours. The team must have access to two sections of the focal course so that the lesson can be retaught with a new set of students.¹

The Process of Adapting the Lesson Study Model

The model described above was developed by the leadership teams and EdNW facilitators during the first phase of the project, as a major project goal was to adapt the original model of lesson study to create one that is usable and feasible at community colleges. Many of the revisions made to the original model and accompanying facilitation materials were in response to the need for a streamlined process that is sensitive to time constraints and provides sufficient guidance for higher education faculty, most of whom are content experts in mathematics rather than trained educators. Templates to guide a team's planning decisions and creation of a lesson plan were simplified and scaffolded to support faculty members who may have limited experience collaborating with colleagues on instruction. For example,

because leadership teams found it challenging to prioritize what to change from the first teaching of the lesson to the second and tended to want to revamp a significant portion of the lesson, EdNW facilitators refined the revision process and protocol. The new process provided an opportunity for individuals to review the lesson plan and underline sections they wanted to keep and sections they wanted to change, informed by observations of student learning. This refinement resulted in a more focused revision process that was intentional and efficient. While some elements of the original model were eliminated for greater simplicity, the model retains essential features critical to lesson study, such as crafting goals, exploring instructional materials, analyzing tasks, anticipating student responses and misconceptions, and outlining pedagogical decisions.

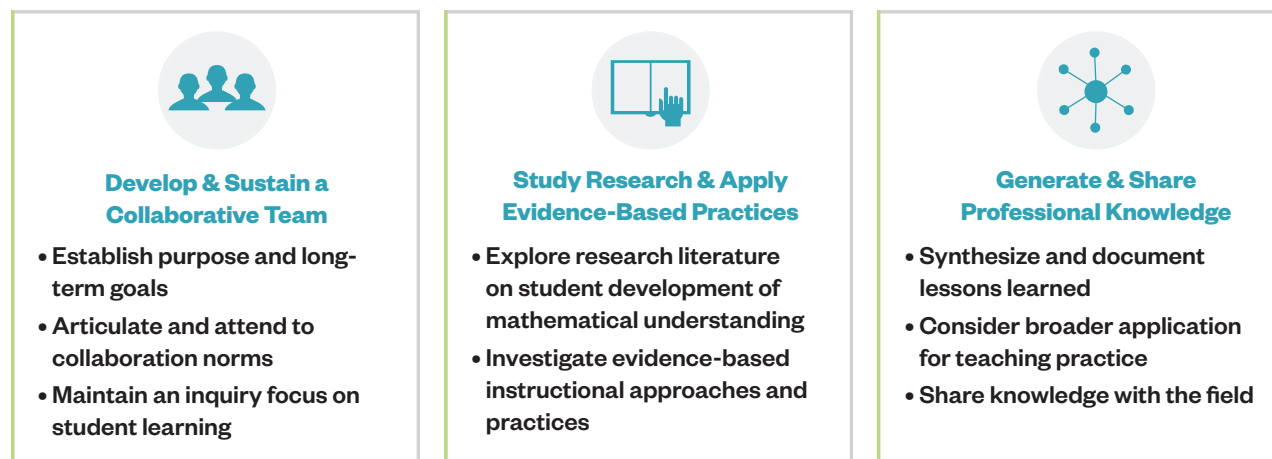
Recognizing the scheduling challenges associated with implementing the model in community colleges, EdNW facilitators and the leadership teams discussed the option of not including stage 3, Revise and Reteach. Some existing lesson study models do not include this phase, and coordinating the logistics of a reteach presents significant challenges. Teams must have access to two course sections, and they must coordinate teaching schedules across course sections so that the teaching, revision, and reteach stages work with the natural flow of both courses. (In the lesson study cycles during the model development and pilot phases, most teams elected to first teach the lesson on a Wednesday or Thursday, revise on Friday, and reteach in the second section on Monday or Tuesday of the following week.) Despite these challenges, faculty found the learning from reteach too important to skip in this project.

As part of the model development phase, we drew on observational data, interviews, and feedback from faculty to identify the core components of the adapted model. Based on these core components, and with input from faculty leaders, we outlined a set of 18 indicators of strong lesson study implementation, which the research team used to measure fidelity of implementation during the pilot (see Appendix B). Among these indicators are three implementation practices identified during the model development phase (Bickerstaff et al., 2019), which reflect the behaviors and patterns of engagement that may help faculty realize the benefits of lesson study in the community college context (see Figure 2). The first implementation practice is to develop and sustain a collaborative lesson study team. This practice points to the importance of building trust among team members and developing a collective belief that gaps in students' knowledge, understanding, and performance can be remedied, at least in part, by an inquiry-focused approach to improvement. The lesson study materials include processes to build each team's capacity for collaboration, including establishing a clear purpose for lesson study through the research theme, developing and abiding by team collaboration norms, and maintaining an inquiry focus on student learning (rather than faculty evaluation) throughout the process.

The second implementation practice is to study research and apply evidence-based practices. Without this emphasis, lesson study participants may design and refine lessons in ways that are counter to the best available evidence on student learning. The focus on research on instruction allows faculty to translate empirical evidence into classroom practice. The third implementation practice is to generate and share professional knowledge. This practice aims to broaden the influence of lesson study by inviting nonparticipating faculty to improve their instruction based on the learnings of the lesson

study team. This may happen through the team disseminating refined lesson plans or sharing a broader set of instructional strategies uncovered during their experiences in the lesson study cycle. This practice also prompts teams to reflect on generalizable lessons learned from the cycle and the ways in which the lesson study experience can have longer-term and more far-reaching impact beyond a single class period.

Figure 2.
Lesson Study Implementation Practices



Comparing Lesson Study to Typical Professional Development in Community Colleges

To understand the extent to which lesson study is distinct from other opportunities for professional learning for faculty at community colleges, we asked faculty and administrators about typical professional development opportunities available to full-time and part-time mathematics faculty. Almost 90% of developmental mathematics faculty in our baseline survey (fall 2018) reported receiving some form of professional development in the past year. In interviews, most faculty reported access to professional development funds, which can be applied to conference attendance or tuition reimbursement, and all faculty and administrators described workshops, speakers, and events hosted by the college (often in the context of a staff in-service day). Most on-campus professional development offerings are relatively low intensity, in the form of a one-hour workshop or one in-service day. And most professional learning experiences are pursued by individual faculty members rather than by groups of faculty together.

The adapted model of lesson study, which is intensive and collaborative, is different from typical professional learning opportunities available to community college faculty. A minority of faculty reported participating in professional learning experiences with similar features to the lesson study model. At baseline, 26% of faculty survey respondents reported receiving more than 15 hours of professional development in the previous year. Examples of more time-intensive learning experiences include graduate-level coursework and multiday professional conferences. Among survey respondents who participated in any professional development in the year prior to the start of the project, 41% reported

participating in professional development that was collaborative in nature. For example, several faculty we interviewed had participated in faculty inquiry groups that convened faculty with common interests to explore a topic collaboratively over the course of a semester or academic year.

While the adapted lesson study model shares some similarities with faculty inquiry groups and other collaborative structures in higher education like scholarship of teaching and learning, it is distinct from other available professional learning opportunities in its highly structured approach to improving disciplinary teaching practices embedded in a specific course. When asked about on-campus professional development offerings, interview respondents described a range of cross-disciplinary topics including instructional technology, accessibility of course materials, active learning strategies, culturally responsive teaching practices, and institutional initiatives and priorities. For instance, two colleges offered a teaching squares model, in which four faculty observe one another’s courses and then meet for reflection. This is intended to be cross-disciplinary to expose faculty to different teaching approaches beyond their department. The vast majority of survey respondents (82%) reported participating in fewer than 10 hours of discipline-specific professional development during the previous year, and only 29% reported participating in a learning experience that involved observing their colleagues’ teaching at least once a year.

The structure of lesson study prompts teams to observe and closely examine specific instructional strategies and their impact on student learning. Some faculty reported that, prior to participating in lesson study, they sought out ad hoc and informal venues to strengthen their mathematics teaching. For example, several interviewees described arranging to observe colleagues in advance of teaching a new course. Others described informal reading groups or collaborative relationships that emerged from shared interests. By contrast, through its focused goals and protocols, the lesson study model provides a degree of structure that is lacking in these informal approaches to strengthening teaching practices.

The structure of lesson study prompts teams to observe and closely examine specific instructional strategies and their impact on student learning.

Table 4.
Comparing Lesson Study to Typical Community College Faculty Professional Development

	TYPICAL PROFESSIONAL DEVELOPMENT	ADAPTED LESSON STUDY MODEL
Expertise	External speakers or off-site conference	Cultivated among the team, with help from research
Teaching Focus	Often discipline-agnostic	Content-specific
Intensity	One-day workshop or shorter	15–20 hours per cycle
Collaboration	No, pursued by an individual	Yes, pursued by a team
Structure	Limited guidance for practice	Detailed protocols to maintain focus on teaching and learning

Findings on Lesson Study Implementation Among Faculty

Once the model development phase was complete, in fall 2019, four teams of faculty from the three colleges participated in a lesson study cycle facilitated by members of the faculty leadership teams, using materials developed by EdNW. The pilot included both faculty who had participated in the model development phase and faculty who were new to lesson study. Faculty volunteered to participate in the pilot. Our findings on how faculty implemented the adapted lesson study model, their satisfaction with the model, and the model's effects on their teaching practices are presented below.

Implementing Lesson Study With Fidelity

Members of the research team observed all team meetings and classroom observations of all four teams during the pilot phase. Using a fidelity rubric that was developed in consultation with faculty leaders, the research team scored each team on the 18 indicators of strong lesson study implementation described above using a three-point scale. A score of “1” means the indicator was not present, “2” reflects moderate implementation, and “3” reflects strong implementation (see Appendix A).

All four teams met the characteristics for either strong or moderate implementation for all 18 indicators. Only four indicators had an average score of less than 2.5 (meaning three or more teams received a moderate implementation score for those indicators). For two of these four indicators, the moderate implementation was a reflection of lack of time. The lesson study protocol prompts teams to generate *anticipated student responses* and *points of evaluation* to prepare for the classroom observation. Teams were likely to run out of time during planning meetings and therefore took a more cursory approach to these lesson planning tasks.

The two additional indicators with moderate scores point to potential challenges to implementing the adapted lesson study model at community colleges that go beyond time constraints per se. One relates to *applying evidence-based instructional approaches*. During the lesson study cycles in the model development phase, EdNW facilitators shared research literature on mathematics teaching and learning, and teams used these resources in their lesson planning. For example, EdNW facilitators provided research on strategies to increase the cognitive demand of mathematics tasks (i.e., Smith & Stein, 1998), and teams incorporated more cognitively demanding tasks in their lessons (this will be discussed further below). In contrast to the model development phase, during the pilot phase, teams were responsible for finding their own research. Perhaps as a result, teams were likely to reference evidence-based practice in general terms, but they were less likely to actively engage in discussions of research articles or draw explicit connections between their instructional decisions and literature on mathematics education. Faculty participants indicated that incorporating research into lesson planning was logistically challenging with the timing of the cycle but also difficult because team members were not necessarily knowledgeable about relevant literature. One participant explained:

One thing that we just really didn't do was to seek out research or articles that would help us to inform improvements to make in the second teaching. And part of that was just because to get it all on our calendars in a way that would work for everybody—we just didn't have the time. And digging around and finding research is not something that we're particularly good at because we don't do it all the time. And it was just really hard for us to find something applicable, get it out to everybody, and give people time to read it over for us to talk about it.

The final indicator with a moderate implementation score was *sharing knowledge*, which reflects one of the goals of the final stage of lesson study in which faculty reflect on what they learned during the cycle and make plans to disseminate that learning to others. During the pilot cycle, each faculty team discussed possible venues for dissemination, but they made few concrete plans. In interviews, faculty reflected on the opportunities and challenges related to sharing knowledge from lesson study. Many noted that there were few formal venues for sharing information about teaching practices within their departments. Each team concluded its lesson study cycle with a revised lesson plan, but it was not always clear if and how those plans should be shared. Two of the three colleges used an Open Educational Resource (OER) as the curricular material for Math 098. The teams at these colleges edited the OER based on knowledge gained from their lesson study cycles, but because the OER is a textbook for students, it was not seen as an adequate venue to share all of the learning associated with the cycles. In postsecondary education, faculty are unaccustomed to sharing lesson plans, and detailed lesson plans developed as part of lesson study were seen as particularly unfamiliar to postsecondary faculty who did not participate in lesson study. One participant explained:

In postsecondary education, faculty are unaccustomed to sharing lesson plans.

The lesson plan that [we] wrote was like ten pages long. You can't give that to somebody and be like, "Okay, you need to teach this tomorrow." So that is the real big challenge we have with lesson study—it's very, very hard to share what you learn unless you're participating.

Participants at the third college, which used a published textbook rather than an OER, also conveyed concern that colleagues may be less likely to use their revised lessons if they were perceived as misaligned with the textbook.

The four indicators with comparatively weaker implementation scores have implications for designing a lesson study program that is sustainable at community colleges, which will be discussed in more detail below. But despite these difficulties, teams generally used the materials and practices associated with the adapted model effectively.

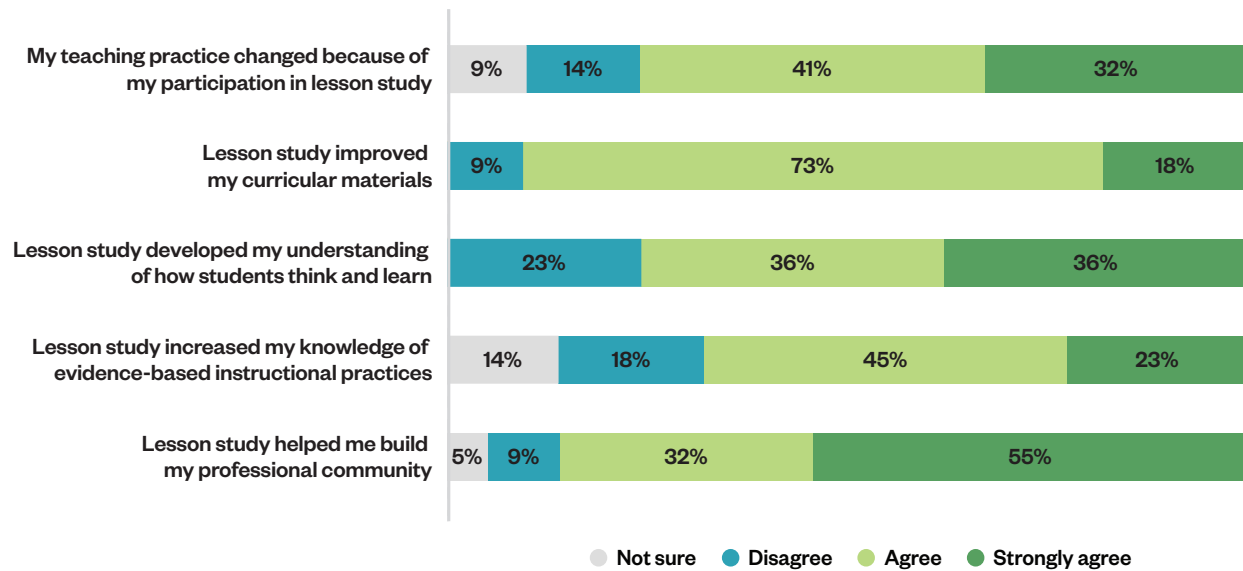
Collaborating to Improve Teaching and Learning

Participants in the pilot phase were overwhelmingly satisfied with their lesson study experiences. Ninety-five percent of faculty indicated in the survey that they were “very likely” or “somewhat likely” to participate again if additional lesson study cycles were available at their college. A large majority of participants also indicated that lesson study

improved their curricular materials, helped build their professional community, and developed their understanding of how students think and learn (see Figure 3).

Figure 3.

Participants' Responses About Their Perceptions of Lesson Study (N = 22)



Data collected during the model development phase of the project suggest that the benefits to lesson study seem to accrue after multiple cycles. The first cycle is marked by a significant learning curve as instructors become familiar with the stages in the process, which are unlike other aspects of faculty work. In subsequent cycles, faculty reported worrying less about navigating the steps of the process and focusing more on their goals to improve teaching and student learning.²

Lesson study's distinctive features—the intensive collaboration, focus on disciplinary teaching, and prescriptive structures and protocols—contributed to faculty's satisfaction with the model. In interviews, faculty described a desire for more opportunities to collaborate with colleagues and for more collaborative professional learning opportunities. One participant, who previously taught in K-12, described her experience in both contexts:

I just value so much the idea of collaboration, and I don't think we get it enough in community college. We get it a lot in public school. I feel like it's part of the culture of public school, to have professional development as part of your job.

Another participant summarized her experience with lesson study, highlighting what's gained from the collaborative process:

I think the biggest plus, in my opinion, is being able to get in other people's classrooms and observe them. To see their students, hear them talk, interact with one another. And then getting together as a team to discuss that.

While professional development was certainly available to faculty prior to the implementation of lesson study, the typical opportunities (conferences and workshops) did not yield the type of deep collaborative engagement that many faculty members valued. One faculty member described departmental colleagues as an untapped resource for peer learning:

Professional development means taking your contracted [professional development] funds and going on a plane somewhere and going to a conference. And that's the way we think about it. So it's a very foreign idea to propose that we spend that money on ourselves paying for our time to talk to each other and tap into the deep wells of expertise and care that we have on our campuses.

This respondent and others argued that the funding that is typically allocated to conference travel would be better spent releasing faculty from some teaching responsibilities so they are able to participate in collaborative learning experiences like lesson study. The time intensity of lesson study, up to 20 hours for a cycle in the adapted model, posed workload and logistical challenges (discussed further below), but faculty indicated that the depth of their engagement was more productive than lighter-touch professional learning opportunities. One faculty member reflected on the limitations of a half-day workshop:

Three hours is not really enough to change the way you do business. It's just enough to know that that's maybe something I should look at. And so that is a problem. I've been to a couple trainings the past couple of years, and you come out of them feeling like, "Okay, but I still don't know what to do."

Unlike other collaborative professional learning experiences (e.g., faculty inquiry groups), lesson study is highly structured, with protocols and guidance for each stage of the cycle. For an example of these structured protocols, see Figure 4. During their first cycle, many faculty participants found this structure uncomfortable and foreign, but those who participated in multiple cycles over the development and pilot phases came to appreciate the ways it helped facilitate productive conversations about teaching and learning. One college had previously brought together faculty teaching the same course for several meetings within a semester. Several stakeholders described challenges with that approach, including finding discussion topics that would engage both novice and experienced instructors. One faculty member at that college reflected:

That part has been missing—like, looking actually at student work or talking about how students are engaging in this deep way. We did talk about how students are going to have trouble with this type of problem, but why? Why are they having trouble? We never really had a method to go deep into that.

A faculty member from a different college spoke more generally about how instructors lack experience in conversing deeply with each other about instruction and student learning:

We consistently find it challenging to talk to one another in a meaningful way. Not just, "Oh, here's what we should put on the test. This is how many students got it wrong." We want to do something that's richer.

How do our students know things? What do I look for to understand their knowing? How do I open the door for them to come in toward this concept? Those kinds of conversations.

Another faculty member explained how the protocols in lesson study created an environment that was conducive to experimentation and risk-taking.

Because of the [debriefing] protocol, there's no finger-pointing. Everybody developed this lesson and everybody thought that this is the way that things should go, so you're off the hook with that. You're taking a risk by having people [observe you], but at the same time, it's not. I think that a great thing about this is that you can kind of experiment with teaching without it necessarily being about judgment.

Figure 4.
Example of How Lesson Study Provides Structure for Faculty Collaboration

The lesson study materials provide detailed guidance for faculty to engage in conversations about teaching and student learning. Here we present an excerpt from the debriefing protocol that takes place after the observed teaching session, providing guidance for how to share feedback and discuss the session.

- **Introductions (5 minutes).** The facilitator expresses appreciation to the instructor for welcoming observers into their classroom and to the team for their work on the lesson. The facilitator briefly restates the lesson goals, learning outcomes, and research theme.
- **Teacher/Instructor Reflections (5 minutes).** The team member who taught the lesson shares their thoughts about implementing the team's plan, including both successes and challenges. This team member leads the way, giving everyone permission to genuinely analyze the lesson and offer feedback based on the evidence. The teacher/instructor's initial observations will set the stage for others to take an analytic but supportive approach to the discussion.
- **Sharing Observational Data (15 minutes).** Lesson study team members, followed by other observers, present data from the lesson focusing on evidence of student thinking and the questions and evaluation points noted in the lesson plan. Comments should focus on what was seen and heard and avoid subjective statements. In addition to anticipated student responses, were there any that were unanticipated?
- **General Discussion (15 minutes).** The facilitator invites a more free-flowing discussion among team members and observers. Additional questions can be asked or observations shared; comments already offered can be probed at a deeper level; and ideas for strengthening the lesson can be proposed.

The lesson study protocols invite the faculty team to identify collaboration norms, direct the team's attention to long- and short-term learning goals, require the team to make collective decisions about detailed instructional plans, and provide the team with opportunities to closely observe student learning. These elements of the model fostered rich and detailed conversations about teaching and learning.

Adopting New Instructional Practices

Almost three fourths of lesson study participants reported that their teaching practices changed because of their involvement in lesson study (see Figure 5). To explore how their instructional habits changed, we analyzed observation notes and lesson plans from 10 lesson study cycles conducted during the development and pilot phases looking for differences between baseline lessons (i.e., how lessons were taught before lesson study) and the lessons used in the second observation (i.e., the reteach). We identified two features that changed: (1) revised lessons included more open-ended, cognitively demanding tasks, and (2) revised lessons included new strategies to increase mathematical communication among students. Cognitively demanding tasks have multiple solution pathways; ask students to draw connections between multiple representations (e.g., visual diagrams, manipulatives, symbols, problem situation) and between and among mathematical ideas in novel situations; and ask students to “engage with conceptual ideas that underlie the procedures” (Stein et al., 2000, p. 16). Mathematical communication refers to conversations among students that focus on possible approaches to solving a problem and justification for those approaches (Imm & Stylianou, 2012; Pourdavood & Wachira, 2015).

At baseline, the curricular materials for Math 098 at all three colleges contained many problems that were contextualized in real-world scenarios. At the same time, the problems were not always cognitively demanding. Instead, student thinking was frequently guided through a series of fixed tasks that emphasized procedures. For example, the following set of questions referred to a bar graph showing the number of earthquakes in a region by year:

- a. *What was the change in the number of earthquakes from 2009 to 2010?*
- b. *What about the change from 2014 to 2015?*
- c. *Which of the changes in problems (a) and (b) was the greatest? How do you know?*
- d. *Use your answer in problem (a) to find the percent change by computing the amount of change compared to 2009.*
- e. *Use your answer in problem (b) to find the percent change compared to 2014.*
- f. *Do your answers to (d) and (e) tell you anything new about these two changes?*

At baseline, most faculty who participated in the lesson study project used the majority of their class time to have students work in small groups or pairs. Yet the nature of the curricular materials meant that there were limited opportunities for rich mathematical discourse. Instead, in group settings, students often worked on problems on their own and then compared answers with their partners. These comparisons were not typically accompanied by discussions about why or how students arrived at these answers.

As compared to the baseline lessons, lessons designed in the lesson study cycles provided less scaffolding, sometimes included problems that did not have clear, correct answers, and frequently included problems that had several possible solution approaches. For example, one team organized a lesson around making sense of this statement: “The wealthiest 20% of the population have 90% of the wealth.” Students were asked to engage in several activities without clear, correct answers, including organizing 100 pennies (representing 100% of the wealth) into quintiles.

In other examples of revised lessons, faculty increased the cognitive demand of new tasks by allowing students to explore the procedures with other students before explicitly teaching an algorithm. For example, at the start of a lesson on unit rates, students were asked to work together in groups to use their prior knowledge, estimation skills, and numerical reasoning to solve the following problem:

My friend and I were at a gas station. I bought a premium 16.9-ounce bottle of water for \$2.49. My friend bought 8.75 gallons of gas for \$28.26. Compare the price of the gas per gallon to the price of water per gallon.

This task is cognitively demanding because students were not given a procedure to follow and therefore needed to draw on their numeracy skills to develop a reasonable approach to solve the problem. Observations from the class sessions in which this lesson was taught showed that different groups used different solution approaches to arrive at the correct answer.

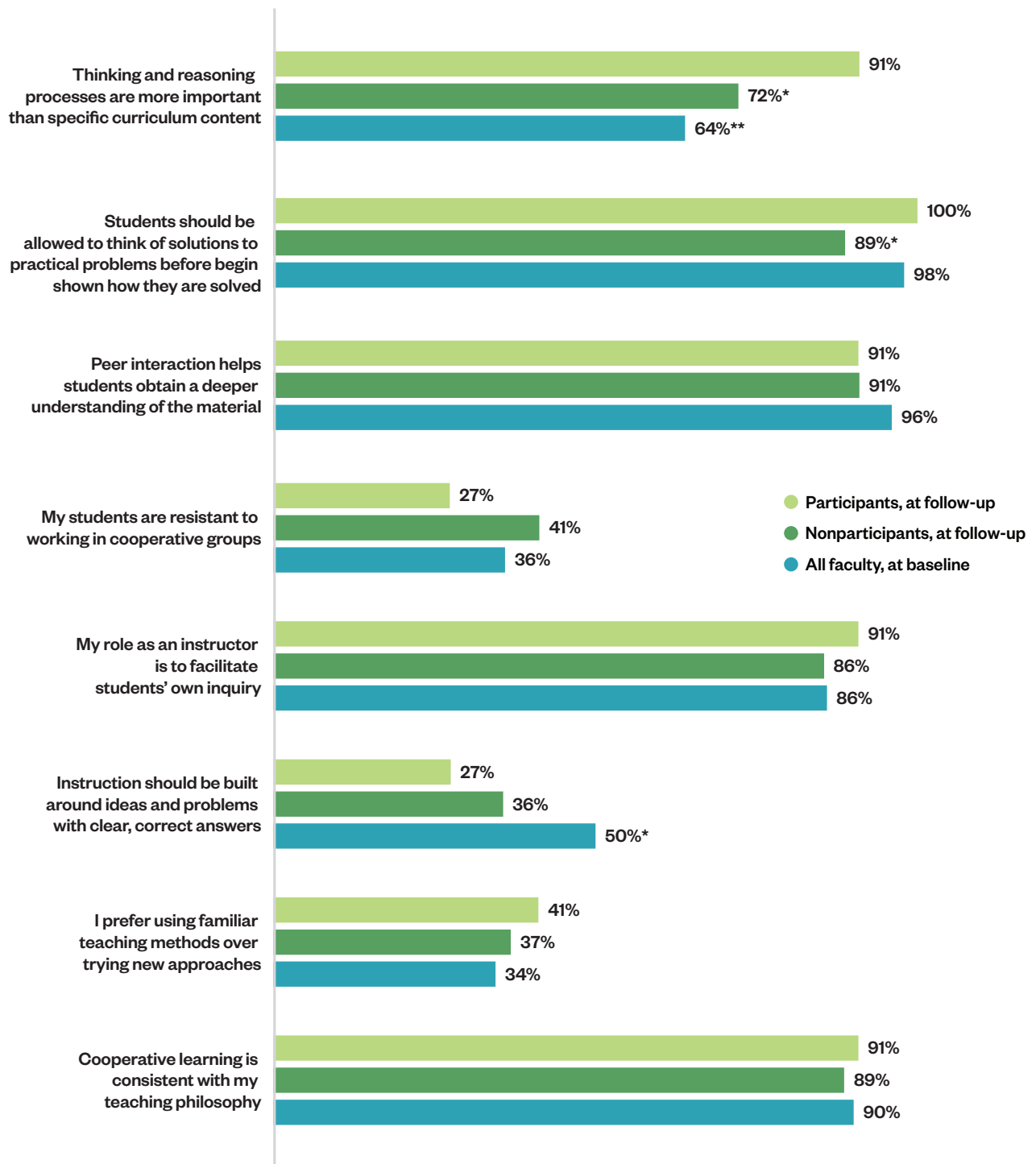
In revised lessons, faculty also introduced new instructional strategies to facilitate mathematical conversations among students, a strategy that complemented the more cognitively demanding tasks. One team adopted a gallery walk format that they used in several lesson study cycles. Small groups of students were presented with a task without a prescribed solution approach. The group was asked to represent their thinking on a large piece of chart paper. Once all of the groups posted their work, each member of the group reviewed one other team's chart paper. Then they returned to their team to discuss these prompts:

What is similar to your team's approach? What is different than your team's approach? On a post-it note, write down something you like about their approach or a question you have. After looking at all the posters, do you think your team's strategy and result are reasonable? Why or why not?

Other lesson study teams employed different strategies to enhance mathematical communication. For example, one team asked students to write their work on note cards, which the instructor collected and showed anonymously on the document camera so that students could describe what they observed. This allowed the instructor to select specific approaches to be analyzed by the class. In another example, two small groups of students were given the same problem and, after solving it, were asked to combine into a single larger group to explain their reasoning.

Increasing cognitive demand and providing opportunities for mathematical communication are aligned with evidence-based approaches to improve mathematics instruction (Imm & Stylianou, 2012; Pourdavood & Wachira, 2015; Stein et al., 2000). We used faculty survey data to understand more about faculty beliefs related to these and other instructional practices.³ While we cannot match respondent data at baseline and follow-up to measure whether lesson study changed the attitudes of individuals, we can compare lesson study participants' results with those of two groups: all developmental mathematics faculty at baseline and nonparticipating faculty at follow-up (see Figure 5). We do see some differences that reflect the types of changes in instructional practices that we documented during the lesson study cycles. Compared to nonparticipants, lesson study faculty were less likely to agree with the statement, "Instruction should be built around ideas and problems with clear, correct answers." Compared with both nonparticipants and all baseline respondents, lesson study participants were more likely to agree with the statement, "Thinking and reasoning processes are more important than specific curricular content."

Figure 5.
Percentage of Faculty Who Agreed or Strongly Agreed With Statements About Instruction



Note. We conducted pairwise statistical testing of means between baseline 2018 survey respondents (all developmental math faculty) and lessons study participants and between 2019 follow-up survey respondents (nonparticipating developmental math faculty) and lesson study participants.

** significant at the 5% level, * significant at the 10% level.

When asked if they planned on incorporating these new practices into their teaching beyond the pilot study cycle, lesson study participants reported that they did. The largely positive reaction from students to the lessons faculty implemented during the pilot cycle provided encouragement for faculty to retain these approaches as part of their ongoing teaching practice. Our data include numerous examples of participants describing students' engagement with the lessons they designed:

The most direct thing I learned was just how much more engagement we could get, just having students work together on a chart paper. All of a sudden, the energy felt different than having to put [the answer] up on the board, where sometimes students can be reluctant.

These positive experiences influenced instructors' perceptions about students' ability to persevere when given more open-ended tasks. As one participant explained, "[I can] let them be in that confused space longer. I don't feel like I have to immediately pull them out of that." Lesson study supported faculty to develop "eyes to see students" (Lewis, 2002); it prompted them to focus their attention on students and their processes for learning.

To Sustain Lesson Study, Institutions Must Provide Continued Support

Most faculty who participated in this project enjoyed their lesson study experience, and many adopted new evidence-based instructional practices as a result of their participation. At the same time, most of the faculty who we interviewed for this study expressed concerns about whether lesson study would be sustainable at their college without continuous institutional investment. During the project period, grant funds were used to provide stipends or payment to part-time faculty for their participation, and some colleges also provided support to some full-time faculty who took on leadership roles during the model development and pilot periods. (See Table 5 for more information on the typical costs of lesson study.)

During the pilot study, teams met for between 15 and 18 hours to complete all of the lesson study cycle activities. While this is a comparatively time-consuming professional development activity in higher education, many faculty members appreciated the depth and intensity of their experience. As noted above, the teams were less likely to find time to identify and read research literature and disseminate knowledge gained from the lesson study cycle, two key components of the lesson study model. This may be because it would require additional time outside of the cycle meetings or expertise in content-specific pedagogy that faculty would need ongoing support to develop. This indicates that the time invested was not quite sufficient to successfully implement every component of lesson study.

Faculty who were charged with facilitating the lesson study pilot cycle invested substantially more time than their colleagues who engaged as participants. Faculty facilitators took on a range of logistical and administrative tasks to make the cycle successful, including recruiting their colleagues to participate, securing meeting rooms, coordinating and aligning schedules for meetings and observations, and arranging for substitutes in cases where faculty needed to miss class to observe the teaching or reteaching

Faculty who were charged with facilitating the lesson study pilot cycle invested substantially more time than their colleagues who engaged as participants.

sessions. In addition, faculty facilitators indicated that they spent time reviewing the facilitation materials in preparation for cycle meetings. It is important to note that members of the faculty leadership teams who served as facilitators in the pilot cycle drew on the knowledge and experience that they gained during the model development phase. Institutions planning to implement lesson study will need to identify faculty facilitators with prior knowledge of lesson study or provide support for facilitators to pursue training.

Faculty facilitators indicated that it would not be feasible to continue playing this role without either released time from teaching or other forms of support from their college. One faculty facilitator explained that she did not wish to continue coordinating lesson study in her department, but she would participate if someone else would lead the initiative. In one example of a sustainable approach to lesson study in higher education, the Center for Teaching and Learning at the University of Wisconsin at LaCrosse has been administering a lesson study program for nearly 20 years (Cerbin & Kopp, 2006). The program operates with center staff matching interested faculty, providing materials, and offering a modest stipend for participation. One of the three colleges in our study continued lesson study beyond the project period by using college funds to provide released time from teaching for faculty facilitators and pay part-time faculty for their participation. The other colleges intended to implement “light-touch” versions of lesson study that preserved the most important features of the model (i.e., classroom observation focused on student learning) but required less faculty coordination and time. Additional research is needed to understand if a less intensive model of lesson study can yield similar benefits for faculty.

Faculty facilitators indicated that it would not be feasible to continue playing this role without either released time from teaching or other forms of support from their college.

Table 5.
Costs of Lesson Study

ADMINISTRATIVE AND COORDINATION COSTS	CYCLE COSTS
Time for training facilitators	15–18 hours per team member
Time for recruiting faculty and forming teams	Additional 5–10 hours of facilitator preparation
Time for polling faculty to identify meeting times, booking meeting rooms, processing payments for part-time faculty, etc.	Payment for substitute instructors to cover team members’ classes during scheduled meetings or observations (as needed)

Findings on Student Outcomes

To assess the relationship between faculty participation in lesson study and students’ learning, course grades, and progression into college-level math, we compared the outcomes of students in course sections taught by faculty who participated in the lesson study pilot to the outcomes of students in sections taught by nonparticipating faculty.

Student Learning

There was no existing common measure of student learning in the quantitative literacy pathway across the three colleges, so faculty leaders worked with the research team to develop an assessment that would test student knowledge of an essential concept in the

course and provide meaningful information about student learning to the teams. The team created a four-item assessment focused on percentages—a key concept that underlies many skills and learning outcomes in the quantitative literacy pathway.

All assessment items required that students refer to a table of sample data: two years of enrollment trends at a community college in California, shown as the percent enrollment by age group. The items were open-ended, which is reflective of the kinds of tasks and real-world applications that students were typically expected to encounter during the course. It is important to note that this brief assessment did not cover all the mathematical topics addressed by the four lesson study pilot teams in their lesson study cycles, nor is it a comprehensive measure of student learning in the course. Only two of the four teams specifically focused their pilot lesson study cycles on the topic of percentages.

The learning assessment was administered in the final two weeks of the fall 2019 academic term in Math 058 and 098 sections taught by lesson study faculty participants and nonparticipants. A total of 197 students completed the assessment; 60% of those students were enrolled in a course section taught by a faculty member who participated in lesson study. A sample of 181 students who completed the assessment in fall 2018 served as a comparison group. Student assessments were submitted to CCRC for scoring using a rubric developed and tested in partnership with faculty. Students received one point for each correct answer. (See Appendix C for a copy of the assessment and scoring procedures as well as additional details on the analysis and results.)

In Math 098, we did not see a statistically significant difference in performance between students taught by participating faculty and those taught by nonparticipating faculty. However, for the 111 students enrolled in Math 058 who completed the assessment, we saw a positive, statistically significant effect of faculty lesson study participation on student performance on the second and third assessment items. The second and third items asked students how an increase in enrollment for one age group would affect that age group's proportion of total enrollment. These questions required students to understand how a percentage reflects the relationship between a part and a whole. After accounting for Math 058 students' demographic characteristics and enrollment information, logistic regressions showed that students in sections taught by participating faculty were about twice as likely to answer the second item correctly and about three times as likely to answer the third item correctly compared to students in sections taught by nonparticipating faculty.

In Math 058, we saw a positive, statistically significant effect of faculty lesson study participation on student performance on the second and third assessment items.

Students' Course Grades and Progression Into College-Level Math

To assess differences in grades and progression between students enrolled in sections taught by lesson study participants and those enrolled in sections taught by nonparticipants, we analyzed student-level administrative data from the three colleges with a focus on four outcomes: their grade in Math 098, whether they passed the course with a C or better, their persistence to the end of the course (that is, they did not withdraw or have an incomplete grade), and their enrollment in college-level math in the subsequent term (winter 2020). In this study, college-level math included college-level algebra and math for liberal arts.

Our sample includes students taught by 15 faculty members in 18 sections of Math 098 in the fall 2019 term.⁴ Eight of those faculty members teaching 10 sections participated in the lesson study pilot. We first examined the descriptive outcomes in the pilot term (see Table 6). Compared to students in sections taught by nonparticipants, students in sections taught by lesson study participants earned slightly lower grades and were less likely to pass Math 098, but a similar percentage of students persisted to the end of the course and progressed to college-level math.

Table 6.

Descriptive Course Outcomes of Students in Math 098 Sections Taught by Lesson Study Participants and Nonparticipants, Fall 2019

	LESSON STUDY SECTIONS	NON-LESSON STUDY SECTIONS
Number of Students	171	160
Student Course Outcomes		
Math 098 letter grade	2.39	2.68
Passed course (A, B, C, or "Pass")	70%	81%
Persisted to course end	96%	97%
Progressed to college-level math	33%	32%

Note. For the course outcomes, letter grades of 2.39 and 2.68 correspond to a C.

Source. Authors' analysis of community college administrative data.

To account for differences in outcomes that could be due to student characteristics, we used propensity score weighting and regression analysis to assess the relationship between enrollment in a Math 098 course taught by faculty participating in lesson study and the outcomes of interest.⁵ To identify the more direct impact of lesson study on student outcomes, the study would have had to ensure that students in the sections taught by lesson study participants and nonparticipants had similar academic achievement (as determined by a continuous academic measure) and socioeconomic status at baseline or prior to the start of the fall 2019 (What Works Clearinghouse, 2019). This type of quasi-experimental design could have potentially met What Works Clearinghouse (WWC) standards with reservations and provided some indication of the impact of lesson study on students.⁶ However, we did not have a measure of academic achievement prior to the start of fall 2019 for students in the sample. By constructing a matched comparison group, we were able to ensure that students taught by lesson study participants and those taught by nonparticipants were demographically equivalent. In addition, we used a multilevel model to account for which college the students attended, as well as for instructor- and classroom-level differences because we found substantial variation in the math course grades and progression outcomes by instructor.⁷

After controlling for student characteristics, instructor, and college, we found that taking a Math 098 course with a faculty member who participated in lesson study had a negative association with passing the course (similar to the descriptive findings in Table 6). There was no association between taking a Math 098 course taught by a lesson study participant and grades in Math 098, persistence to the end of the course, or progression to college-level math. See Appendix D for further detail on sample characteristics, the analytic method, and results.

A Theory of Change for Lesson Study's Effects on Students

Although this project found several benefits for faculty participating in lesson study and stronger performance on some assessment items for some students, we did not find a positive relationship between faculty participation in lesson study and student course performance. In this section, we contextualize these findings within the limitations of our study design and propose a theory of change that can inform the design of future research on the impact of lesson study on student outcomes.

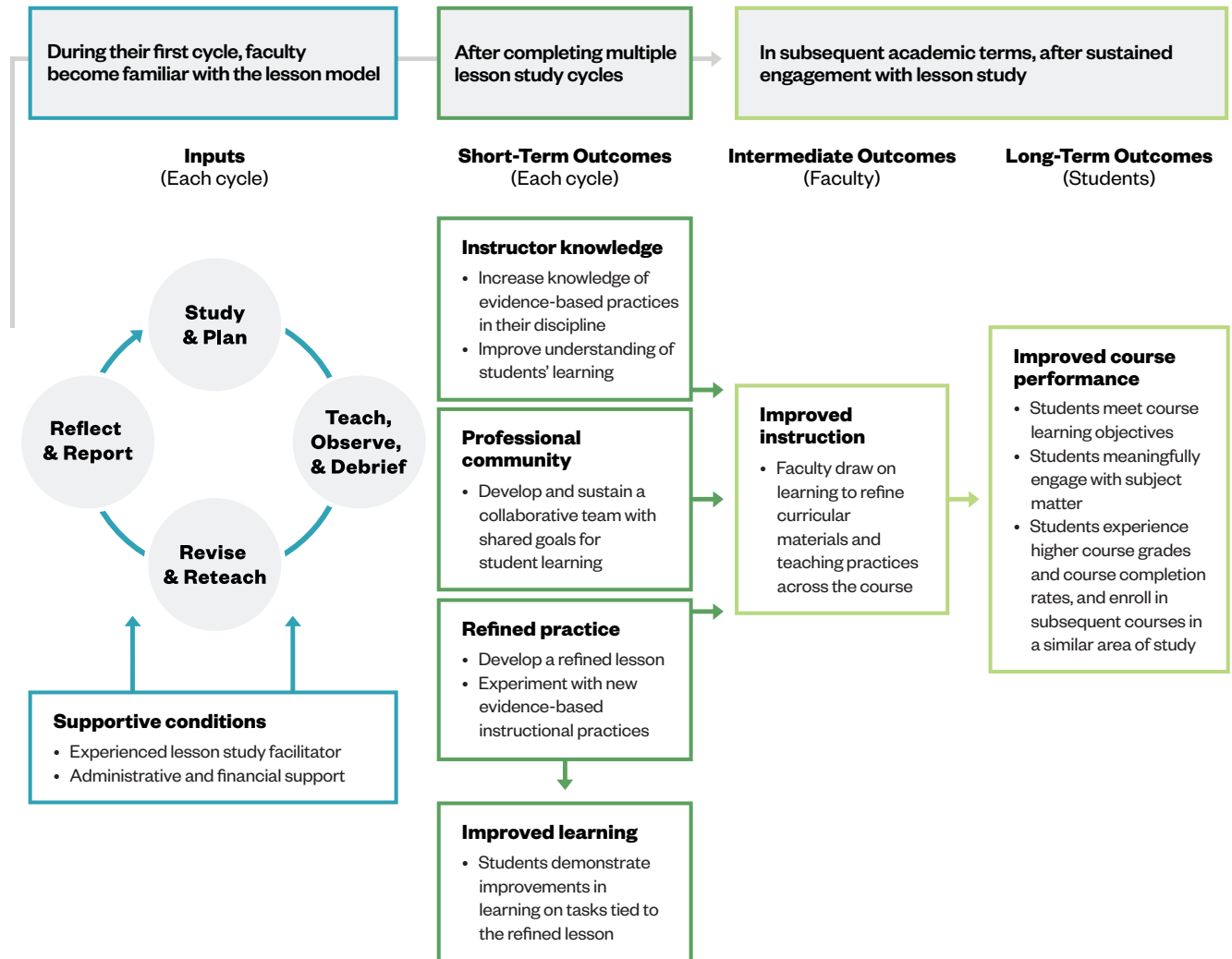
The pilot study design was limited, as noted above, by the fact that we could not account for potential differences in prior academic achievement between students taught by participating and nonparticipating faculty. Additionally, a pilot study focusing on one term may not provide enough time to test the full effects of lesson study, as it may take additional time for faculty to incorporate what they learn from lesson study into their teaching practice. During the lesson study pilot cycle, faculty revised one lesson. The lesson study implementation practices suggest that faculty should extrapolate learnings from that single lesson to apply to their course more broadly. Just as previous research has shown that effective professional development is long-term and sustained (e.g., Darling-Hammond et al., 2017; Fowler et al., 2016), it is reasonable to expect that the broader rethinking and refinement of curricular materials and teaching practices involved in lesson study—and thus effects on students—would unfold over time. Finally, previous studies of professional development in higher education measure the impact on student learning outcomes aligned to the goals of the intervention (Condon et al., 2016; Stes et al., 2010). Our ability to extrapolate the effects of lesson study on student learning was hampered by our use of a short nonstandardized assessment that was not universally aligned with the focus of each team's lesson study cycle.

Based on our implementation research and drawing on Lewis and Perry's (2015) lesson study model, we propose a theory of change that shows how lesson study may affect short-term outcomes in a single cycle and student outcomes after long-term faculty engagement (see Figure 6). This theory provides a framework for the design of future research on the impact of lesson study on instructors and students.

As shown in the figure, this framework acknowledges that it takes more than one cycle for faculty to become comfortable with lesson study, particularly given how different the approach is from other professional development opportunities in higher education. A lesson study cycle is supported by an experienced facilitator and resources to address administrative and logistical considerations. Once faculty become familiar with the lesson study model, they increase their knowledge of evidence-based practices, develop new understandings of students and their learning, form a productive professional community, and develop a refined lesson plan with each new cycle (short-term outcomes). The theory of change holds that after repeated cycles, these experiences will translate to improved instruction more broadly as faculty implement new teaching practices learned through lesson study throughout their courses. In the long term, improved teaching employing evidence-based instructional practices will lead to improved student learning and course performance.

It takes more than one cycle for faculty to become comfortable with lesson study, particularly given how different the approach is from other professional development opportunities.

Figure 6.
Lesson Study Theory of Change for Effects on Student Outcomes



Based on this theory of change, future research should account for the time it takes for faculty to become comfortable with the lesson study approach and to then integrate new curricular and instructional practices into their course. To address the other limitations of the current study design, future research should account for baseline differences in student achievement and use an assessment of student learning that is either tied to the concepts taught in the cycle’s focal lesson or administered after faculty have engaged in multiple cycles. To account for variation in grading across instructors, future research should consider how faculty members grade before, during, and after their participation in lesson study to more accurately gauge lesson study’s effects on student course grades.

Conclusion

A primary goal of this project was to understand if and how lesson study, an intensive and collaborative model of professional development used primarily in K-12 settings, could be adapted for use in community colleges. With input from mathematics faculty leaders at three community colleges, the project team developed a lesson study model that teams were able to implement with fidelity. Participants reported finding value in their lesson study experience, and our results indicate that they adopted new evidence-based instructional practices in mathematics. These findings are encouraging because there is limited research on models of professional development in higher education that result in changes to teaching. This study adds important knowledge to a small but growing field of research. Moreover, research on mathematics teaching from K-12 and higher education shows that adopting cognitively demanding, student-centered approaches to instruction is challenging. Stigler and Hiebert (1999) highlight the deeply ingrained cultural habits associated with teaching that make it difficult to change and introduce new practices. Lesson study's prescriptive protocols and structures help to facilitate in-depth conversations about teaching and learning. The experience experimenting with new teaching practices and looking closely at students and their learning helped faculty to increase their confidence with new instructional practices. As in K-12, lesson study in community colleges appears to be a promising model for supporting changes to teaching practice.

While we were not able to detect consistent positive effects on student outcomes, likely due at least in part to the limitations of our study design, we drew on our implementation research to develop a theory of change for structuring lesson study to improve student outcomes. This project offers guidance for designing future studies of the impact of lesson study on students.

Our implementation findings, along with other research, point to the cultural and structural features of community colleges that make it challenging to scale up and sustain instructional improvement efforts (Demir et al., 2012). These challenges include a tendency toward faculty autonomy and individualism, limited instructional resources, high teaching loads, and large numbers of part-time faculty. By contrast, the conditions in many K-12 schools—including collective or shared leadership focused on how to structure and support student learning, dedicated time throughout the year for teachers to collaborate on improving instruction, and regular use of data and cycles of inquiry to drive change (Bryk et al., 2010; Lytle, 2012; Mourshed et al., 2010; Robinson, 2011)—may be better able to support the implementation of lesson study. Under these conditions, K-12 schools are often committed to developing and strengthening a coherent curriculum across classrooms, and professional development is aligned with the specific improvement goals identified by the school. When a continuous improvement culture is strong, the reform goals are clear to everyone at the school. They are supported at multiple levels throughout the school, and all staff are more likely to hold themselves accountable for achieving them.

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Without these conditions, lesson study may still meet the learning and improvement needs of individual faculty members who participate in the cycles. But if lesson study were to be integrated into a broader, goal-oriented, leadership-supported instructional improvement initiative, it may have the potential to generate more meaningful widespread change. As noted above, Centers for Teaching and Learning may offer one structural home for lesson study in higher education, in that they could provide the necessary logistical support that would make lesson study sustainable at a college. In our project, one college used lesson study as part of its annual departmental learning outcomes assessment. Connecting lesson study to existing initiatives could provide direction and focus to faculty teams, assist with challenges around disseminating and sharing knowledge, and support the sustainability of the model.

In community colleges and in higher education more broadly, the need to support faculty to improve instruction has never been more urgent. Institutions are rapidly redesigning course structures and pathways, providing students referred to developmental education with accelerated access to college-level courses, and creating coherent program maps for all students. And in response to the COVID-19 crisis of 2020, colleges are increasing their online course offerings, presenting unique challenges for faculty. As colleges rightly focus their attention on inequitable student outcomes by race/ethnicity, they must consider how to implement instructional approaches that could close opportunity gaps. The adapted lesson study model developed in this project provides an approach to supporting faculty to learn about evidence-based practices, examine student learning, and experiment with new instructional approaches. Institutional investment in these kinds of learning opportunities for faculty may support the kinds of transformations to instruction that are needed in the current higher education context.

As colleges rightly focus their attention on inequitable student outcomes by race/ethnicity, they must consider how to implement instructional approaches that could close opportunity gaps.

Endnotes

1. More information on the adapted model, including facilitation materials, can be found in [EdNW \(2021\)](#).
2. Seven of the 22 survey respondents participated in only the pilot cycle. The remaining respondents participated in at least one additional cycle during the model development phase.
3. Items drawn from the Organisation for Economic Co-operation and Development's (2018) *Teaching and Learning International Survey*.
4. We excluded Math 058 students from this analysis because this course does not lead directly to college-level math.
5. We originally intended to use an interrupted time series design for this analysis; however, this design was not appropriate to use since only about half of the Math 098 faculty members participated in lesson study in fall 2019, and the design would have pooled outcomes across lesson study and non-lesson study sections in fall 2019 (see Appendix D for more details).

6. WWC uses a set of standards and procedures to review education research in a consistent and objective manner and to answer the question: What works in education?
7. We found substantial variation in the course grades and progression outcomes by instructor. For example, pass rates in Math 098 ranged from 42% to 91%, and course persistence rates ranged from 64% to 100%.

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