TEACHERS' HOMEWORK STRATEGIES IN THE CONTEXT OF AMBITIOUS MATHEMATICS INSTRUCTION: DEVELOPING NEW PRACTICES

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ABSTRACT

This article examines teaching practices designed to support community college students in productively engaging with mathematics homework. Two cases of how teachers *set up* homework, or prepare students to leave class and do homework are presented. The case studies examine how the teachers developed and implemented their strategies, with a focus on how their identities as teachers and the meanings they attach to homework shape their decisions. The study was conducted in a professional development component of a mathematics department committed to ambitious instructional practices, that is, those aligned with NCTM and Common Core Standards. Thus the teaching strategies presented in the cases, and the analysis of how teachers developed their practices, have implications for current efforts to implement new curricula and teaching practices.

Keywords: Mathematics homework; Ambitious instruction; Teacher identity.

RESUMO

Este artigo analisa práticas de ensino destinadas a ajudar estudantes, de uma faculdade comunitária, produtivamente engajados com lições de casa de matemática. São apresentados dois casos sobre como professores configuram lições de casa, ou sobre como preparam os estudantes para sair da aula e fazer lições de casa. Os casos estudados analisam a forma como professores desenvolveram e implementaram suas estratégias, com foco sobre como as suas identidades como professores e os significados que atribuem à lição de casa moldam suas decisões. O estudo foi realizado em um componente de desenvolvimento profissional de um departamento de matemática comprometido com práticas de ensino ambiciosas, isto é, estas alinhadas com NCTM e com as principais diretrizes comuns. Então, as estratégias de ensino apresentadas nos casos, e a análise de com professores desenvolvem suas práticas, tem implicações nos esforços atuais para implementar novos currículos e práticas de ensino.

Palavras-chave: Dever de casa de matemática; Ensino ambicioso; Identidade docente.

1. Introduction

This paper examines teaching strategies designed to support community college math students in engaging with homework. For educators at all levels, homework may seem like a necessary evil. It is necessary if we want students to continue learning outside of class (NCTM, 1980, 2000; AMATYC, 2006), but evil when it is viewed as inequitable (Kralovec & Buell, 2000) or as an imposition on families (Coutts, 2004). Much of the homework debates center on the relationship between homework and achievement. However, the positive effects of homework have been demonstrated in secondary settings (cf. Cooper 1989, 1998), and in college mathematics courses (Sasser, 1981; Weems, 1998; Yalcin and Kaw, 2011). Thus a necessary consideration is *how* we make homework a learning opportunity for students.

This issue is crucial in the context of ambitious mathematics instruction. For several decades mathematics education reformers have called for learning that includes reasoning and problem solving, conceptual understanding, and productive dispositions (NCTM, 1989; 2000; Kazemi, Franke, & Lampert, 2009). Such learning requires that students engage with authentic problems (Lampert, Boerst, & Graziani, 2011; Mehta & Fine, 2012), have opportunities to explain their reasoning, and solve problems in multiple ways (Jackson & Cobb, 2013; NCTM, 2000; Stein et. al. 2000). These learning goals entail teaching practices such as facilitation of student problem solving (Kazemi et. al., 2009) and the co-construction of mathematical explanations by the teacher and students (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). These practices foster both deep learning and equitable learning opportunities (Jackson & Cobb, 2013). Similar teaching practices are recommended for community college mathematics instruction (AMATYC, 2006), which is a context in great need of research (Mesa, Wladis, and Watkins, 2014).

This notion of ambitious instruction creates an image of classrooms different from traditional ones and requires an understanding of learning as a social and cultural process. Often referred to as a sociocultural perspective (Cobb, 1994), this view of learning underlies a definition of homework as something more than a task or an artifact of work. Rather, homework is conceptualized as a social practice in which students and others in their lives engage together (Landers, 2013). Given a context of ambitious instruction and this definition of homework, questions arise about teachers as homework participants. This article examines homework-related teaching practices designed to support community college students in productively engaging with math homework. I present two cases of how teachers *set up* homework, or prepare students in class to leave and do homework. The case studies examine how the teachers developed and implemented strategies, with a focus on how their identities as teachers and the meanings they attach to homework shape their decisions. Identity and meaning are central to social practice and allow us to understand how teachers make decisions in practice.

The paper is organized as follows. I begin by describing the theoretical perspective underlying homework as a social practice, highlighting how research has shown teachers as participants in this practice. Then I present the methods of the current study, describing the professional development context in which the two teachers participated and developed their strategies, data sources, and analytical approaches. Next, the cases are presented, which provide examples of homework set-up strategies, but also shed light on *how* these teachers were able to engage in the

ongoing development of their practice, which is crucial in the context of ambitious instruction. The article concludes with a discussion of limitations and implications of this work.

2. Homework as a Social Practice

While most homework research defines homework as a *task*, (c.f., Cooper, 1989) I define homework as a *social practice* that students participate in with teachers and others in their lives (e.g., family members or peers) across school and home contexts (Landers, 2013). Practice refers to "doing in a historical and social context that gives structure and meaning to what we do" (Wenger, 1998, p.47). Researchers have long studied social practices as central to learning and development (e.g., Cole, 1996; Lave & Wenger, 1991; Rogoff, 2003) and for several decades this perspective has been taken up by mathematics education researchers (Lerman, 2000). Such research examines how participation in a practice provides opportunities for learning, problem solving, and development. Below I describe the concepts of meaning and identity as central to this perspective and how teachers participate in the practice of homework.

2.1 Meaning and Identity in Practice

In Wenger's social theory of learning, individuals "negotiate" the meaning of their work in and across communities of practice (Wenger, 1998, pp. 53–55). Through this participation, particular ideas become personally meaningful to participants, and they may construct new meanings, contributing to what is valued in a community. From past experiences, teachers bring to their classrooms and schools their ideas about the value or purpose of homework. Over time they may take on new perspectives or reinforce existing beliefs. For example, as a student, one might view homework as punishment or a game, but as a teacher, one might see homework as a learning opportunity. Further, an individual teacher can shape the meanings of homework in her school through collaboration with other teachers or contributions to school policies and practices.

Participation in social practice is also about identity development. Within what Lerman (2000) has called the "social turn" in mathematics education, the concept of identity has been increasingly used as a lens on understanding students' participation in mathematics. Math identity has been conceptualized as self-beliefs or understandings related to a student's experiences with mathematics (Martin, 2000; Horn, 2008) and as narratives of a person's current and future self (Sfard and Prusak, 2005). Drawing on anthropological perspectives (e.g., Holland, Lachicotte, Skinner, & Cain, 1998) identity is also defined as the ways in which individuals understand and enact their positions in social worlds (Boaler & Greeno, 2000: Esmonde, 2009; Horn, 2008). What is shared across this body of work is a commitment to understanding identity as constructed through social experience. Hence identity is dynamic and relational, or a "constant becoming" that forms trajectories within and across communities of practice (Wenger, 1998). These conceptualizations of identity have also been utilized as a lens on teachers' participation in the practice of teaching, especially teacher development (Battey & Franke, 2008; Beauchamp & Thomas, 2009; Hodges & Cady, 2012; Soreide, 2006).

Identity development and meaning making are deeply intertwined processes and both are grounded in the notion of practice. Wenger explains that, "building an identity consists of negotiating the meanings of our experience of membership in social communities" (p.145), and that ownership "refers to the ways meanings, and our abilities to negotiate them, become part of who we are (p. 201). Given the connections among the concepts of meaning, identity, and practice, the current study examines how meaning and identity together shape teachers' participation in the practice of homework.

2.2 Teachers' Homework Practices

Homework can be viewed as a practice that is done through a cycle of contexts, which begins and ends in school. The cycle begins when teachers assign homework tasks. Students may start working on these tasks in class, and then the students and the tasks travel home, and back to school, where they may complete, check, and turn in homework artifacts to their teachers. Then teachers process the artifacts in some way and return them to students. The cycle begins again with new tasks assigned. Therefore while students are positioned as the "owners" of homework (Varenne & McDermott, 1999), the practice of homework is *prefigured* (Kemmis & Grootenboer, 2008) by teachers' school experiences, professional training, assessment of students' needs, and institutional requirements.

Some researchers have examined teaching practices related to homework. In particular, homework feedback has long been documented as beneficial to students (Austin, 1976; Elawar & Corno, 1985; Paschal, Weinstein, & Walberg, 1984). When teachers provide written feedback they are also generating information for formative assessment (Bang, 2011; Fang, 2010). Fang's study illustrates the homework cycle from a teacher's perspective. Teacher Wang assigns students problems to be completed in notebooks, and she spends much of her day writing feedback, in collaboration with colleagues. She returns the notebooks to students, uses her findings to structure lessons, and expects students to fix their errors and resubmit their work. In this fashion she creates a cycle: "By connecting classroom teaching with continued analysis of and feedback to student learning, a consistent feedback loop within teaching is built on a teacher's sense-making of and support for student error correction" (Fang, 2010, p.614). This teacher's homework cycle is not the norm in US schools (Fang's study was conducted in Shanghai). However, it provides an example of how a teacher participates in the practice of homework beyond assigning tasks to students and grading their work.

Feedback focuses our attention on the homework cycle *after* tasks have already been assigned. Others have studied teacher participation earlier in the process, including: providing clear homework instructions (Bang, 2011; Epstein & Van Voorhis, 2001), making accommodations for English language learners (Bang, 2011), and choosing real-life tasks to increase student homework completion (Bryan & Sullivan-Burstein, 1998). At the college-level, teaching practices that motivate students to do homework have also been documented, such as checking and returning work for correction (Bluman, 2010), and verbal praise (Hancock, 2000), which was also connected to student performance on instructor created assessments. Another practice, "pre-homework" (assignments to prepare students for a new topic in class) has been shown to increase student performance and self-efficacy in developmental math (Mireles et al, 2013). The

current study adds to this literature by examining the development and implementation of teaching strategies used at the beginning of the homework cycle. Next I describe the methods of the current study, beginning with the context that supported the teachers in developing homework set-up strategies, and then detailing data sources and analytical approaches.

3. Methods

3.1 Setting and Participants

The current study was conducted at a community college in Northern California. The college's student body is diverse along several dimensions, including age, race/ethnicity, and socioeconomic status. As is the case at many of California's community colleges (Grubb, 2011), the majority of students must take developmental math and English courses before the college-level courses needed to transfer to a four-year institution The National Center for Developmental Education defines developmental education programs as supporting "traditional and nontraditional students who have been assessed as needing to develop their skills in order to be successful in college" (www.ncde.appstate.edu). Developmental math programs include courses from arithmetic to intermediate algebra, and progressing through this sequence has proven to be a challenge and even a barrier to educational advancement for an alarming number of students (Bonham & Boylan, 2011).

Given these issues, the math department at this college created a developmental program grounded in research-based best practices, including opportunities for faculty professional development (Bonham & Boylan, 2011). The program is also designed around a set of learning outcomes aligned with both the NCTM and AMATYC standards, and hence aligned with ambitious instruction. The professional development component of this program consists of teaching communities (TCs), or groups of faculty members who meet for a semester to study their teaching and to develop practices that support student development with respect to the program's learning outcomes. As a facilitator of these groups since 2009 I have often chosen topics related to the program's *Effective Learning Attributes* learning outcome, which includes expectations such as students' abilities to self-assess strengths and weaknesses and to use appropriate resources and strategies to improve learning. This area of teaching is the least familiar to math faculty, yet the related skills for students are perhaps the most useful and applicable beyond a given course. In one semester I organized a TC around the concept of the homework cycle and related teaching strategies. I began the semester by presenting the homework cycle and the idea that what we do in practice is related to our beliefs about teaching. Then the group discussed what messages we want to give students about homework through our actions. For example, if teachers give homework as punishment, it sends the message that homework *is* punishment. After this introduction the group worked on three categories of strategies, summarized in table 1.

Table 1.

Categories of teaching strategies

Strategy Category	Description	Examples
Set up	Teaching strategies or actions that occur at the start of the cycle when work is being assigned	• Writing the assignment on the board • Giving a typed assignment sheet • Reading the assignment in class
Assessment	Methods of assessing student work	• Assigning points per problem • Using rubrics to score work
Closing the loop	Strategies for providing feedback and engaging students with feedback	• Sharing summaries of student work with the class • Assigning students to read feedback and summarize

Each category was the focus of two meetings, for a total of six meetings that semester. In the first meeting for each category example strategies were presented and participants shared examples from their teaching. Then participants tried out new strategies and shared their findings during the second meeting.

This TC included two full-time and three adjunct faculty members. As one of the two full-time faculty, I facilitated the group but also shared examples from my teaching. The other full-time member, Valerie, participated in each activity, but also served as a co-facilitator by providing initial examples of strategies. After the group discussed set-up strategies and participants had the opportunity to try new strategies with their classes, I asked them to commit to using a new strategy for the entire semester. Two of the adjunct faculty, Frank and Emily, committed to continue using the new strategies set-up they had tried out. (Valerie, Frank, and Emily are pseudonyms.)

Once this commitment was made, I invited Frank and Emily to participate in my research, focusing on how they developed and implemented their strategies, and their students' reactions. Frank and Emily were chosen for this research because of their commitment to TC participation and the ambitious instructional practices of the program. The case studies presented document on how they developed and implemented their chosen strategies, and situate their decisions in terms of their identities and homework meanings.

3.2 Data Sources

Data sources include a transcript of the second TC meeting in which set-up strategies were discussed, end-of-semester interviews with Frank and Emily, their TC "assignments" (written reflections from between meetings), their follow-up reflections several semesters later, and student surveys. The teacher interviews included three sections. The *background* section included questions about how the teacher came to teaching and his/her early experience, as well as questions about teaching philosophy. The questions in the *TC experience* section included the teacher's homework concerns before the TC and how the TC influenced their thinking. The

strategy implementation section asked the teacher to describe how the strategy worked, to evaluate how effective the strategy had been, and to discuss future implementation.

Student surveys included two sections. The first focused on homework in general, including a self-assessment of effective homework behaviors (e.g. turning in homework on time) a question of what the teachers do to help students be effective at doing math homework, and a question about what the student should improve on with respect to homework. The second section focused on the teacher's chosen set-up strategy, including questions about how students participated.

3.3 Analytical Approaches

Researchers interested in understanding a phenomenon in a given context turn to the methodology of case studies in the qualitative or interpretive tradition, with a focus on understanding how people make meaning in context (Dyson & Geneshi, 2005). To build a case study, a "social unit, for example, a person, a group, a place or activity, or some combination of those units" is identified and that unit becomes " a case of *something*, of some phenomenon (Dyson & Geneshi, 2005, p.3). This approach to understanding human experience in general, and the work of teachers in particular, aligns with the theoretical perspective of teachers as participants in the homework cycle. Within this framework, we can examine a TC participant as he or she develops and implements a strategy, and we can understand that work in terms of the teacher's identity and what meaning he or she makes out of experience. Thus we can understand Frank and Emily each as a case of how teachers develop and use set-up strategies. The case studies are guided by two questions:

(1) How did the teachers develop and implement set-up strategies?

(2) How do meaning and teacher identity shape their decisions in this work?

The case studies are each organized in 4 dimensions, summarized in Table 2.

Table 2.

Case study dimensions and data analysis

Case dimensions	Description	Data source	Analysis
1. Teaching background	Context for understanding current teaching practices	Interview	This portion of interviews were coded for teacher identity (research question 2) but also provide context for current teaching practices
2. Development and use of the strategy	Choice of strategy, how it was implemented	Transcript of TC meeting 2, TC assignments, Interview	Data sources were reviewed for teacher's statements about how strategy was chosen and how it was implemented. Addresses Research question 1.
3. Understanding implementation	Using teacher identity and	Transcript of TC meeting 2,	Transcripts were coded for meaning of homework, teacher

of strategy	homework meanings as a lens to understand decisions around the use of the set-up strategy	Interview	identity, and connections to teacher's decisions and practices. Addresses Research question 2.
4. Reflection and extension	Teacher's and students' responses to the strategy; teacher's extension of strategy for future practice	TC assignments, Interview, Student survey, Follow-up-reflection	TC assignments, interview, and follow-up-reflection were reviewed for teacher's evaluation of the implementation of the strategy, plans for future use, and actual future use. Students' responses to survey questions were summarized for evaluation and use of strategy. Addresses Research questions 1 and 2.

3.3.1 Dimension 1, background

Each case begins with a description of the teacher's background in teaching. This dimension was created from the teacher's interview narrative detailing both early teaching experiences and how he or she became a teacher. This dimension provides context for the teacher's current teaching practice and identity.

3.3.2 Dimension 2, development and use of the strategy

This dimension addresses research question 1 by describing the teacher's development and use of a set-up strategy. The TC meeting transcript, teachers' written reflections, and interview transcripts were coded for instances in which the teacher described how or why the strategy was chosen and how the strategy worked. The first issue was directly prompted in the TC meeting and assignments, while the second issue was directly prompted in the interview.

3.3.3 Dimension 3, understanding strategy use

This dimension addresses research question 2 by describing the teacher's use of the set-up strategy via the lens of identity and meaning. Documents were coded for the teacher's statements about the meaning of homework (i.e., value, purpose, goals for students) and teacher identity (i.e., the role of the teacher, teaching style). The meeting and interview transcripts were also coded for instances in which the teacher positioned him or herself with respect to students or colleagues, as well as instances in which colleagues attempted to identify or position the teacher in particular ways. For example, in the TC meeting and his interview Frank's colleagues discussed how his decisions around his set-up strategy could position him differently with respect to his students. In each case the codes for identity and meaning were compared to the teacher's descriptions of the strategy to identify connections.

Student surveys were also analyzed for ways in which the students positioned the teacher. Students' responses to the question "What does your math teacher do to help students be effective at doing math homework?" were summarized and then used to create categories of how they viewed the teacher. For example in Frank's class, four students' responses were coded as "availability" because they wrote about how he was available outside of class.

3.3.4 Dimension 4, reflection and extension

This dimension presents the teacher's and students' evaluation of the set-up strategy. The teacher's evaluation draws from a description in the interview of the effectiveness of the strategy. The students' evaluation draws from survey questions about the strategy. This dimension also examines how the teacher extended the use of their strategy into future semesters, based on the follow-up reflection. This final dimension addresses both research questions in that it describes teacher practices and connects their practices to homework meaning and identity.

3.4 Confirming Findings

The purpose of collecting and analyzing multiple data sources is to build triangulation into a study. However, to provide further confirmation of conclusions I also used the strategy of getting feedback from the participants (Miles & Huberman, 1994). After writing each case, I asked the teacher to read and comment on it. This provided Frank and Emily with opportunities to confirm, question, and add to their cases.

4. Frank and Emily: Two Cases of Homework Set-up Strategies

Each case is presented below, organized by the four dimensions. A discussion of the cases follows.

4.1 Frank: If I Was Looking Over Their Shoulders

4.1.1 Teaching background

At the time of this research, Frank had been teaching mathematics for about a decade. His earliest experiences included tutoring in high school and college. During graduate school in computer science he worked as a teaching assistant and tutor. While tutoring math students, Frank found that they needed affective support: "I realized what these students who were failing math class needed most was *therapy*" he explained. When tutoring focused on supporting students in believing in themselves, the students were much more successful, "and they completely transformed." Frank greatly enjoyed this work: "It was more fun than the thought of teaching C++ [programming language] for the rest of my life."

When Frank decided to pursue a teaching career, he took graduate courses in education, where he learned about and conducted some research. Frank has continued to develop his teaching strategies by reading, attending conferences, and collaborating with colleagues. It was in the TC that Frank began to develop a homework set-up strategy.

4.1.2 The tip sheet strategy

One of the set-up strategies presented in the first TC meeting was that of giving students a written assignment. After that discussion, Frank chose to create an assignment sheet using a technique he had previously developed in a different context. When he had taught a course many times during graduate school, Frank wrote a "tip sheet" for other instructors that listed places in the materials where things could go wrong and how to manage these issues. Frank believed that the instructors found the tip sheets useful, as did his students when he tried a similar strategy as exam.

After Frank initially tested out this strategy with his Intermediate Algebra class and reported back during the second TC meeting, he committed to giving this class a tip sheet with every assignment that semester. Each sheet contained a bulleted list of tips to draw students' attention to common errors that students had made in the past. Frank distinguished between common errors that were *not* productive for learning - and hence were noted on the tip sheets- and errors that would be productive as part of coming to understand course concepts and problems. (See Appendix 1 for a sample homework problem and the associated tip sheet.)

When he introduced the tip sheets to his class, he explained that it was a collection of clarifications and hints related to problems that students had asked about in past semesters, or he felt they *should* have asked about. He explained that he wanted them to use the tip sheets to be more successful on assignments. He did not give directions for how to use the sheets; however, throughout the semester he reminded the class to read and use the sheets. Using the tip sheets to review and check their work would help them to make sure they hadn't missed the point of any of the problems and it would provide them with help in place of being able to ask questions of a teacher. This was important because although the assignments were designed to be done in a supervised math lab, many students are not always able to get to the lab. So the tip sheets would provide students with homework support at any time outside of class.

4.1.3 Understanding Frank's implementation of the strategy

Frank's decision to use this strategy aligns with how he identifies (positions) himself as a teacher and his perspective on the meaning of homework. From his early tutoring experience he connected teaching math with affectively supporting students. Frank's teaching philosophy depicts a classroom atmosphere in line with the notion of ambitious instruction: students would be solving problems and the teacher would be there to help. The teacher and students should know each other well, such that they can feel comfortable trying out different strategies. Frank also wants his students to feel like they are capable of doing math and that math is useful. In depicting this ideal classroom atmosphere, Frank describes the kind of teacher he aims to be: one who supports students in their learning and motivation to learn. Frank's students identify him as this kind of teacher. In response to the survey question of what the teacher did to help students be effective at doing math homework, the class focused on Frank's supportiveness, describing his patience, willingness to answer questions and review material, and availability outside of class during office hours and online.

From Frank's perspective, homework is something that students should take seriously as a learning opportunity. Before the semester in which he introduced the tip sheets, he was concerned that students were doing homework just to get it done. In response, he had given back incomplete work to be finished. He also gives written feedback so students can learn from their mistakes. And from our TC discussions about messages, Frank came to believe that assigning work at the end of class was too casual and did not put forth a message about how important homework is. This realization was part of the reason Frank decided to use the tip sheets. His motivation was also his desire to support students as they worked, to be there for them when he was not physically there:

> I just make a list of all the things I *wish* I could tell my students *as* they were working. If I was looking over their shoulder as they were going, what would I tell them. What would I say, "Oh watch out for this. And you write that down." All the mistakes you think you're likely to see. All the mistakes you *do* see that you really wish you could tell students about.

Frank encouraged his students to view the tip sheets as a way to get help, reminding them to pay attention to the tips, ideas, and "things to ask yourself." Frank was also concerned that students might not always ask for help. He had learned from an interview study he conducted in graduate school that some students, especially women and students of color, did not always ask for help because they did not want to demand the teacher's time. So the tip sheets could provide help to students with "less social capital" who knew they could ask for help but were hesitant to do so.

While Frank was positioning himself as a supportive teacher, his TC colleagues also asked him to consider the relationship between his teaching decisions and how his students see him. During the second TC meeting, Frank described making the tip sheets and how he hoped it would be "good for the students." Valerie and I responded by connecting the tip sheets to his professional image.

Valerie: I think it establishes you also as a professional? Like [another teacher] does a lot in his teaching. Here's where I'm qualified to be your teacher. And I think saying I'm gonna give you *tips* for roadblocks and how to maneuver this class. To me as a student that says here's why I'm professionally qualified to be teaching this class.

Author: I think it also sends a message that you're really serious about what you want from them. But also that you've really thought about how students engage with this material. Cuz I think it'd be *really* easy… you could just say "do this assignment." THIS tells them that you have *looked* at the assignment, you've done it, you've seen students do it, and you understand how students think about it. So not only does it help your students, but it gives them this really strong message about like Valerie was saying, sort of who you are as a teacher.

I also pushed Frank during his interview to consider how his approach might be too much "hand-holding". I explained how "part of problem solving is grappling with things" and while I don't want students to misunderstand homework questions, I wondered if students "might lose some of

that grappling" by reading tip sheets. Frank explained that he did not tell students they *had* to use the tip sheets or *how* to use them. This was to avoid students using the tips when they did not need them. Frank further described how he aimed to clarify questions without telling students how to solve problems. Yet he was unsure: "I tried not to be too explicit" he explained. "I've tried. I don't know whether I've succeeded or not. I've tried not to give too many details."

While my suggestions were about Frank's teaching, they were about him as a teacher. Is he too supportive, potentially depriving students of part of the learning process? Frank's responses indicate that he did not want to be positioned as the teacher who makes things too easy, and that he was open to shifting his use of the strategy. We see the results of this discussion in Frank's continued use of tip sheets.

4.1.4 Reflecting on and extending the strategy

At the end of the semester Frank wasn't sure if the tip sheets had made a difference in student performance on assignments, as he felt that the class was particularly strong. He did, however, believe that the tip sheets might have made a difference: "what I can say is that I've noticed that the errors I always see, even from good students? I'm not seeing as many." He also noticed that students picked up the sheets at the end of class and that they looked for the tip sheets when they had missed class, which Frank took as students associating homework with the tip sheets.

While Frank's students did not describe the tip sheets in the open-ended question about his homework support (only 4 mentioned them explicitly), they claimed to use the tip sheets when asked directly. Twenty-two of twenty- five who completed the survey indicated using them. In response to the question of *how* they used them, students revealed some differences in *when* they used them. Seven students indicated using them while they worked, five read them before starting, and three used the tips when they got stuck. One student described a specific strategy he or she used: read the tips, read the assignment, and connect the tips to the relevant parts of the assignment. (The remaining responses were unrelated to *when* the sheets were used. For example, some students just wrote that they read the tips.)

The students' descriptions of *when* they used the tip sheets made me wonder if there were more or less sophisticated ways to use them, which led me to broach the subject of how much support the tips provide. In continuing to develop and use this strategy, Frank has taken this issue seriously. Reflecting over the last few semesters, Frank described how he now organizes the tips into three sections. (See Appendix 2 for a sample.) The "before you begin" section provides general advice and reminders of ideas discussed in class. The "when you are finished" section covers things to check before turning in work. Now when Frank introduces the tip sheets, he directs students to read these two sections. The third section gives tips on specific problems and is "there as a reference as you need it." Frank initially wrote the specific tips as the second section, but moved them to the bottom of the sheets based on a student's request: "Now all the stuff I expect everyone to read is at the start, and they don't have to skim past the specific tips and risk spoiling themselves to find stuff they need to look at."

Frank's continued use of this strategy demonstrates his commitment to supporting his students in making homework a learning opportunity. Yet the ways in which he has adjusted his strategy

reveal how he is shifting how he positions himself: Frank identifies as a supportive teacher, but he has adjusted the nature of this support to create more space for students to support themselves.

4.2 Emily: Accessing the Collective Mind

4.2.1 Teaching background

Emily found her way to teaching through her affinity for learning mathematics and several opportunities to try on the work of teaching. While working in industry she ran trainings in her department, which she found to be something she "gravitated towards." During graduate school in mathematics she also had the opportunity to work as a tutor and mentor in community college math classes. This experience was so powerful for her that she took it as a sign she should pursue teaching further, which she did while taking graduate mathematics courses at a local state university. There she had the opportunity to teach Algebra and to collaborate with faculty and other students around issues of teaching.

In 2006 Emily came to the community college to teach mathematics as part of a program for students studying child development. Since then she has taught one or more classes each semester and she continues to develop her teaching practice through both informal discussions with colleagues and the more structured TC setting.

4.2.2 The homework preview activity

During the first TC meeting, Valerie presented a set-up strategy that she had developed while teaching in the developmental program. One of the challenges of teaching in this program is that, in order to meet the learning outcomes, the faculty have written curriculum for the sequence of Algebra courses. The curricula, in the form of activity packets, provide problems for classwork and for assignments. However, without a standard textbook, students can struggle to find homework resources. Valerie shared her in-class preview activity, which prompts students to read an assignment and connect the problems to related classwork problems.

After the first TC meeting, Emily chose to test out this strategy in her Algebra class and to report back in the second meeting. She had concerns that students who didn't fully understand classwork would have difficulty using their classwork as a homework resource, yet she noted that most students in the class seemed to understand the preview process and were enthusiastic about it. After the second meeting, Emily chose to continue using the preview activity for the rest of the semester, in hopes of helping students develop the skill of connecting classwork and homework, and to "understand what their resources are, to help them not be stuck."

Throughout the semester Emily developed her preview routines. At the end of each activity she asked students to turn to the assignment, which she projected using the overhead as well. Then she directed their attention to specific problems. She asked students to read problems and to connect them to class problems, asking questions such as "What is that like in the work we have done already? What kind of problem would you find an example for that?" For problems that Emily and her colleagues previously had identified as confusing to students, she would clarify what the question was asking before asking students to connect back to class problems. In some

cases she gave hints, but her questions were "material dependent," or tailored for each assignment.

Emily expected students to participate in the preview in order to understand how each assignment connected to classwork, as well as to "build the effective learning skill of using what they learned." She also expected students to take notes during this discussion in order to make their own classwork a homework resource.

4.2.3 Understanding Emily's implementation of the strategy

Emily's decisions can be understood in terms of how she identifies or positions herself as a teacher as well as what homework means to her. Two salient aspects of Emily's practice speak to her teacher identity. First, she seeks to organize her teaching in alignment with ambitious instruction: her role is to engage students in problem solving, including understanding problems in multiple ways. This requires creating a classroom environment in which students work collaboratively and are willing to share their ideas. Second, Emily approaches teaching as a learner. She utilizes colleagues as resources for strategies in-line with her teaching goals. During the interview she mentioned five different colleagues from whom she had taken ideas about teaching, and throughout the TC meetings she posed questions to the group about managing various situations. What she found most useful about the TC was the opportunity to hear about colleagues' strategies, or "accessing the collective mind."

Through her teaching practices such as returning work to students to complete and searching for new ways to supplement the department's curriculum, Emily reveals her belief in homework as a learning opportunity. Yet the meaning of homework for her is more specific: she views homework as the continuation of in-class learning. Emily attributes her perspective on homework to an idea from a colleague. From a discussion early in her career she came away with the idea that as a college teacher her role is to "get students working outside of class" because most of their learning time will be out of class. Emily made this connection between homework and classwork in her written reflections between TC meetings as well as during the meetings and the interview. Her main reason for choosing the preview strategy was her desire to help students make the connection between what they learned in class and the work they would do outside of class. The strategy also gives the message that teachers are not "throwing students off the deep end," but helping them support themselves.

Thus the preview strategy exemplifies the meaning of homework for Emily and it supports her ambitious instructional goals. It also exemplifies how Emily positions herself as a learner with respect to colleagues. This is not to say that Emily sees herself as subordinate, rather that she envisions herself on a continued learning trajectory. The institutional roles of the TC members - Emily as an adjunct faculty member, and Valerie and I as full time faculty members and TC facilitators – reinforce Emily's role as a learner in this context.

4.2.4 Reflecting on and extending the strategy

At the end of the semester Emily was unsure about the effect of the preview strategy. She hesitated to conclude that the preview activity was producing student success because she had

made several changes to her homework practices that semester, including collecting in-class work from the activity packet and not just the assignments. However, students had voiced to her that the strategy had been effective for them, and she was committed to using this strategy in the future when teaching courses with our faculty-written activity packets as the main curriculum.

When we surveyed Emily's students, what she was interested in learning was whether or not the students took notes during the preview and whether or not they used them. Of the 21 students who took the survey, 13 indicated that they took notes and four indicated that they did not. (Four students did not answer the question.) Of the four who did not take notes, one explained that he/she already understood the material, and the other three explained how they found it difficult to take notes while participating in the preview. All 13 students who took notes said they used them, with 12 of them rating their use as "often" or "always". The four students who did not take notes all indicated that they understood the purpose of the preview as helping them know what to expect on the homework. They also indicated that they saw other ways of getting homework support in Emily's class, such as having time in class to ask questions. Their responses point to the need for multiple supports, which was in line with Emily's efforts.

Emily has continued to use this strategy in her developmental math classes and she has extended it in several ways. Her preview now includes a prompt to identify difficult questions that students will want to focus on during their time in the lab. In higher-level courses such as Precalculus and Calculus, Emily has used a similar strategy that prompts students to identify homework problems from their textbook that extend the work done in class. Her students find the previews useful, and Emily continues to believe in the previews as a means for students to generate their own homework resource. Further, this strategy gives students the message that Emily expects students to use the preview as well as other homework resources. Emily's continued development of the strategy demonstrates her commitment to finding ways to best support students' homework efforts.

4.3 Discussion

These cases illustrate how teachers can develop and use homework set-up strategies in the context of ambitious instruction. Frank and Emily share several key characteristics: a commitment to aligning their teaching to the practices of ambitious instruction, ongoing engagement in the TCs in order to develop their practices, ownership of the value of homework for learning, and a desire to support students' homework efforts. Yet there are differences in how aspects of their meanings and identities play out in practice. Frank's identity as a supportive teacher and his past experience giving tips leads him to a strategy that leads others to position him as possibly too helpful. Through input from his colleagues and students, he adjusted the strategy to better support student independence and to position himself as a teacher who supports independence. Emily's learning orientation, respect for colleagues' ideas, and desire for homework to continue class learning leads her to Valerie's preview strategy. Emily too positions herself as a supportive teacher - she doesn't want to leave students without homework help, but her concern is that they build their *own* homework resource.

5. Conclusion

When mathematics educators shift their practices towards ambitious instruction, so must homework tasks and practices shift to support students in successfully engaging with homework. The cases of Frank and Emily present teaching strategies designed to set up students for successful homework participation in such a context. They also provide understanding of what it takes for teachers to engage in such work. Frank and Emily came to the TC already committed to ambitious instruction, ready to learn, and looking for ways to support student learning. These conditions point to some limitations of the current study as well as implications for teaching and research.

5.1 Limitations

Presenting only two cases necessarily limits our ability to generalize findings. What is important here is that the cases are not meant to generalize beyond the current context, but rather to illustrate what is possible through learning opportunities such as the TC, and in a context where ambitious instruction is the norm. The homework setup strategies make sense in this context, given the nature of the curriculum and instructional practices. They may require adaptations in a learning environment with different curricula and resources. Further, the conditions that support Frank and Emily (commitment to ambitious instruction, learning orientation, commitment to supporting student learning) may not be sufficient in all contexts. The cases also do not provide quantitative evidence of the effect of the strategies. This issue is addressed below in terms of future research.

5.2 Implications for Teaching

The concept of the homework cycle and the associated strategies explored by the TC represent a move towards defining teachers' homework roles in the context of ambitious mathematics instruction. In the community college context, the kinds of developmental mathematics courses Frank and Emily teach present barriers to success for many students. That is, while the majority of students must complete these courses prior to college level mathematics required for transfer to 4-year institutions, few students make it through. Part of the struggle is that community college students often need to balance school commitments with life's ongoing challenges, including work, family responsibilities, and financial and personal problems. Even in a context with a mathematics lab as a resource (and requirement), students are often left to handle homework on their own at night or on weekends. If assignments are more in-depth than basic skills practice, that is, they involve significant reasoning and problem solving, students may feel demotivated without resources. Thus the set-up strategies address the need for homework resources by providing both support from teachers as well as methods by which students can learn to support themselves.

The set-up strategies could also be used or adapted in secondary mathematics classrooms using curricula aligned with NCTM and Common Core Mathematics Standards. Now as schools are beginning to implement Common Core Standards, teachers face the same challenges that occurred in the 1980's and 1990's, when schools attempted to implement curricula aligned to NCTM standards. Sending home assignments that look unfamiliar to parents has always created

tensions and can feed into claims that homework is inequitable, given unequal access to homework help at home. This is the case especially in math, where students claim they are less likely to be able to get homework help by middle school (Dauber & Epstein, 1993). For students who have little or no homework help at home, as well as for students and parents in general, resources such as tip sheets and previews have the potential to make a difference, especially when assignments involve the kind of reasoning and problem solving demanded by the Common Core Standards for Mathematical Practice.

The cases of Emily and Frank also point to the value of TC style collaboration. For teachers to learn about ambitious mathematics instruction in general, and homework strategies in particular, they must have opportunities to learn about, test, and reflect on new strategies in a non-evaluative environment. Such opportunities are especially crucial in the context of community college mathematics, where faculty have subject matter expertise, but often have little or no background in pedagogy or curriculum.

5.3 Implications for Future Research

Although Valerie, Frank, Emily, and their students find the set-up strategies useful, questions remain about the effects of such strategies. Further research could examine how students use the tangible resources of tip sheets and preview notes as they are doing homework, as well as how they participate during in-class previews. How do students make sense of the relationship between classwork and homework? How do they use these resources while solving homework problems? How does the availability and use of resources influence student learning and performance?

Questions also remain about how teachers can develop and use set-up and other homework strategies explored by the TC. How can teachers be trained to use such strategies? What opportunities support teachers in taking ownership of the value of homework for learning, and identifying themselves as learners? Understanding how to support teachers in these ways has the potential to provide teachers with a toolkit for truly supporting homework as a learning opportunity.

6. Acknowledgements

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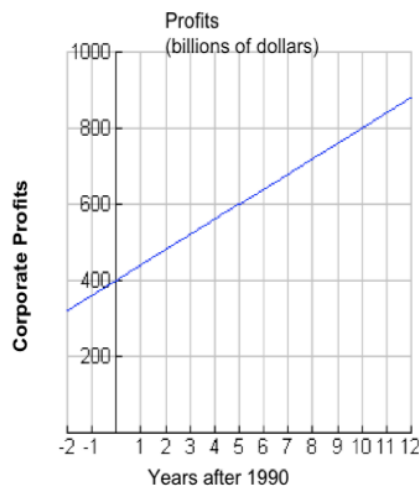
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APPENDIX 1: Sample Intermediate Algebra Homework Problem and Tip Sheet

Sample homework problem	An example of Frank's early tip sheets

1. Corporations in the United States did quite well until recent years. The graph shows corporate profits, in billions of dollars, from 1988 through 2002.

a. Interpret the point (3,520) in this context.

b. Find a linear model (equation) for the graph. Clearly define the variables. Document your process so that another student could follow your method.

c. Clearly explain the meaning of the slope of the line in the context of the problem situation.

d. Clearly explain the meaning of the y-intercept in the context of the problem situation.

e. Use your algebraic model to find when the profit was $700 billion.

f. Use the graph to show that your answer in (e) is reasonable. Write a sentence to explain *and* mark the graph.

Lab Assignment for Unit 1, Activity 1
Due: Monday, February 14

Tips for the lab assignment:
- Some questions don't give you enough space to write. If you need more, write your answers on extra paper.
- In part 1b, "linear model" means a linear equation. In part 1e, "algebraic model" means your equation, too.
- For part 2a, make sure you pay attention to your audience. We talked about this a couple of weeks ago, when we discussed excellent communication. The audience is the person you are writing to. In 2a, you aren't writing to your math teacher. You are explaining something to a classmate. Write to your classmate.
- Part 2i asks you to make a graph. There are a few important things to think about when you do this.
  - First, tell me what your axes mean. What does your x axis represent? How about the y-axis?
  - How far left should your graph go? In other words what is the least x value that you want to show? On your TI graphing calculators, that's called the XMIN.
  - How far right should your graph go? What's the greatest x value that you want to show on your graph? On your TI calculators, that's the XMAX.
  - How far up should your graph go? What's the biggest y that you want? That's the YMAX.
  - How far down should your graph go? What's the least y that you want? That's the YMIN.
  - Once you know how far left and right and up and down, you can figure out how big each of the grid marks should be. Remember, the distance between each grid mark must mean the same amount. If you have 1990 on the first grid mark and 1995 on the second, the third has to be 2000, and so on.
- Part 2j asks you to show on the graph how the constants (the numbers) in your equation relate to the graph. Do you see the y-intercept on the graph? Where is it? How about the slope?
- You might want to do a little research to answer Question 3. Make sure you read the whole question, because it is actually several related questions.

Writing Assignment
Due: Monday, February 14
Describe at least four things that make graphs and tables easy (or hard) to read.
Carnegie Unit 2
Due: Wednesday, February 16

APPENDIX 2: Sample Elementary Algebra Homework Problem and Revised Tip Sheet

Sample homework problem

(Note: the student curriculum includes a table and graph grid)   Elementary Algebra Tip Sheet (Frank's revised structure)

Problem: Cheryl works at a frozen yogurt shop where customers are charged for their yogurt by the ounce. The yogurt is self-serve, so customers take cardboard cups and fill them with as much yogurt as they want. At the cash register, Cheryl has a scale so she can weigh cups of yogurt. At the end of her shift she gets herself a 6-ounce serving of yogurt and it costs $2.41. When Cheryl weighed an empty cup she found that it weighed 0.176 ounces.

a. What is the cost of one ounce of yogurt? How do you know? (Hint: notice the price of the cup in the table below.)

b. Construct a table, an equation, and a graph to model the relationship between the number of ounces of yogurt and the value. Explain how you determined your equation.

c. During another shift at work, the cash register stops working, and Cheryl needs to figure out the cost of a customer's yogurt that weighs 18 ounces. She sets up the following proportion to figure out the cost. Does this proportion give the correct cost? How do you know? WHY does the proportion work or not?

d. A customer only has $5.00 to spend on yogurt and has already filled his cup with 8 ounces of yogurt. How much more yogurt can he add to his cup and still keep to his budget?

What you should know before you start:

- Always define the variables you use. It's probably a good idea to define variables before you write the equation.
- Try to be specific when you define variables, and make sure you include the unit. Rather than saying "x is time," say "x is the number of hours Laura spent on the Internet."
- Remember, proportions probably won't work! If your x and y aren't zero at the same time, proportions will fail. That's the whole point of this activity. You should know what to do even if proportions (and most of the techniques you normally use) don't work. That means you can't set up a proportion to figure something out, unless you are very careful (like Yesenia was on page 63). That means you can't double one thing to double the other. That means you can't find something like dollars per ounce by just dividing dollars by ounces. You will have to go back to page 63.
- Don't forget, if you want to read an equation in English, it should tell you how you calculate things. For example, 45g = m doesn't mean "45 gallons for 1 mile." It means "Multiply 45 by the number of gallons to find miles," so each gallon gets you 45 miles.
- The story for Question 1 can be confusing. It talks about ounces of yogurt, but you pay for ounces of yogurt plus ounces of cup! So a 6oz serving of yogurt is 6oz plus the cup.

When you have finished:

- Did you define all of your variables?
- Did you use something like Δ P / Δ D (from page 63) to solve Part A of Question 1?
- The line on your graph for Question 1 should be straight.
- Did you explain why the proportion in Part C of Question 1 does or does not work?
- Has the customer in Part D of Question 1 spent exactly $5? If not, they could get more yogurt, so your answer is wrong. Find how much they could get for exactly $5.
- Did you explain why you would pick the bank you picked for parts B and C of Question 2?

Tips while you work on the lab assignments:

- For part A of Question 1, the 6 ounces of yogurt does not include the weight of the cup. That's just the weight of the yogurt. Cheryl has to pay for the total weight, so you have to include the cup when you figure out how much she has to pay.
- Part C of Question 1 is not asking "Will her proportion give her some number?" Every proportion will give her a number. Part C is asking "Will her proportion give her the right number?" You can't answer that by working the proportion out and saying, "Yes, I got a number!" Tell me why that number has to be right or wrong.
- Part D of Question 1, tell me the most yogurt the customer could get and stay within their budget. Your answer might involve a decimal. That's fine. You have a calculator.
- For Part A of Question 2, one thing you should do is tell me what each of those numbers means.