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Teacher Video Clubs: A Method for Creating a Mathematical Discourse Community through Collective Reflection

Nancy Jo Schafer

ACCEPTANCE

This dissertation, TEACHER VIDEO CLUBS: A METHOD FOR CREATING A MATHEMATICAL DISCOURSE COMMUNITY THROUGH COLLECTIVE REFLECTION, by NANCY JO SCHAFER, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chair, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

____
Ann Cale Kruger, Ph.D.
Committee Chair

____
Laura D. Fredrick, Ph.D.
Committee Member

____
Sheryl A. Gowen, Ph.D.
Committee Member

____
Lynn C. Hart, Ph.D.
Committee Member

____
Date

____
Peggy L. Gallagher, Ph.D.
Chair, Department of Educational Psychology and Special Education

____
Ronald P. Colarusso, Ed.D.
Dean, College of Education

AUTHOR'S STATEMENT

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Nancy Jo Schafer

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Nancy Jo Schafer
1267 Briarwood Drive
Atlanta, GA 30306

The director of this dissertation is:

Dr. Ann Cale Kruger
Department of Educational Psychology and Special Eduaction
College of Education
Georgia State University
Atlanta, GA 30303-3083

VITA

Nancy Jo Schafer

ADDRESS: 1267 Briarwood Drive
Atlanta, Georgia 30306

EDUCATION:

Ph.D. 2006	Georgia State University Educational Psychology
M.S. 2000	Georgia State University Educational Psychology
K-8 Certificate	University of Michigan-Flint Elementary Education
B.A. 1989	University of Michigan-Flint Marketing

PROFESSIONAL EXPERIENCE:

2005 – Present	Coordinator – Urban Alternative Preparation Program, Department of Early Childhood Education, Georgia State University; Atlanta, GA.
2003 – Present	Instructor – Department of Early Childhood Education, Georgia State University; Atlanta, GA.
1993 – 2000	Teacher - Clifton Elementary School, DeKalb County School System; Decatur, GA.

PROFESSIONAL SOCIETIES AND ORGANIZATIONS:

2003 – Present	National Council of Teachers of Mathematics
2003 – Present	American Education Research Association, Classroom Management SIG, Secretary/Treasurer
2000 – Present	American Education Research Association
1998 – Present	Association for Supervision and Curriculum

PRESENTATIONS AND PUBLICATIONS:

Hickey, D. T., & Schafer, N. J. (2006). Design-based, participation-centered approaches to classroom management. In C. Evertson & C. Weinstein (Eds.), *Handbook of classroom management: Research, Practice, & Contemporary Issues* (pp. 281-308). New York: Simon & Schuster Macmillan.

Schafer, N. J. (2004, April). *Design experimentation with multiple perspectives to enhance learning and engagement: The GenScope Assessment Project: Using video feedback to facilitate classroom assessment conversation year 2.* Structured poster at the annual meeting of the American Educational Research Association, San Diego, CA.

Hickey, D. T. & Schafer, N. J. (2004, April). *Participatory, Sociocultural Views of Classroom Management.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Kruger, A. C., Schafer, N., Russell, H. A., (2004, April). A comparison of four different ways of coding engagement in videos of classroom activity. Poster presented at the 2004 Annual Meeting of the American Educational Research Association, San Diego, CA.

Hickey, D. T., Zuiker, S. J., Michael, M. A., & Schafer, N. J. (2004, June). *Balancing formative and summative assessment to attain systemic validity: Three is the magic number*. Paper presented at the EARLI SIG Assessment Symposium, Bergen, Norway.

Hickey, D. T., Kruger, A. C., Fredrick, L. D., Schafer, N. J., Russell, H. A., Bable, B., Hand, B., Micheal, M. & Zuiker, S. (2003, April). *Design experimentation using multiple perspectives.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Schafer, N. J., Hickey, D. T., Zuiker, S., Kruger, A. C. & Russell, H. A. (2003, April). *Using video feedback to facilitate classroom assessment conversation.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Kruger, A. C., Hickey, D. T., Fredrick, L. D., Schafer, N. J. & Kindfield, A. C. H. (2002, April). *Balancing Formative and Summative Science Assessment Practices: Year One of The GenScope Assessment Project.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

ABSTRACT

TEACHER VIDEO CLUBS: A METHOD FOR CREATING A MATHEMATICAL DISCOURSE COMMUNITY THROUGH COLLECTIVE REFLECTION
by
Nancy Jo Schafer

Although the reform movement in mathematics education has been very influential within colleges of education and among researchers, it has had less of an effect on mathematics education at the K-12 level (National Center for Educational Statistics, 1999). As a part of the reform movement, the National Council of Teachers of Mathematics (1991) recommends that teachers engage students in mathematical discourse. Given that situated learning theory suggests that reflection, particularly collective reflection, is necessary for professional development (Borko & Putnam, 1998; Lave & Wenger, 1991), this study examined the use of teacher video clubs as a space in which novice teachers can publicly and collectively reflect on ways to create productive mathematical discourse communities within their elementary classrooms. This study advances prior research by using teacher video clubs as a tool for enhancing *mathematical discourse communities* among *novice* teachers who *facilitate* video club sessions. This mixed-methods study examines (a) video club teacher-to-teacher discourse around teaching mathematics by using qualitative comparative analysis, (b) elementary students' mathematical discourse in a case study of one video club member's classroom by diagramming and coding classroom discourse, and (c) teachers' (video-club group vs. traditional-coaching group) specialized content knowledge and reform beliefs measured by *Teachers' Knowledge for Teaching Mathematics Survey* (Ball, Hill, Rowan, & Schilling, 2002) and *Elementary Teacher's Commitment to Mathematical Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003) respectively. The main findings are: (a) Teacher-to-teacher discourse focused of pedagogical issues across all video club session, but changes in later video club sessions to include questioning of goals and authority. Analysis of the discourse also reveal three possible affordances of video club participation: noticing, encouragement, and alternative ideas and strategies; (b) Classroom discourse became increasingly more horizontal and students increased initiation of discourse topics; and (c) As a group, video club members' specialized content knowledge of students and content was found to be marginally significant over the traditional coaching group. No group difference was found in reform beliefs between the two groups. This study shows that video clubs have promising potential as an approach to professional development for the implementation of reform initiatives.

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ABBREVIATIONS

ANCOVA	Analyses of Covariance
ANOVA	Analysis of Variance
CKT-M	Content Knowledge for Teaching Mathematics
CFGs	Critical Friends Groups
FCL	Fostering a Community of Learners
IRE	Initiate, Respond, Evaluate
IRF	Initiate, Respond, Follow-up
IRT	Item Response Theory
M	Mean
NBPTS	National Board for Professional Teaching Standards
NCTM	National Council of Teachers of Mathematics
NOCK	Number and Operations Content Knowledge
NOKSC	Number and Operations Knowledge of Student and Content
PFACK	Patterns, Function, and Algebra Content Knowledge
PreK	Pre-Kindergarten
PSTM	Professional Standards for Teaching Mathematics
SD	Standard Deviation
TIMSS	Third International Mathematics and Science Study

Chapter One

TEACHER REFLECTIVE PRACTICES: THEORIES, CONTROVERSIES, AND NEW DIRECTIONS

The irony of life is that it is lived forward but understood backward.
Soren Kierkegaard

It seems intuitive that teachers must reflect on their practice in order to improve upon it. Mills and Satterthwait (2000) state that “the ability to reflect is often held up as an important attribute of an effective teacher” (p.29). The National Board for Professional Teaching Standards (NBPTS), in agreement with this, maintains that “accomplished mathematics teachers regularly reflect on teaching and learning” (NBPTS, 1998, p. 12).

Reflective practice is a hallmark of many teacher education programs. Most teacher preparation programs promote the training of their student teachers’ reflective ability to improve their learning of the pedagogical process at least to some degree (Berg & Freese, 2002; Bleakley, 1999; Clarke, 1995; Dinkelman, 2000; Loughran & Gunstone, 1997; McMahon, 1997; Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990; Tremmel, 1993). Some teacher education programs’ use of reflective practice is relatively indirect in that student teachers are not trained on a particular approach of reflective practice, but rather they engage in a variety of reflective practices often with the guidance of a coach after formal observations. Conversely, some teacher preparation programs use reflective practice in more systematic and integral ways. These programs directly teach a particular framework for reflective practice as an essential process of the student teachers' professional development. Some of the common methods for promoting teacher reflection are: journaling, case study reflections, peer discussions, conferencing, video reflections, and creating reflective portfolios.

One problematic issue that both researchers and educators face is that the term "reflection" is ill-defined. This makes it both hard to research its effectiveness and to promote its use. Reflective practice is generally seen as a process of being conscious of the complex undertakings of teaching, critically examining them, and acting upon this consciousness in the hopes of improving both one's ability to teach and in turn the students' ability to learn (Buysse, Sparkman, & Wesley, 2003; Hart, Schultz, Najee-ullah, & Nash, 1992; Hatton & Smith, 1995; Laboskey, 1994). Notably, Zeichner and Liston (1996) argue "that not all thinking about teaching constitutes reflective teaching" (p.1). They emphasize that to be a reflective practitioner teachers must question goals and values, consider the context of their teaching, and examine their preexisting assumptions. Loughran (2002) asserts that one common element of many definitions of reflection is the notion of a "problem". In that regard, Merriam and Caffarella (1999) assert the following three major assumptions that underlie the process of reflective practice:

> *Assumption One*. Those involved in reflective practice are committed to both problem finding and problem solving as part of that process. In problem finding, the assumption is that often the problems we are presented with in practice are murky and ill defined. Therefore, we need to be open to discovering new problems or different ways of looking at old problems.
>
> *Assumption Two*. Reflective practice means making judgments about what actions will be taken in a particular situation. Because these actions usually involve seeking changes in ourselves, other people, or in systems, there is an ethical dimension to reflective practice.

> *Assumption Three*. Reflective practice results in some form of action, even if that action is deliberate choice not to change practice. Without this action phase, the reflective practice process is incomplete. The lack of attention to this phase as a critical part of reflective practice often frustrates practitioners who are committed to reflection, but see it as a dead-end endeavor when nothing tangible results. (p. 233)

There has been debate over whether there is a difference between the terms "reflective practice" and "critical reflection". Critical reflection is at times used interchangeably with reflective practice. Hatton and Smith (1995) state that "the term **critical reflection**, like reflection itself, appears to be used loosely, some taking it to mean no more than constructive self-criticism of one's actions with a view to improvement" (p. 35). Dinkelman (2000) defines critical reflection as "deliberation on moral and ethical dimensions of educational practice" (p.195). Others would argue that all teacher reflection requires consideration of moral and ethical dimensions of teaching to truly be reflective (Fendler, 2003).

Not only is reflective practice promoted for its promise to improve teachers' ability to teach, but it is also promoted as a way of “professionalizing” the teaching profession. Teachers as reflective practitioners are seen as professionals who can solve educational problems, not simply as technicians that who are only able to implement “top-down forms of educational reform that involve teachers only as conduits for implementing programs and ideas formulated elsewhere” (Zeichner & Liston, 1996, p. 4).

This paper will examine the nature of reflective practice by first looking at its history. Second, we will review traditional frameworks developed to promote the reflective practices of teachers and examine research findings about their effectiveness. Next we will examine the controversy surrounding reflective practice. Finally we will examine a new direction in reflective practice that holds promise for teacher development, namely collective reflection.

History of Reflective Practice

Three researchers/philosophers have influenced to some extent most of the theoretical frameworks for implementing reflective practice in teacher preparation programs. They are the writings of John Dewey, Donald Schön, and Max Van Manen. The following is a brief overview of their theories and contributions to reflective practice.

John Dewey

John Dewey (1859 – 1952) was arguably one of the most important American educational philosophers of our time. In his 1910/1991 book, *How We Think*, he defines and proposes how to promote reflective thinking. Dewey asserts that reflection is more complex than simply thinking. Specifically he states, "Active, persistent, and careful consideration of any belief or supposed form of knowledge in light of grounds that support it, and the further conclusions to which it tends constitutes reflective thought" (p.6). He further explains that reflective thought involves two phases: "(a) a state of perplexity, hesitation, doubt; and (2) an act of search or investigation directed toward bringing to light future facts which serve to corroborate or nullify the suggested belief" (Dewey, 1910/1991, p. 9).

For Dewey, reflection served a purpose: solution of perplexity or problems. According to Dewey, to engage in reflective thought a person must first be faced with a problem that must be examined for a solution. However, the solution must also be examined by “turning the thing over in the mind” in search of evidence that supports it or proves its irrelevance; without this examination we have uncritical thought void of reflection (Dewey, p.13). Dewey's concept of reflection was not a series of steps to be followed, but rather a holistic approach to problem solving that involved logic as well as curiosity, intuition and passion (Zeichner & Liston, 1996). As such, Dewey advanced teachers as professional decision makers who could reflectively solve perplexities in order to make effective educational choices as opposed to technicians in need exact procedures to follow.

Donald Schön

Donald Schön (1930-1997) was a philosopher who first developed theories of reflection in the field of architecture, engineering, and management before applying them to education. His biggest contribution to reflective practice is in distinguishing between two categories of reflection he coined: *reflection-on-action* and *reflection-in-action*. Reflection-on-action occurs outside the actual teaching event, when a teacher contemplates and tries to solve perplexities of a past or future teaching experience. Merriam and Caffarella (1999) assert that this form of reflection is an analytical exercise designed to result in "new perspectives on experiences, changes in behavior, and commitments to action" (p. 235). Reflection-on-action can be developed by teachers through a number of methods including teachers keeping portfolios, writing in journals, reviewing themselves on videotape, and discussing teaching with mentors or peers.

In contrast, reflection-in-action is reflection during the actual act of teaching. It is reflecting in the heat of the moment. Schön describes reflection-in-action for teachers as:

> In each instance, the practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomena before him, and on prior understandings which have been implicit in his behavior. He carries out an experiment which serves to generate both a new understanding of phenomena and a change in the situation. (Schön, 1983, p.68)

Reflection-in-action allows teachers to be flexible and meet the unexpected needs of their students and the situation. This type of reflection is often tacit and harder to teach and research.

Schön spoke about the importance of what he called framing and reframing reality. A frame is the perspective and context in which a problem is seen and understood. Reframing is seeing the problem from a different perspective. For Schön (1983), “when a practitioner becomes aware of his frames, he also becomes aware of the possibility of alternative ways of framing the reality of his practice” (p.310).

Schön’s influence is seen in many teacher education programs that promote reflective practice as a cyclical process. This cyclical process starts with reflection-on-action prior to the actual teaching event, where the teacher plans for the teaching event based on past experiences. Next is reflection-in-action, which involves reflecting on the lesson and the students’ learning as the lesson unfolds. Finally, there is again reflection-on-action, where the teacher reflects on the lesson that has just occurred in order to learn and thus improve future pedagogy. This cycle is then continued in the ongoing process of teaching and learning.

Max Van Manen

Max Van Manen, a Professor at the University of Alberta, is a world leader in human science research methods. Van Manen (1977) sees reflective practice as a hierarchical process involving three levels: technical reflection, practical reflection, and critical reflection. The first level, technical reflection, involves deliberate rationality, and entails application of “educational knowledge and basic curriculum principles for the purpose of gaining a given end” (p. 226). Van Manen sees the higher second level, practical reflection, as reflection focused on "an interpretive understanding both of the nature and quality of educational experience, and the making of practical choice" (p. 226). At this level teachers are concerned with more than just implementing curriculum; they are also concerned with understanding how the curriculum affects learning and with making choices to improve the teaching and learning experience. At the highest level, critical reflection, the focus is concerned with "the question of the worth of knowledge and to the nature of the social conditions necessary for raising the question of worthwhileness in the first place" (p. 227). At each level of Van Manen's framework, reflection becomes more abstract and ethically based.

Traditional Frameworks to Promote Reflective Practice and Research Findings

Out of the theories of reflective practice come various frameworks which were developed to increase a teacher's ability to reflect in order to improve her or his pedagogy. Many of these frameworks use a cyclical process that involves (1) reflecting on past experiences in order to plan for an actual teaching event, (2) reflection-in-action during a teaching event, (3) reflection-on-action after a teaching event in order to improve future teaching, and (4) then repeating this cycle for increased learning. Many of the traditional frameworks used in teacher development aim to develop teachers as independent reflective practitioners. The following is a review of six frameworks and research findings about their effectiveness.

Boud, Keogh, and Walker's Framework for Reflective Practice

Boud, Koegh, and Walker (1985) defined reflection as: "those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations” (p.19). Similar to many frameworks, Boud and Walker (1990) propose a three-phase model for reflection that starts with preparation, then reflection-in-action during the experience of teaching, then engaging in the “reflective process” after the actual experience. This reflective process focuses on three stages: “retuning to the experience, attending to the feelings connected with the experience, and reevaluating the experience through recognizing implications and outcomes” (Boud & Knight, p. 25). This is a cyclical model that intertwines experience and reflection. While an experience is happening there is an interaction between the learning milieu (i.e., social-psychological and material environment) of that experience and the past experiences the person brings to the current experience. Boud and Walker (1990) propose two types of reflections-in-action: (1) that of “noticing” what is occurring in an experience, and (2) that of “intervening” within the experience. Regardless of which type of reflection-in-action a person chooses it will affect future experiences and the cycle continues.

In reviewing previous work, Boud and Walker (1998), stated that “reflection needs to be flexibly deployed, that it is highly context-specific and that the social and cultural context in which reflection takes place has a powerful influence over what kind of reflection is possible to foster and the ways in which this might be done” (p. 191). In their article they also addressed a plethora of problems that they have encountered in implementing and researching reflective practice, including: reflective practice being taught as if it were a recipe, reflection being exercised without learning from it, reflection type being mismatched to the setting in which it is used, reflection being treated as solely an intellectual exercise that ignores the emotions of the activity, the experience being uncritically accepted, and reflection being technically and ethically misused by the teacher educators. Boud and Walker then describe how to create a 'local context' in which reflection might be promoted more effectively. They assert that one of the benefits of creating a local context in which to promote the development of reflective practice is that a local context can filter out the negative influences of the larger context. Local context also enables the building of trust, the setting of boundaries, and it allows for the making of meaning.

In their study, Herrington and Oliver (2000) examined the use of a multimedia program (computer software that included videos of teachers using various teaching and assessment activities, interview transcripts, student work samples, investigations, and an electronic notebook which enabled students to write reflections) as a way to help pre-service teachers learn mathematics methods in an authentic learning environment. As one of their goals, they hoped to create a learning environment that promoted reflection. They used Boud, Keogh, and Walker's (1985) three stages of the "reflective process" to evaluate interviews of eight secondary preservice teachers after completing the multimedia activities. The goal was to see if the learning environment promoted reflection. The interviews were recorded and transcribed. Herrington and Oliver found much evidence of students reflecting in all three stages of the reflective process. They used this evidence to support the use of authentic multimedia learning environments.

Sparks-Langer Framework for Reflective Thinking

Sparks-Langer, Simmons, Pasch, Colton, and Starko (1990) conducted a study examining what promotes reflective pedagogy and how to measure it. This study was conducted as a part of a student-teaching program called the Collaboration for the

Improvement of Teacher Education (CITE). Specifically, they examined pre-service teachers' ability to develop reflective thinking about curriculum, methods, and sociopolitical issues. As a part of this study, Sparks-Langer et al. developed a framework for reflective thinking to analyze preservice teacher interviews for reflective thinking and language. This hierarchical framework, as shown in Table 1, ranges from the lowest level, *Level 1 (No descriptive language)* to the highest level, *Level 7 (Explanation with consideration of ethical, moral and political issues).*

Table 1.

Framework for Reflective Thinking (Sparks-Langer et al., 1990, p.27).

Level	Description
1	No descriptive language
2	Simple, layperson description
3	Events labeled with appropriate terms
4	Explanation with tradition or personal preference given as the rationale
5	Explanation with principle or theory given as rationale
6	Explanation with principle/theory and consideration of context factors
7	Explanation with consideration of ethical, moral, political issues

In Sparks-Langer et al's. study, pre-service teachers were broken into three groups based on their previous course work: high-achieving students, average-achieving students, and low-achieving students. All groups showed that they were beginning to apply pedagogical principles in making teaching decisions. A one-factor ANOVA showed that there was a difference between groups with the high achieving group out performing the other groups on the reflective thinking interview. However, very few students in any of the groups displayed *Level 7 (Explanation with consideration of ethical, moral, political issues thinking).*

In a subsequent article, Sparks-Langer and Colton (1991) state that there are three elements that are important to promoting teacher reflective thinking:

> The first is the cognitive element, which describes how teachers process information and make decisions. The second, the critical element, focuses on the substance that drives the thinking—experiences, goals, values, and social implications. The final element of reflection, teachers' narratives refers to teachers' own interpretations of events that occur within their particular context. (p.37)

Sparks-Langer and Colton assert that the few occurrences of *Level 7* of the Framework for Reflective Thinking may have been because "the program did not have a coherent, critical-theorist orientation in the social foundations courses" (p. 41).

Laboskey's Conceptual Framework

Laboskey (1994) points out that people come to the teaching profession with long held beliefs that are not sensibly derived or tested and are hard to change. It is for these reasons she asserts that it is difficult to get student teachers to evaluate their belief in light of the context and the individual needs of a situation. Laboskey's fundamental goal for teacher education "is to teach novices to temper their judgments, to replace unsubstantiated opinion with what Dewey (1910/1991) called 'grounded beliefs'—grounded belief that is constantly in flux and open to revision" (p. 9). The ability to have judgments constantly in flux and open to revision is necessary for good teaching. The phases that teachers go through in order to make effective judgments and to solve educational problems are illustrated in Laboskey's Conceptual Framework for reflective teacher education (See Figure 1.). Laboskey developed this framework as a first step. The second step is to use this framework to develop and test specific reflective practices that may lead to new comprehensions.

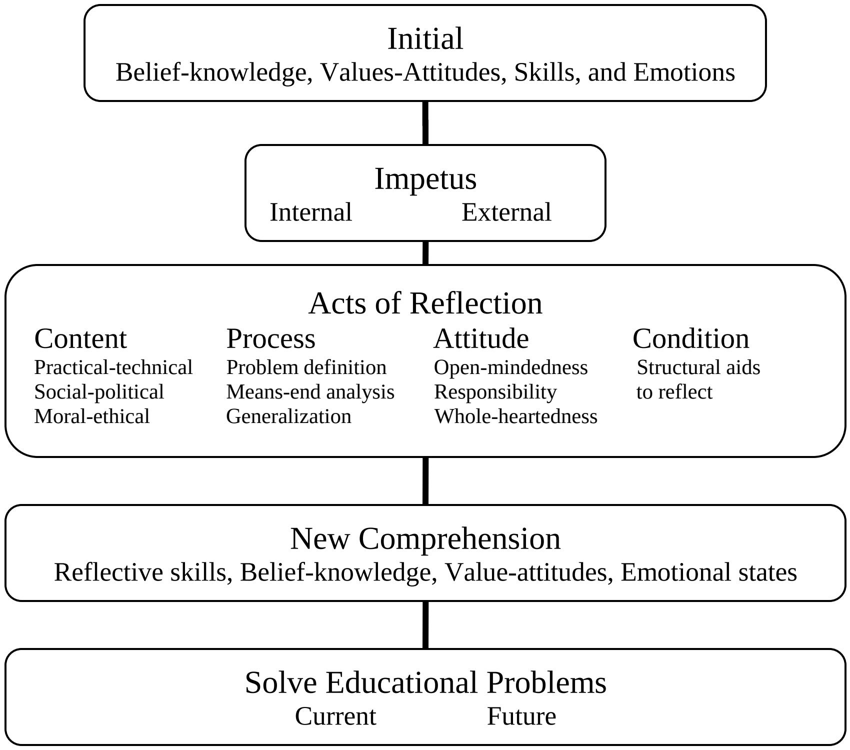

Figure 1. Laboskey's (1994) Conceptual Framework for reflective teacher education (p. 10).

Laboskey (1994) used this conceptual framework to guide a study that looked at conditions needed to encourage student teachers to reflect. She first determined the student teachers' "reflectiveness" prior to the study using the pre-study questionnaire that she developed. Based on the result of the pre-study questionnaire, student teachers were categorized as either Reflective (Alert Novice) or Unreflective (Commonsense Thinker). The interventions to promote student teachers' reflectiveness were case investigations (like a case study but less rigorous) that required the student teachers to set a problem, gather data, analyze the data, and report conclusions. All stages of the case investigations were reported in writing so that they could be analyzed for reflection. Student teachers were then given a post-study questionnaire. Laboskey found that student teachers who were reflective in the beginning of the study remained so, as did the unreflective student teachers. The fact that the student teachers' reflectiveness remained for the most part constant suggests that teaching teachers to be reflective practitioners is difficult if not questionable.

Giovannelli (2003) used Laboskey's research method to analyze student teachers' reflective disposition to determine if it is related to teacher effectiveness. Teacher effectiveness was established using the Survey of Teacher Effectiveness, which is a performance assessment that is broken down into four domains: classroom management, instructional behavior, classroom organization, and teacher expectation. Results of this study suggest that student teachers' reflective disposition had a small but statistically significant effect on their effectiveness as a teacher.

Hatton and Smith's Developmental Framework

Hatton and Smith (1995) developed a hierarchical framework which combined the theories of Schön and Van Manen as well as others (see Table 2). They assert that this framework may be "a developmental sequence, starting the beginner [pre-service teacher] with the relative simplistic or partial technical type, then working through different forms of reflection-on-action to the desired end-point of a professional able to undertake reflection-in-action" (p. 45). Unlike Van Manen who places critical reflection as the highest level of reflection, Hatton and Smith assert that reflection-in-action is the most complex form of reflection. Their logic is that reflection-in-action applies the abilities of other specific forms of reflection (technical, descriptive, dialogic, and critical) in the complex context of teaching and thus is at the highest level of reflective teaching.

In a study, Hatton and Smith (1995) analyzed written reports, self-evaluations, videotapes of teaching and "critical friend" interviews (critical friends are dyads of pre-service teachers who work together for planning, reflecting, and peer support) of pre-service teachers in the third and fourth year of their teacher preparation program for evidence of reflection. The results showed that teachers did engage in reflection, however, a majority of that reflection was at the *descriptive level* (60%-70%) and there were only a few instances of reflection at the *critical level.* Students report that critical-friend interviews were the most effective strategy for fostering reflective practice.

Table 2.

Hatton and Smith's (1995) Developmental Framework (p.45).

Reflection type	Nature of reflection	Possible content
"Reflection-in-action" (Schön, 1983, 1987), addressing IMPACT after some experience in the profession.	5. **Contextualization of multiple viewpoints** drawing on any of the possibilities 1-4 below applied to situations as they are actually taking place.	Dealing with on-the-spot professional problems as they arise (thinking can be recalled and then shared with others later).
	4. **Critical** (social reconstructionist), seeing as problematic, according to ethical criteria, the goals and practices of one's profession.	Thinking about the effects upon others of one's action, taking account of social, political and/or cultural forces (can be shared).
"Reflection-on-action" (Schön, 1983; Smith & Lovat, 1991; Smith & Hatton, 1992, 1993), addressing TASK and IMPACT concerns in later stages of preservice program.	3. **Dialogical** (deliberative, cognitive, narrative), weighing competing claims and viewpoints, and then exploring alternative solutions.	Hearings one's own voice (alone or with another), exploring alternative ways to solve problems in a professional situation.
	2. **Descriptive** (social efficiency, developmental, personalistic), seeking what is seen as 'best possible' practice.	Analyzing one's performance in the professional role (probably alone), giving reasons for action taken.
"Technical rationality" (Schön, 1983; Shulman, 1988; Van Manen, 1977), addressing SELF and TASK concerns early in a program which prepares individuals for entry into a profession.	1 **Technical** (Decision making about immediate behaviors or skills), drawn from a given research/theory base, but always interpreted in light of personal worries and previous experience.	Beginning to examine (usually with peers) one's use of essential skills or generic competencies as often applied in controlled, small scale settings.

Larrivee's Framework for Developing Critically Reflective Teachers

Larrivee (2000) proposed a framework for conceptualizing the development of critically reflective teachers. She asserts that effective teaching requires much more than accumulated skills and strategies (bag of tricks) in order for it to be successful. Teachers need to be flexible and able to attend to the complexity of the situation. When teachers becomes reflective practitioners they are able to make decisions on what skills and strategies are appropriate, as well as inventing new strategies for a given situation when needed.

Similar to other theorists discussed in this review, Larrivee reasons that to be a truly reflective practitioner teachers must engage in *critical reflection.* Critical reflection combines self-reflection and critical inquiry, and "involves examination of personal and professional belief systems, as well as the deliberate consideration of ethical implications and impacts of practices" (Larrivee, 2000, p. 294). To be critically reflective, teachers must examine their beliefs, values, and motivations. Larrivee states that calling one's beliefs and values into question can be a painful and scary procedure. It can be uncomfortable to analyze why we react in certain ways. One reason that this process is uncomfortable is that many of our beliefs and values are conflicting. Larrivee offers an example of the dilemma a teacher faces when she or he values both consistency and fairness, when being fair means being inconsistent. Being critically reflective may allow teachers to be better prepared for handling such situations, which occur commonly in the complex setting of the classroom. It allows teachers to have a sense of vision and purpose, and the professional ability to make complex decisions.

The process of becoming a critically reflective practitioner is not a linear process that can be prescribed, but rather it is a personal discovery process. Larrivee (2000) does however offer actions and practices that are essential to the development of critical reflection: making time for solitary reflection, becoming a perpetual problem-solver, and questioning the status quo. By becoming a "perpetual problem-solver", Larrivee means:

> A teacher's *modus operandus* should be solving problems not enforcing preset standards of operation…. Becoming a perpetual problem-solver involves synthesizing experiences, integrating information and feedback, uncovering reason, and discovering new meaning. (p. 297)

Larrivee (2000) asserts that the information a teacher perceives passes through filters that block out certain information limiting the teacher's perceptions and thus interpretations and decisions. When a situation occurs, such as when a student doesn't do her homework, it passes through various filters such as: past experiences, beliefs, assumptions and expectations, feelings and moods, and personal agendas and aspirations. This filtering of information means that the teacher does not interpret and make decisions based on all the information but rather on personally biased information. In the case of a student who doesn't do her homework, one teacher may see this as laziness, while another teacher may see this as lack of parental support, while still another teacher may see this as a sign of an inappropriate assignment. One, some, or none of these may be true; the point is that our filters guide our interpretations and reactions. Developing the practice of self-reflection allows us to examine our filters and open up the possibility of new interpretations and reactions. For Larivee:

> Self-reflection involves developing the ability to look at what is happening, ithholding judgment, while simultaneously recognizing that the meaning we attribute to it is no more than our interpretation filtered through our cumulative experiences. When teachers develop the practice of self-reflection, they learn to: (1) slow down their thinking and reasoning

> process to become more aware of how they perceive and react to students, and (2) bring to the surface some of their unconscious ways of responding to students. (p. 298)

In her textbook, *Authentic Classroom Management: Creating a Community of Learners*, Larrivee (1999) uses the Framework for Developing Critically Reflective Teachers as a method for teaching teachers authentic classroom management. This approach is quite different from most classroom management methods, which tend to be prescriptive in nature. To date no research was found that supports or discredits this framework.

Loughran's Reflective Framework

Loughran's (1996) reflective framework is a three-part framework, which is both collaborative and systematic in nature. Student teachers are assigned to a mentor teacher. Together they reflect before, during, and after a lesson in order to improve the student teacher's pedagogy. This process involved a gradual building up over time of the intensity of reflective conversations with the student teachers. Initially, the teacher educators observe the class, and then have a conference with the student teachers giving them positive feedback and offering alternative strategies. This has the dual purpose of developing trusting working relationships and also improving the student teachers' pedagogy. During the middle phase of this framework, teacher educators observe the student teachers in action, but they also walk around monitoring the children and asking them questions. This is followed by a post-teaching conference where the teacher educators offer the children's views to the student teachers. In the final phase the teacher educator engages in reflective shared planning and debriefing to help the student teachers develop a better understanding of the teaching and learning experiences. This final stage of the process then continues (Loughran & Gunstone, 1997). Loughran (2002) asserts that "Effective reflective practice is drawn from the ability to frame and reframe the practice setting, to develop and respond to this framing through action so that the practitioner's wisdom-in-action is enhanced and, as a particular outcome, articulation of professional knowledge is encouraged" (p. 42).

Loughran and Gunstone (1997) found that very few studies they reviewed involved quantitative research to address the issue of reflective practices. A small number of studies looked qualitatively at teachers' feelings and beliefs about being involved in reflective practice to improve pedagogy. A general finding of these studies was that teachers felt that reflection helped improve their pedagogy. Unfortunately, once the structure of the study was removed, some teachers reported that their systematic and continued use of a specific reflective practice model faded over time. Loughran and Gunstone report that:

> The interesting aspect of the research is how, despite obvious acceptance, enthusiasm and ownership by participants, the impetus for change dramatically diminished when the external support ceased. It appears as though the nature of teachers' work and their workplace itself creates demands which continually affect those involved in change despite their best intentions. (p.159)

Loughran and Gunstone assert that perhaps the overall culture of these schools did not change in a way that individual and collaborative reflective practices were absorbed as a natural occurring activity within the school community.

Berg and Freese (2002) conducted a two-year study, which examined the effects of Loughran's reflective practice model on pre-service and in-service teachers' planning and teaching activities. The researchers collected and coded audiotapes and videotapes of lesson planning sessions, teaching sessions, and post-teaching reflection sessions. The results of their study showed that mentors and pre-service teachers seem to gain from Loughran's systematic and collaborative reflection model. It appears that this process helps pre-service and mentor teachers consider the "situation-specific nature" of teaching, and they become more reflective over time.

Lee and Loughran (2000) used Schön's notion of framing (the first phase of the reflective cycle where the teacher recognizes the problem) and reframing (the phase where the teacher constructs a new understanding of the problem) to study reflection. In this study they used an interview-video-interview technique previously developed by Loughran (1996) to elicit pre-service teachers' reflections. They found that:

> (1) reflection was prompted by issues or concerns which changed over time during the school-based teaching period; (2) reflections were characterized by the nature of reframing that occurred over time throughout the nine-week school-based practicum; and (3) pre-service teachers' reflections were facilitated by the specific nature of the school-based teaching programme as more time, opportunities and support were made available to them. (p. 69)

The reflective frameworks reviewed in this section endeavors to help teachers to become reflective practitioners who are able to analyze their teaching, and thus, improve upon it. Research findings were limited and mixed. Teachers' self-reports showed that they believed that reflective practices helped to improve their pedagogy, however, in many studies teacher reflection was found to be relatively low-level (descriptive verses critical) and fixed.

Reflective Practice Controversies

Although reflective practices are widely accepted by teacher preparation programs and praised as being highly effective in the development of good teachers, there are controversies that surround the alleged benefits of reflective practices. One of the biggest criticisms is that if reflective practices lead to so many good results for teachers' development and students' learning, why is it so hard to get teachers to adopt reflective practice and even harder to get them to continue to use it for ongoing improvement of their pedagogy?

Another debate among researchers concerns whether reflective practice theory tends to make people separate the teaching experience into that of mind and body (thought and action) or artistry and technique. This type of division has been criticized since John Dewey's time for avoiding the complexities of the teaching and learning process. In this regard, Tomlinson (1999) criticizes Donald Schön's reflection-in-action as promoting a dualistic model of thought and action that boosts "still further the traditional tendency to see conscious deliberation as vital to intelligent action and capability in teaching" (p. 410). Tomlinson is concerned that the explicit knowledge obtained by reflective practices overshadows the implicit knowledge which he feels is inherent in the learning environment. He also feels this separation of thought and action is not real but imposed by the theory. He quotes Gilbert Ryle as insisting that, "When I do something intelligent, […] I am doing one thing not two" (p. 450).

Schön (1983), himself, points out four criticisms of how reflection may interfere with action:

1. There is no time to reflect when we are on the firing line; if we stop to think, we may be dead.
2. When we think about what we are doing, we surface complexity, which interferes with the smooth flow of action. The complexity that we imagine unconsciously paralyzes us when we bring it to consciousness.
3. If we begin to reflect-in-action, we may trigger an infinite regress of reflection on action, then on our reflection on action, and so on ad infinitum.

4. The stance appropriate to reflection is incompatible with the stance appropriate to action. (p. 277-278)

Schön dismisses these arguments by providing an analogy of a tennis player who gives himself a moment, perhaps a split-second, to plan his next move and is better off for this reflection than if he allowed the game to happen without consciously participating in its outcome.

Tremmel (1993), in his entertaining article: *Zen and the Art of Reflective Practice in Teacher Education*, counters many of the criticisms of Donald Schön's idea of reflection-in-action. He believes that some of the criticisms come from a lack of knowledge of non-Western notions and the idea of "mindfulness." Mindfulness is a Zen Buddhist tradition which means, "to return" as in to return to mindful awareness of the present moment. With all there is to attend to and be distracted by as a teacher engaged in teaching, "mindfulness" is a way of returning to the moment and the needs of that moment. Tremmel warns that you cannot research reflection-in-action in the traditional, technically rational way that is customary. However, he states that this "is not to say that technical rationality is of no value, but rather in the terrain of professional practice, applied science and research-based technique occupy a critically important though limited territory, bound by several sides of artistry" (p. 437). Tremmel also warns that in research you cannot separate the teacher from the student because they operate as one unit, and to separate them would be to destroy the unit.

Bleakley (1999) also criticizes reflective practice as being "in danger of being widely adopted in higher education without rigorous interrogation of the central notion of 'reflection' itself" (p. 315). It is not that he does not think reflective practice has merit, but rather it does not have an empirical basis. He is also afraid that reflective practice is becoming a catch-all title for an ill-defined process and that reflective practice will become a set of procedures that do not require any reflection to be carried out. To make learning more palatable we often reduce its complexity to a technical recipe to be followed. The nature of reflection-in-action is that it is ambiguous by nature, in fact there would be no need to reflect (think on one's feet) if it were not.

One criticism of Van Manen's highest level of reflection, the process of critical reflection (reflection about the moral and ethical aspects of education), is whether the process can be taught, particularly to pre-service teachers. Dinkelman (2000) reports that "for what little is known about the process of teaching reflective teaching, even less is understood of how *critically* reflective teaching is promoted among pre-service teachers" (p. 2). Dinkelman goes on to discuss whether pre-service teachers are capable of critical reflection, or if it is only more experienced teachers who are able to attend to critical reflection. His studies show limited but promising use of critical reflection by pre-service teachers.

Owens (2002) argues that not only does the concept of reflection suffer from being ill-defined, but also from a lack of appreciation for the social context in which reflection takes place and is understood. He offers the concept of *discourse communities* as a lens to understand different communities' definition and application of reflection. Discourse communities are created by the practices of their contributing members and "offer a way to analyze the social construction of a concept like reflection" (p. 3). Owens asserts that the concept of reflection is not constant and as a result cannot be simply learned and applied, but rather is mobilized in particular contexts. Among the limitless number of discourse communities, Owens examines three: the phenomenological, the critical, and the situated learning communities. Each of these communities theorizes about reflection differently, and thus makes different recommendations.

Fendler (2003) highlights various criticisms of reflective practice. One criticism is on the overuse of reflective practices in teacher preparation programs to the excess of point of reflecting on one's ability to reflect on reflective teaching. Although this sounds humorous, it is not meant as a pure exaggeration. Fendler also accuses reflective practices as serving "to reinforce existing beliefs rather than challenge assumptions" (p. 16). Because of this, Fendler asserts that reflective practice serves to thwart educational reform movements. Finally, Fendler is critical of many reflective practice frameworks because they often avoid issues of social justice.

New Directions in Reflective Practice of Teachers

The traditional approaches to reflection reviewed thus far in this paper aim to guide teachers to be reflective practitioners, eventually able to engage in reflection independently in order to improve their pedagogy and student learning. Although the training of a teacher as a reflective practitioner may be done in collaboration with a mentor or as a part of a teacher development program, this collaboration is short term with the ultimate goal being that teachers can independently solve their own educational dilemmas. Kumaravadivelu (2003) states:

> First, by focusing on the role of the teacher and the teacher alone, the reflective movement tends to treat reflection as an introspective process involving a teacher and his or her reflective capacity, and not as an interactive process involving the teacher and a host of others: learners, colleagues, planners, and administrators. (p.12)

Frameworks that focus on teachers as individual reflective practitioners assume that teachers have alternative approaches from which to reframe their educational problems in order to solve them. Zeichner and Liston (1996), however, state that "teachers often lose sight of the fact that their everyday reality is only one of many possible alternatives, a selection from a larger universe of possibilities" (p. 9). Dewey expresses the need for past experiences and knowledge in which the problem is contextualized in order to have alternative action. Dewey (1910/1991) asserts that, "unless there has been experience in some degree analogous, which may now be represented in imagination, confusion remains mere confusion. There is nothing upon which to draw in order to clarify" (p.12).

An approach to teacher reflective practice that has promise for helping teachers reframe their educational dilemmas is *collective reflection*. Collective reflection occurs when teachers come together in a professional learning community to reflect and problem-solve in order to improve their pedagogy and student learning. From a sociocultural perspective, learning is socially constructed and occurs as a function of activity, context, history, and culture (Lave & Wenger, 1991; Vygotsky, 1978). From this perspective, learning requires social interaction and co-participation, which is what professional learning communities afford teachers. In this vein, Collier (1997) suggests that "reflection is a social arena for public exchange and examination of ideas" (p.4). Specifically, Cobb defines collective reflection as a "communal activity of making what was previously done in action an object of reflection" (p. 258).

Three promising frameworks that involve collective reflection are Lesson Study, Critical Friends Groups, and Teacher Video Clubs. In addition to allowing a space for collective reflection, all of these professional development approaches are ongoing, integral parts of teachers' practice. They serve as a bottom-up approach to educational reform where teachers are seen as professionals able to solve their own education dilemmas. In an interview, James Stigler, author of The Teaching Gap and coauthor of the Third International Mathematics and Science Study (TIMSS), states that high-quality teacher professional development is site-based, an ongoing part of teacher work, curriculum-based, directly related to teacher practice, and collaborative (Willis, 2002). The three frameworks reviewed below have promise for such professional development.

Lesson Study

Lesson Study is a Japanese approach for improving instruction. Specifically Lewis, Perry, and Murata (2006) state that lesson study involves the "observation of live classroom lessons by a group of teachers who collect data on teaching and learning and collaboratively analyze it" (p. 3). Lewis points out that there are four key features to a Japanese lesson study which include (a) the sharing of long-term teacher goals, (b) the targeting of critical lesson content, (c) the focusing on student learning and development, and (d) the observing of live teaching of a research lesson (Lewis, 2002). In interviews, Japanese teachers report that the lesson studies provide opportunity for collaboration which is essential for the improvement of instruction. Lesson study is not a one-time professional development activity with the objective of improving a single lesson, but rather ongoing teacher activity that allows teachers to collectively reflect on the improvement of instruction. The typical lesson study cycle involves: (a) studying curriculum and formulating goals, (b) planning for instruction, (c) conducting research by observing and collecting data, and (d) reflecting collectively with colleagues (Lewis, Perry, & Hurd, 2004).

Lewis and Tsuchida (1998) reported that Japanese teachers who were interviewed regarding what allows teaching in Japan to go from “teaching as telling” to “teaching for understanding” repeatedly reported that it was the influence of lesson study. After years of research, Lewis, Perry, and Hurd (2004) report seven benefits of successful lesson study: “increased knowledge of subject mater, increased knowledge of instruction, increased ability to observe students, stronger collegial network, stronger connection of daily practice to long-term goals, stronger motivation and sense of efficacy, improved quality of available lesson plans” (p. 19). Lesson study serves as a vehicle for a public form of collaborative reflection that serves to improve instruction, and it has promise as a bottom-up reform method.

Critical Friends Groups

Critical Friends Groups (CFGs) was initiated by the National School Reform Faculty “as a job-embedded form of professional development focused on learning in community through the collaborative examination of student work and teacher practice” (p. 1). CFGs are “not a recipe-for-success workshop, but a coaches’ training program for building collaboration and reflection among colleagues” (Bambino, 2002, p. 25). CGF involve 8-12 teachers who come together on a regular basis to reflect on educational dilemmas involving teachers’ work and students’ learning. Teachers in CFGs utilize numerous protocols that guide them through the analysis of their work. Protocols are structured approaches that help teachers analyze student work, address text (such as professional articles), and tackle teacher dilemmas in an efficient and productive manner.

Bambino (2002) credits CFGs as being “the catalyst for changes in teaching, learning, culture, and climate of learning communities in a great variety of schools” (p.27).

Key (2006) reviewed the research literature on CFGs and found the research to be sparse. Although there was abundant literature describing CFGs, Key only found sixteen research articles, which included eight dissertations, three peer-reviewed articles, three conference papers, and two reports. From the review of the literature Key reports four claims about the effects of CFGs:

1. CFGs foster a culture of community and collaboration.
2. CFGs enhance teacher professionalism.
3. CFGs have the potential to change teacher thinking and practice.
4. CFGs have the potential to impact student learning. (p. 1)

The first two claims are reported in multiple studies, whereas the last two claims are more tentative. Although most of the research reviewed by Key touted CFGs’ benefits, a study by Curry (2003, as cited in Key, 2006) cautioned that its benefits may be limited because of waning interest in its long term use. Additionally, it was reported that the use of protocols may inhibit some from pursuing particular lines of inquiry. Overall the limited research supports the benefits of CFGs as an ongoing professional development method that encourages collective reflection to improve teachers’ work, and in doing so professionalizes the teaching profession by giving teachers the tools to reform education.

Video Clubs

Another collaborative approach to reflection and analysis that has promise for improving teacher pedagogy is teacher video clubs. Video clubs are a type of professional development activity in which teachers come together to watch and discuss videotapes from their classrooms in order to improve their pedagogy (Berg & Smith, 1996; Frederiksen, Sipusic, Sherin, & Wolfe, 1998; Sherin, 2000; Sherin & Han, 2004; Thomas et al., 1998). The process of communally reflecting on teaching and learning is contextualized by the viewing of videotapes of authentic classroom activity.

Sherin and Han (2004) maintain that “teachers cannot be expected to learn simply by being told what to do” (p. 163). Their study examined change in teacher discourse while participating in teacher video clubs. They found that teacher discourse changed over time in two ways: (a) the primary focus of teacher discourse changed from teacher action to student actions and ideas, and (b) discussions of students’ thinking changed from simple restatement of students’ ideas to detailed analysis of student thinking. Their study, along with other studies on video clubs (Frederiksen et al., 1998; Thomas et al., 1998), did not systematically look at how participation in video clubs ultimately affected classroom activity. However, Frederiksen et al. reported anecdotal evidence that video club participation results in improving teaching practice. After a teacher illustrated with video from her classroom how she exclusively used collaborative groups in her mathematics classroom, three other video club members who used teacher-centered methods for teaching mathematics reported they decided to incorporate more group work into their classroom. Video clubs allow a space for teachers to come together to collectively reflect on contextual events of the classroom, and in doing so give teachers space to reform teaching.

Discussion

This paper reviewed reflective practice's history, traditional frameworks for reflective practice and related research findings, controversies surrounding these approaches to reflective practice, and finally a new direction in reflective practices, namely collective reflection. It is hard to imagine that good teachers do not reflect on their practice. Although it seems intuitive that reflective practice helps improve teachers' pedagogy, there is relatively little research that supports this. There is, however, an abundance of theoretical writings promoting the use of reflective practice frameworks; unfortunately, the number of research studies supporting these frameworks pales in comparison. Further, even fewer studies report the effects of reflective practice on student learning outcomes.

Most teacher educational programs use reflection for teacher development to some extent, whether it is highly systematic, or whether it is loosely implemented. The goal of most of these approaches is to develop teachers’ capability to *independently* reflect in order to improve their pedagogy. If a goal of the use of reflective practice is to improve upon teachers' abilities to effectively teach, then teacher preparation programs need to analyze whether the reflective practice they promote meets this goal. A new direction for reflective practice that may have potential for impacting the immediate needs of teachers, as well as impacting reform movement in education is *collective* reflection. The three approaches (Lesson Study, Critical Friends Groups, and Teacher Video Clubs) reviewed in this paper use collective reflection as an instrumental tool for professional development. In addition to allowing a space for collective reflection, all of these approaches advance the need for collaboration and professional development that is an ongoing integral part of teachers’ practice. They serve as a bottom-up approach to educational reform, where teachers are seen as professionals able to identify and solve their own education dilemmas through collective reflection and in doing so have the potential for changing education and as a result improving both teacher work and student learning. However, there is still a need for more empirical evidence regarding the effectiveness of collective reflection as a professional development approach, particularly what attributes lead to its effectiveness.

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Chapter Two

TEACHER VIDEO CLUBS: A METHOD FOR CREATING A MATHEMATICAL DISCOURSE COMMUNITY THROUGH COLLECTIVE REFLECTION

As a part of the National Council of Teachers of Mathematics' (NCTM) reform movement in mathematics there has been a shift in what is recommended as an effective mathematical learning environment: from classrooms as a collection of individuals toward classrooms as mathematical communities; from the teacher as sole authority of mathematical knowledge toward logic and mathematical evidence as verification of knowledge; from memorization of procedures toward mathematical reasoning; from an emphasis on mechanistic answer-finding toward conjecture, inventing, and problem solving; and from treating mathematics as a body of isolated concepts and procedures toward connecting mathematics, its ideas, and its applications (NCTM, 1991). Although the reform movement in mathematics education has been very influential within colleges of education and among researchers, it has had less of an effect on mathematics education at the K-12 level (National Center for Educational Statistics, 1999; The National Academy of Science, 1997). As a part of the reform movement, NCTM presents six standards for the teaching of mathematics that are organized under four categories that are "major arenas of teachers' work that are logically central to shaping what goes on in mathematics classes" (NCTM, 1991, p. 20, See Table 3). They are based on research and extensive input from educators and researchers (NCTM, 1991, The National Academy of

Sciences, 1997), and the goal of these standards is to provide guidance for change in how mathematics is taught.

Table 3

NCTM Professional Standards for Teaching Mathematics

Categories	Standards
Task	1. Worthwhile mathematic tasks
Discourse	2. The teacher's role in discourse
	3. The student's role in discourse
	4. Tools for enhancing discourse
Environment	5. The learning environment
Analysis	6. The analysis of teaching and learning

Arguably, all six of the professional standards for the teaching of mathematics can be met when teachers are able to support meaningful discourse through the creation of a *mathematical discourse community*. A mathematical discourse community is characterized by students engaging in discourse around mathematics that involves reasoning, defending, listening, responding, initiating, questioning, and arguing. As will be elaborated, it is hypothesized that meaningful student discourse occurs when teachers thoughtfully organize the learning environment and implement worthwhile mathematical tasks in ways that allow and encourage students' participation. Teachers' ability to orchestrate productive student discourse is not an easy charge; as students, most teachers in the United States did not experience the learning of mathematics through deliberate discourse communities. This lack of experience may make it difficult for teachers to learn how to effectively implement or trust NCTM's reform recommendations.

From a sociocultural perspective, learning is socially constructed and occurs as a function of activity, context, history, and culture (Lave & Wenger, 1991; Vygotsky, 1978). William F. Hanks (Lave & Wenger, 1991, Forward, p. 22) states that discourse should be seen as a social and cultural practice, and that it serves as "one of the most basic modes of access to interaction in social life." From this perspective, learning requires social interaction and co-participation, and participation within a discourse community constitutes learning. Kovalainen and Kumpulainen (2005) further state that "while conceiving learning as a collective meaning-making process which is reflected in qualitatively different participation practices, this perspective emphasizes the role of social interaction and discourse in knowledge creation" (p. 214). Consequently, both students' learning mathematics as well as teachers' learning how to teach mathematics would benefit from participation within a discourse community. A sociocultural perspective would suggest that in order for teachers to be able to understand and apply reform approaches for teaching mathematics, specifically the need for student discourse in the mathematical learning process, it is important for teachers to have a space in which to collectively reflect on their pedagogy and try on new identities. Consequently, in order for teachers to learn most effectively how to create mathematical discourse communities within their classrooms, their practice needs to be presented and learned in a social and authentic context.

The purpose of this paper is to study an approach to professional development that facilitates novice teachers' ability to orchestrate the six Professional Standards for Teaching Mathematics (PSTM) with the goal of creating productive mathematical discourse communities in elementary classrooms. The NCTM's Professional Standards for Teaching Mathematics will be used to guide the readers' understanding of the various considerations, components, and goals that make up the professional development approach used in this study.

The NCTM's Professional Standards for Teaching Mathematics

Tasks

> Tasks are the projects, questions, problems, constructions, applications, and exercises in which students engage. They provide the intellectual context for students' mathematical development. (NCTM, 1991, p. 20)

In order for students to participate in a mathematical discourse community, teachers must be able to identify and create *Worthwhile Mathematical Tasks* (PSTM Standard 1) that are complex and interesting enough to promote sustained student discourse (Ball, 1993; Henningsen & Stein, 1997; Stein, 2001). Stein, Smith, Henningsen, and Silver (2000) developed *The Mathematical Task Framework* which categorizes mathematical tasks as falling into one of four categories of increasingly higher cognitive demand: *Memorization, Procedures Without Connections*, *Procedures With Connections*, and *Doing Mathematics*.

The lowest level of cognitive demand, *Memorization*, is characterized by the committing to memory of facts, rules, formulas, or definitions without a connection to meaning. An example of this would be the memorization of multiplication facts through repetition. At the second level of cognitive demand, *Procedures Without Connections*, tasks are algorithmic without connections to conceptual meaning. Learning the procedure for determining the area of a rectangle by learning to multiply its length times its width is an example of *Procedures Without Connections.* At the second highest level of cognitive demand, *Procedures With Connections*, tasks require procedures that are connected to conceptual meaning usually through the use of manipulatives, visual diagrams, or symbols. An example of a task at this level would be when first-grade students separate connecting cubes into even piles to demonstrate division. At the highest level of cognitive demand, *Doing Mathematics,* tasks are characterized as complex, non-algorithmic problems that require students to explore and understand the nature of mathematical concepts through conjecture, interpretation, and justification. Stein et al. (2000) offer the following example of a task at the *Doing Mathematics* level of cognitive demand:

> Ms. Brown's class will raise rabbits for their spring science fair. They have 24 feet of fencing with which to build a rectangular rabbit pen to keep the rabbits. If Ms. Brown's students want their rabbits to have as much room as possible, how long would each side of the pen be? How long would each of the sides of the pen be if they had only 16 feet of fencing? How would you go about determining the pen with the most room for any amount of fencing? (p. 2)

A task such as this fence task will inspire and sustain more student discourse than a task that simply requires students to memorize the fact that a square offers the largest rectangular area. If students are told how to get the "correct answer" by an expert (the teacher or the textbook) what is there to discuss?

In the case of traditional approaches to mathematics education, the vast majority of mathematical tasks are at the *Memorization* and the *Procedures Without Connections* level of cognitive demand (low level). Perhaps because of the influence of reform initiatives, currently in elementary schools you will find increasing numbers of teachers connecting the procedures to meaning particularly through the use of manipulatives (*Procedures With Connections)*. However, the *Doing Mathematics* level of cognitive demand is still quite rare. Research from the QUASAR Project (Stein et al., 2000), which used the *The Mathematical Tasks Framework* to analyze hundreds of lessons, yielded two major findings:

> (1) mathematical tasks with high-level cognitive demand were the most difficult to implement well, frequently being transformed into less-demanding tasks during instruction, and (2) student learning gains were greatest in classrooms in which instructional tasks consistently encouraged high-level student thinking and reasoning and least in classrooms in which tasks were consistently procedural in nature. (p. 4)

Boaler (1998) found that students who followed a traditional textbook approach to learning mathematics developed a procedural knowledge that had limited use in unfamiliar situations. However, students who learned mathematics in an open, project-based approach (in line with *Doing Mathematics)* developed a conceptual understanding that was advantageous in a range of situations including assessments. Importantly, *The Mathematical Tasks Framework* gives teachers a shared language that can be used to discuss the affordances and constraints of various mathematic tasks in order that they improve their ability to effectively create mathematical discourse communities.

Discourse

> Discourse refers to the ways of representing, thinking, talking, and agreeing and disagreeing that teachers and students use to engage in those tasks. The discourse embeds fundamental values about knowledge and authority. Its nature is reflected in what makes an answer right and what counts as legitimate mathematical activity, argument, and thinking. Teachers, through the way in which they orchestrate discourse, convey messages about whose knowledge and ways of thinking and knowing are valued, who is considered able to contribute and who has status in the group. (NCTM, 1991, p. 20)

Why have teachers focus on creating mathematical discourse communities? From a sociocultural perspective, learning is a social process in which discourse is a critical tool (Kraker, 2000; Morine-Dershimer, in press; Vygotsky, 1978). From this perspective, participating in discourse is how one becomes a member of a community of learners, and “learning about a certain content area is seen as involving learning to use its particular discourse (Kovalainen & Kumpulainen, 2005, p. 215). Out of the six NCTM Professional

Standards for Teaching Mathematics, three specifically promote the importance of discourse in mathematics classrooms*: Teacher's Role in Discourse* (PSTM Standard 2*), Students' Role in Discourse* (PSTM Standard 3) and *Tools for Enhancing Discourse* (PSTM Standard 4).

Developing effective student discourse is not an easy charge. However the recommendation is clear: students need to engage in thoughtful discourse which must involve explaining and defending their reasoning in order to build a deep understanding of mathematical concepts (Cobb, Yackel, & Wood, 1993; Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Hufferd-Ackles, Fuson, & Sherin, 2004; Lampert, 1990; Nathan & Knuth, 2003; NCTM, 1991; Sherin, 2002; Strom, Kemeny, Lehrer, & Forman, 2001). Traditionally the most common roles for teachers and students (PSTM Standard 2 and 3) in discourse follows a three-part exchange, starting with the teacher *initiation (I)* of discourse, followed by student *response(R),* and then by teacher *evaluation(E)* or *follow-up (F),* often referred to as IRE/IRF discourse (Cazden, 2001). IRE/IRF discourse is characterized by discourse that is initiated, evaluated, and directed by the teacher. This type of discourse typically is implemented between the teacher and an individual student, one student at a time. It is also often characterized by the teacher doing most of the talking, and by a lack of student explanation and defending their reasoning. Cazden contrasts IRE/IRF discourse that occurs in traditional math lessons with discourse that occurs in nontraditional lessons. In nontraditional lessons the amount of teacher discourse is reduced and student discourse is increased. In addition, discourse norms change to include students' initiation of discourse topics, as well as the importance of student explanation, defending, questioning, and listening. Nathan and Knuth (2003) call the

IRE/IRF style of verbal exchange *vertical* discourse because of the top-down interaction between the teacher and the students, whereas *horizontal* discourse is characterized by peer-to-peer discourse.

Many researchers consider discourse that is *horizontal* in nature to be more productive than *vertical* discourse in developing student conceptual mathematical knowledge (Nathan & Knuth, 2003; Sherin, Mendez, & Louis, 2004). Over a two-year period, Nathan and Knuth (2003) worked with an experienced mathematics teacher to improve discourse within her classroom. After the first year's attempt at creating productive classroom discourse, the teacher was able to engage most students in the classroom discourse; however analysis showed that the nature of this discourse was predominately between the teacher and individual students, thus *vertical* discourse. Between year one and year two of the study the teacher engaged in professional development activities with the research team, and committed to providing training for students in the area of active listening and effective presentation. Analysis after the second year of their study showed that the teacher was able to achieve the goal of discourse among students, thus *horizontal* discourse. Unfortunately, the student discourse lacked the mathematical precision which was previously given by the teacher. The researchers hypothesized that the teacher changed her role in the classroom community to promote *horizontal* student discourse, but removed herself too far from the discourse community. As a result, the integrity of the mathematical concept being learned was compromised. In many cases, even when teachers support the reform movement's recommendations, they do not understand what their role is in the creation and maintenance of discourse communities within their mathematics classrooms.

The teacher's role (PSTM Standard 2) is no longer as sole mathematical authority (Hamm, 2002). The teacher's role in developing a mathematical discourse community is in the selecting and appropriating of worthwhile mathematical tasks, clarifying students' reasoning and justifications, and scaffolding student thinking (Ball, 1996; Brown & Campione, 1994; NCTM, 1991; Sherin, 2002; Stein, 2001). Nathan and Knuth (2003) summarize literature that describes scaffolding as falling into two categories: analytic and social. Analytic scaffolding refers to the scaffolding of students' mathematical ideas, whereas social scaffolding refers to the scaffolding of the norms of students' participation in classroom activities and interactions. Both forms of scaffolding are important to the development of a mathematical discourse community. However, teachers must be careful not to lower the level of intended cognitive demand of a task due to over-scaffolding students analytically or socially by modeling the "correct" method leaving nothing for the students to figure out or discuss. In order to orchestrate the new role teachers are being asked to perform, professional development may be necessary.

In addition to worthwhile mathematical tasks already discussed, in order for teachers to orchestrate a productive mathematical discourse community within their classrooms they need tools (PSTM Standard 4) for enhancing discourse. The Professional Standards for Teaching Mathematics (1991) recommend that teachers use a variety of both conventional (e.g. text, rulers, calculators, etc.) and non-conventional mathematical tools (e.g. computers, models, pictures, contextual stories, etc.) to improve the effectiveness of classroom discourse. Tools, such as manipulatives and computers, give students something tangible to scaffold their discourse. These tools also can be used to illustrate their point of view.

One non-conventional tool for developing effective discourse is the use of video. Video examples can be used to show teachers or students what it looks like to engage in effective discourse. Schafer, Kruger, and Hickey (in review) investigated the use of formative video feedback's effects on students' ability to engage in argumentation (discourse that includes explaining, supporting, criticizing, evaluating, extending, clarifying, or refining ideas about science) around classroom assessments. As a part of this study, they showed the experimental group of students short video clips of students from their class engaged in productive discourse from a previous lesson. Analysis of subsequent student discussions showed that students in the formative video feedback condition engaged in significantly more high-level (*Doing Science*) discourse than students in the non-video feedback condition, and high-level discourse was correlated with better academic performance. Many researchers suggest that student discourse can lead to improved learning outcomes (Cobb, Wood, & Yackel, 1993; Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Nathan & Knuth, 2003; Sfard, 2000), while other researchers have suggested that students' ability to learn to participate in domain-specific discourse is an important skill in and of itself (Jimenez-Aleixandre, Rodriguez & Duschl, 2000; Schafer et al., in review). From a sociocultural perspective, in order for students to truly become mathematicians they must be able to engage in the discourse of mathematicians.

Learning Environment

> Environment represents the setting for learning. It is the unique interplay of intellectual, social, and physical characteristics that shapes the ways of knowing and working that are encouraged and expected in the classroom. It is the context in which the tasks and discourse are embedded; it also refers to the use of materials and space. (NCTM, 1991, p. 20)

Teachers should be mindful that taking part in mathematical discourse involves students taking risks. In order for students to be willing to take that risk the *Learning Environment* (PSTM Standard 5) must be seen as a safe and respectful environment in which students feel that their voices are valued. This can occur when teachers actively foster a productive learning community. Brown and Campione's (1994) pedagogical innovation, *Fostering a Community of Learners* (FCL), may offer some insight into how to create productive learning environments. The FCL model is based on four principles: activity, reflection, collaboration, and community (Sherin, Mendez, & Louis, 2004). The physical arrangement of the classroom as well as the materials of instruction must support the active and collaborative nature of activities in which FCL (and *Doing Mathematics)* are implemented. In addition, the social tone must be respectful and support many voices and different points of view.

A common learning environment problem that many teachers believe prevents them from implementing reform standards (including classroom discourse) is classroom management issues. As an example, Hickey and Schafer (2006) illustrated this point by describing a pilot study in which they worked with a mathematician who had taken her sabbatical to teach sixth-grade mathematics in a struggling inner city school. She initially asked for help in controlling the misbehavior in the classroom, which made it difficult to hold whole-class discussions about mathematics. Her request was a common one, how to keep kids from misbehaving and increase their motivation to learn, in order to allow the class to engage in productive discourse. In this case, the teacher wanted to focus first on managing the activity of individuals so that she could engage the whole group in discourse activities. Hickey and Schafer suggest that implementing discourse activities where students' voices are valued is a method of classroom management. When students feel that they are a legitimate part of the classroom learning community they are less likely to misbehave.

Analysis

> Analysis is the systematic reflection in which teachers engage. It entails the ongoing monitoring of classroom life—how well the tasks, discourse, and environment foster the development of every student's mathematical literacy and power. Through this process, teachers examine relationships between what they and their students are doing and what students are learning. (NCTM, 1991, p. 20)

The Analysis of Teaching and Learning (PSTM, Standard 6) is critical to changing mathematics education in order to meet the reform goals. The National Board for Professional Teacher Standards (1998) states that "accomplished mathematics teachers regularly reflect on teaching and learning" (p. 12). Situated learning theory suggests that teacher reflection and analysis of their pedagogy is important to the ongoing improvement of a teacher's ability to enhance student learning through the establishment of communities of learners. In the complex and fast paced world of teaching, deliberate reflection and analysis that is focused on improving student learning through the building of community is a difficult task at best. Thomas, Wineburg, Grossman, Myhre, and Woolworth (1998) argue that as "compelling as the idea of a community of learners may be, it will forever remain a fragile entity if no parallel community exists among teachers" (p. 212). Within a teacher community of learners, discourse can support "communal forms of memory and reflection" (Lave & Wenger, 1991, p. 109). Unfortunately, teaching in the United States has long been an isolated venture which may make productive reflection and analysis more difficult because teachers may have trouble objectively analyzing their own abilities and interactions in isolation (Stigler & Hiebert, 1998). Even when teachers are able to pinpoint their weaknesses, they may not know alternatives in order to make improvements. Bloome and Harste (2001) indicate that to "experience what it means to be an intellectual, all of us need a community within which to grow" (p. 38).

One collaborative approach to reflection and analysis that has promise for improving teacher pedagogy is *Teacher Video Clubs*. Video clubs are a type of professional development activity in which teachers come together to watch and discuss videotapes from their classrooms in order to improve their pedagogy (Berg & Smith, 1996; Frederiksen, Sipusic, Sherin, & Wolfe, 1998; Sherin, 2000; Sherin & Han, 2004; Thomas et al., 1998). The process of communally reflecting on teaching and learning is contextualized by the viewing of videotapes of authentic classroom activity. Sherin and Han (2004) maintain that "teachers cannot be expected to learn simply by being told what to do" (p. 163). Their study examined change in teacher discourse while participating in teacher video clubs. They found that teacher discourse changed over time in two ways: (a) the primary focus of teacher discourse changed from focusing on teacher action to focusing primarily on student actions and ideas, and (b) discussions of students' thinking changed from simple restatement of students' ideas to detailed analysis of student thinking. Their study, along with other studies on video clubs (Frederiksen et al., 1998; Thomas et al., 1998), did not systematically look at how participation in video clubs ultimately affected classroom activity. However, Frederiksen et al. (1998) did report anecdotal evidence that video club participation results in improving teaching practice. After a teacher illustrated with video from her classroom how she exclusively used collaborative groups in her mathematics classroom, three other video club members who used teacher-centered methods for teaching mathematics reported they decided to incorporate more group work into their classroom. More systematic investigations are needed to determine how teacher video clubs may affect classroom activity, student learning, and reform efforts.

As stated above, it is reasoned that meaningful student discourse about mathematics occurs when teachers reflectively organize the learning environment and implement worthwhile mathematical tasks in ways that allow and facilitate students' participation. Video clubs may offer a space for teachers to collectively reflect and analyze curriculum, pedagogy, teacher and student roles, and the learning environment to improve their practice. This study advances prior research in three ways; (a) by using a teacher video club with *novice* teachers to enhance practice; (b) by having the teachers take turns *facilitating* video club sessions; and (c) by using a video club to support these teachers' ability to create *mathematical discourse communities* within their elementary classrooms. The study investigated how and what video clubs afford novice teachers in their professional development and any changes in the sophistication of teacher discourse over time. The study also examined changes in one video club member's classroom discourse on mathematics and changes in teachers' specialized content knowledge and reform beliefs.

Methods

This mixed-methods study examined (a) video club teacher-to-teacher discourse around teaching mathematics, particularly as novice teachers collectively reflected on improving the student discourse in their mathematics classrooms, (b) elementary students' mathematical discourse in a case study of one video club member's classroom, and (c) teachers' specialized content knowledge and reform beliefs. As a mixed-methods study, this analysis is lead by both guiding questions (qualitative) and hypotheses (quantitative). Specifically, this study examined the following research questions:

1. Video Club Discourse: What is the nature of novice teachers' participation in a video club? What is the focus of their discourse and how does it change over time? This was explored by coding the discourse topics and by a qualitative analysis of discourse themes.
2. Student Mathematical Discourse Community: In looking at the elementary classroom of one video club member, how does the classroom discourse about mathematics change over six lessons? This was explored by diagramming and coding the flow of classroom discourse.
3. Specialized Content Knowledge: Does experience in a video club increase teachers' specialized content knowledge that is necessary to effectively teach elementary mathematics compared to other teachers who are in the same mathematical methods cohort, but are not in the video club? This was examined by hypothesis testing using data from a standardized instrument.
4. Reform Beliefs: Does experience in a video club lead teachers' mathematical beliefs to change to be more aligned with the NCTM mathematical reform beliefs compared to other teachers who are members of the same mathematical methods cohort but do not participate in a video club? This was examined by hypothesis testing using data from a standardized instrument.

Participants

The participants for this study were: (a) 16 novice teachers who comprised a Master's degree cohort and taught in urban schools in a southeastern metropolitan area of the United States, including two African American males, two European American males, four African American females, seven European American females, and one Asian female; (b) a subset of 6 teachers from the Master's degree cohort who participated in a video club, including four European American females, one African American female, and one European American male, all of whom were first year teachers; and (c) a case-study teacher selected from the video club group and her third-grade elementary students. The 16 cohort members were novice teachers in their first to third year of teaching who were completing their Master's degrees in Early Childhood Education. All cohort members had received undergraduate degrees in an area other than education and had gone through an alternative certification program in early childhood education (PreK – 5) the year before. All members of the cohort were invited and consented to participate in the study.

As a part of their Master's degree field experience, teachers in the cohort were assigned to one of three coaching groups (two traditional and one video club) based on the proximity of the schools at which the teachers taught. That is, teachers whose schools were closest geographically were assigned to the same group. Generalizability may be limited because non-random assignment to group was used. However, given that groups in this study were formed by geographic location, this approach may increase ecological validity for both teachers in schools who would most likely form a video club group by inviting teachers from the same school to participate and for teacher education programs that typically form coaching groups by geographic location. In the traditional coaching group model, a university faculty coach first observed a Master's candidate teaching a live lesson in her or his actual classroom and then conferenced with the teacher to discuss ways of improving her or his pedagogy. The concentration for the traditional coaching observations for the semester was mathematics instruction. The video club group consisted of the Master's candidate teachers who were assigned to the researcher's coaching group. Two of the video club teachers taught first grade, one taught second grade, one taught third grade, one taught fourth grade and one taught fifth grade. The researcher was a participant observer in the video club sessions. The video club met to review and discuss tapes of teachers' actual lessons and the focus of these sessions was also on mathematics instruction. The video club group met together six times, and individuals from the traditional coaching group met individually with their coach six times during the semester. Each meeting for both groups lasted between an hour to an hour and a half, and after each meeting all cohort members were required to write a reflection based on what they learned from their respective experiences.

A case study was conducted on one teacher who was chosen from the video club group. The teacher and her class's mathematics discourse was further analyzed. The case study teacher was chosen from the video club group through purposeful sampling of the group for the teacher who most typified the other teachers in the Master's program. Merriam (2001) states "a *typical* sample would be one that is selected because it reflects the average person, situation, or instance of a phenomenon of interest" (p. 62). With a small sample size, purposefully choosing a typical case avoids the selection of an extreme case which could limit the generalizability on the behalf of the reader. The case study teacher that was chosen was a female European American in her first year teaching at a school that served low-socioeconomic students, and she represented average teaching ability compared to other video club members (she had received proficient student teacher evaluations the year before, yet still questioned her ability to be effective). Table 4 illustrates participant involvement in each research question and the data collection timeline over the course of one semester.

Table 4.

Timeline Over One Semester of Participation and Data Collection

Research Question	Group	Pretest	Time1	Time2	Time3	Time4	Time5	Time6	Posttest
Question 1: Video Club Discourse	Video Club Group (n = 6)		X	X	X	X	X	X	
Question 2: Student Mathematical Discourse Community	Video Club Case Teacher and Students (n = 21)		X	X	X	X	X	X	
Question 3: Specialized Content Knowledge	Video Club Group (n = 6)	X							X
	Traditional Coaching Group (n = 10)	X							X
Question 4: Reform Beliefs	Video Club Group (n = 6)	X							X
	Traditional Coaching Group (n = 10)	X							X

Data Collection Procedure

During the first session of their fall semester mathematics methods course, cohort members were given the details of the research study and asked to participate. All members accepted the invitation to participate in this study. At the end of that first class, all cohort members were given the *Elementary Teacher's Commitment to Mathematical Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003, see Appendix A) survey pretest, which they completed independently. During the second class of the semester, all cohort members completed the *Content Knowledge for Teaching Mathematics Measure Form A* (CKT-M, Ball et al., 2002, see Appendix B for released test items) pretest independently.

At the conclusion of the second class, the six video club members met with the researcher to discuss the procedures and the goal (to assist teachers' ability to implement effective mathematical discourse communities within their classrooms) of video club sessions. At this meeting, video club members were also told that they would take turns facilitating the video club meetings and were instructed on the role of the facilitating teacher (see Appendix C for video club facilitator directions). Thus, each club meeting was led by a different teacher, and each member led a meeting only once. Subsequently, the Video Club Group met to take part in video club sessions approximately every two to three weeks over a semester for a total of 6 meetings.

Prior to each video club meeting, the facilitating teacher videotaped his or her class involved in a mathematical lesson at the *Doing Mathematics* level of cognitive demand. Also prior to the meeting, the facilitating teacher analyzed the video by diagramming the flow of classroom discourse (the diagramming of classroom discourse is described below in *Question 2: Student Mathematical Discourse Community*) and selected video clips to share with the other video club members. The video club meeting started with the facilitating teacher showing the club members video clips of her or his class involved in a mathematical lesson at the *Doing Mathematics* level of cognitive demand, particularly students engaged in discourse around mathematics. The facilitating teacher then led a discussion among video club members guided by the PSTM Standards and The Mathematical Tasks Framework (Stein et al., 2000). Finally, the facilitating teacher reported the findings of the flow diagram of classroom discourse. The researcher of this study coordinated the video club sessions and as a participant observer scaffolded the teachers' deepening discourse. The focus of this element of the study was the teacher-to-teacher discussions; thus, each of the video club sessions was videotaped, transcribed, and coded using Transana (2005) software.

Over the same time period as the video club meetings, one teacher from the video club was chosen, based on the criteria described above, to take part in a descriptive case study (Merrian, 2001) that analyzed change in her classroom discourse community. So that the discourse in the elementary classroom could be examined in the same time sequence as the video club meetings, the case-study teacher's class was videotaped prior to each video club meeting for a total of six lessons, but only one of these tapes was presented at a video club meeting. This process was done to place the observations of classroom discourse in the context of video club discourse, making it possible to examine any link between them. Each class period was videotaped in full, but only the whole-class discourse was analyzed. For this study, only the case study teacher's classroom videotaped discourse was analyzed by the researcher and reported here.

On the second to last day of the semester, the Master's cohort were given both *Elementary Teacher's Commitment to Mathematical Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003) survey posttest and the *Content Knowledge for Teaching Mathematics Measure Form B* (Ball et al., 2002) to be completed independently.

Data Analyses

For conceptual clarity, the description of the coding procedures and data analyses as well as their results will be presented in the order of the research questions and not in the chronological order of the data collection procedure.

Question 1: Video club discourse. This element of the study was an informal design-based analysis, in that the process and product of each video club meeting informed and affected the process and product of the subsequent meeting. Similar to Sherin and Han's (2004) study, it was expected that the novice teachers' discourse over the course of the video club meetings would change from surface level discourse, with a higher percentage of conversation concentrated on teacher action, to deeper level discourse, with a higher percentage of conversation concentrated on student conception and classroom discourse.

In order to analyze video club discourse, two qualitative coding processes were used. First, topic coding of the discourse was conducted. The coding scheme that was used to analyze teacher-to-teacher discourse during video club sessions is a modified version of Sherin and Han's (2004) coding scheme and reflects the major categories of discourse during video clubs in their study (See Table 5). That scheme was modified for the present purpose in that the pedagogy category was refined by adding two categories:

Classroom Management Pedagogy and Discourse Pedagogy. Classroom Management Pedagogy as a coding category was distinguished from Sherin and Han's General Pedagogy because a pilot study by this paper's author found it to be a specific topic of concern in the discussions of novice teachers. In addition, the coding category Discourse Pedagogy was distinguished from General Pedagogy because the primary focus of the present study was teachers' ability to develop mathematical discourse communities, so it was important to distinguish this information from the more generic code of General Pedagogy. Conversational turns (units determined by conversation changing from one speaker to the next) served as the level of analysis. Each conversational turn was coded as belonging to one of the seven mutually exclusive and exhaustive categories outlined in Table 5. Twenty percent of conversational turns across the video club sessions were independently coded for inter-rater reliability. A Cohen's kappa of .81 was obtained; Bakeman and Gottman (1986) consider a Cohen's kappa of .75 or higher to be excellent for establishing reliability.

Table 5

Video Club Discourse Codes

Teacher Video Club Discourse Coding Categories	Operational Definition	Video Club Example
General Pedagogy	Discourse about teacher action and decisions around planning and implementing lessons (excluding discourse that is focused on student discourse or classroom management).	I just gave them the um the problem, said ok, here are your groups, go and I gave them a container, uh little Tupperware container, and said ok how can you tell me how much water fits in there without using water.
Discourse Pedagogy	Discourse about teacher actions and decisions regarding student discourse.	What do you do, I was talking to Lauren about this earlier, what do you do with the rest or the class when they are just going at this discussion?
Classroom Management Pedagogy	Discourse about teacher actions and decisions regarding classroom management.	They moved into the tables really well. They seem to understand that drill really well. It wasn't like a chaotic free-for-all or anything.
Student Conception	Discourse about student’s understanding and reasoning about mathematics.	Yeah but they are saying four without knowing what that four meant.
Classroom Discourse	Discourse about students and teacher classroom conversations.	See already the kids are checking up on her as she is writing it on the wrong color. A few of them called out, "why are you writing it on yellow because we are doing green?" They are pretty use to catching each other's mistakes.
Mathematics	Discourse about the teacher understands of mathematical ideas.	I'm like sitting here thinking like how do you convert?
Other	Discourse that does not fit in any of the other categories.	So did you tape two days?

Second, the discourse was subjected to close analysis. That is, video club discourse underwent further fine-grained analysis using qualitative methods (Merriam, 2001; Strauss & Corbin, 1998) that respond to the discourse data, as opposed to forcing the discourse to fit into a well-defined coding scheme. This discourse analysis was an iterative process that used constant comparative analysis methods (Merriam, 2001; Strauss & Corbin, 1998) to develop themes from the data. This is done by examining the data, in this case videos, for incidents that are notable and then comparing those incidents from the data with other incidents in the data until tentative categories are developed that can be compared, adjusted, and then compared again to the corpus of video data until consistent themes emerged. Comparing categories across all six video club sessions assisted in the establishment of reliability. Validity was established through the triangulation of data by comparing the themes generated through comparative analysis with teacher reflections that were completed throughout the video club semester, and by member checks with the video club participants to determine if the themes resonated. The purpose of this analysis was to describe the affordances of a video club for novice teachers' attempts to implement reform initiatives.

Question 2: Student mathematical discourse community. An analysis similar to that of Nathan and Knuth (2003) was employed, in which the discourse between and among the case study teacher and her students was studied by diagramming and coding the flow of classroom discourse. Miles and Huberman (1994) assert that "qualitative data rest very centrally on displays that compress and order data to permit drawing of coherent conclusions, while guarding against the overload and potential for bias that appears when we try to analyze extended, unreduced text" (p.141).

Six times over the same time period as the video club sessions, the case study teacher's classroom discourse was videotaped and analyzed. Although each class period was videotaped in full, only the whole-class discussions, which ranged from 6 to 21 minutes in length, were analyzed by the researcher. The method used to analyze the classroom discourse in this study is illustrated in Figure 2. To determine the flow of the classroom discourse, each conversational turn is noted by numbering the conversational turn next to an arrow that illustrates the direction of the discourse. In this example, (a) the Teacher first speaks to Student 7, (b) Student 7 then replies back to the Teacher, (c) next, Student 6 initiates the third conversational turn directed at the Teacher (the number of the turn is circled to note the fact that Student 6 initiated this discourse topic). Student initiations are defined by the student making a comment or asking a question without prompting from the teacher. Arrows inside the circle represent on-task conversational turns and arrows outside the circle represent conversational turns that deal with off-task behavior (e.g. conversational turn 4 from the Teacher to Student 1). Finally, counts were taken and recorded including the following coding categories: the total number of conversational turns, total teacher turns, total student turns, teacher-to-student turns, student-to-whole class turns, student initiated turns, on-task student-to-student turns, and off-task student-to-student turns. Since subjective coding was not a part of this analysis, no inter-rater reliability was needed; however, flow diagrams were reviewed for accuracy. Each teacher applied the flow diagram analysis to his or her classroom discourse prior to the one video club session he or she facilitated (see above), and the researcher independently conducted a flow diagram analysis on all six of the case study teacher's tapes. Only the researcher's analysis of the case study teacher's classroom discourse is reported below. It was anticipated that the case study teacher's initial classroom discourse would be predominately *vertical* in nature (See Figure 2). Over time it was anticipated that the case study teacher's classroom discourse would change to being primarily *horizontal* in nature (See Figure 3).

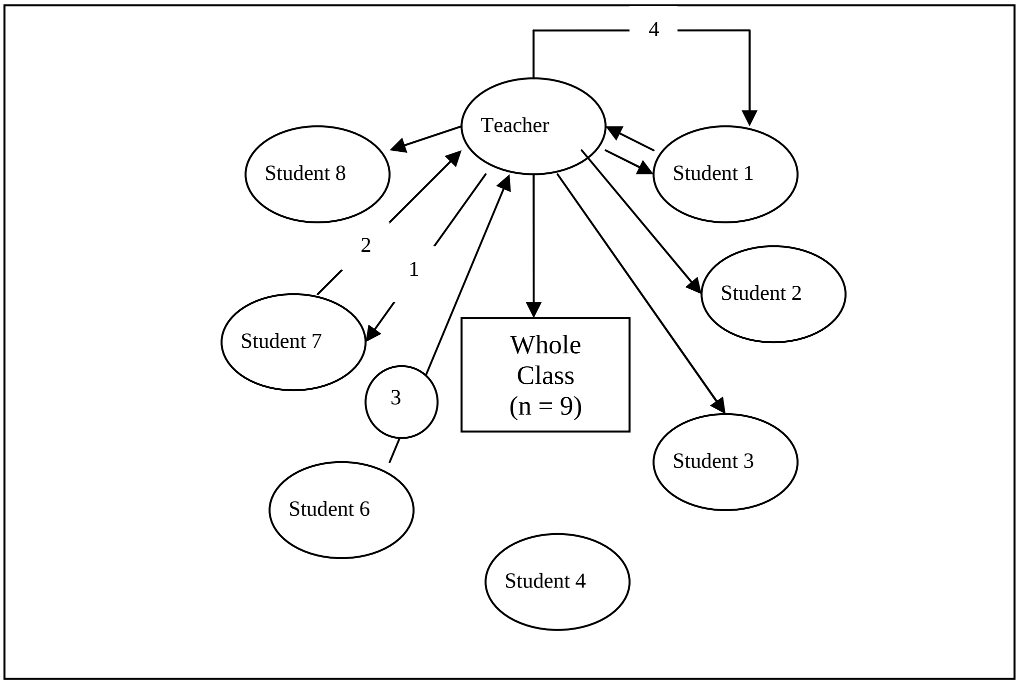

Figure 2. A *vertical* discourse flow diagram.

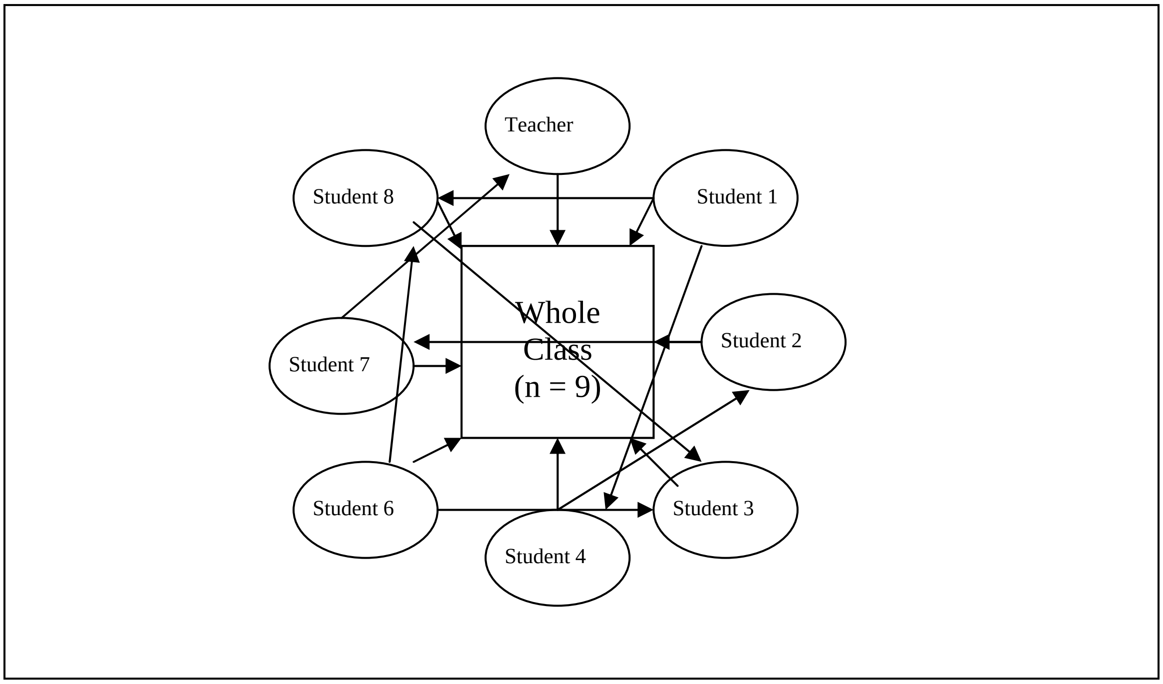

Figure 3. A *horizontal* discourse flow diagram.

Question 3: Specialized content knowledge. The ability to understand not only how to do mathematics, but also how to teach mathematics and analyze student work is what Ball, Hill, Rowan, and Schilling (2002) call *specialized content knowledge*. It was hypothesized that teachers in the video club group would become more knowledgeable about mathematics and how to teach it compared to other teachers who were a part of the same math methods cohort but were not in the video club. It was predicted that the enhanced opportunities to talk about mathematics and student learning in the video club would deepen teachers' specialized content knowledge. Because non-random assignment to condition was used, this element of the proposed study was quasi-experimental. Data to test this hypothesis were collected using the instrument *Content Knowledge for Teaching Mathematics Measure* (Ball et al., 2002) which was administered at the beginning and the end of the mathematic methods course. The CKT-M is made of three constructs: (a) number and operations content knowledge (NOCK); (b) patterns, function, and algebra content knowledge (PFACK); and (c) number and operations knowledge of student and content (NOKSC). NOCK and PFACK assess teachers' specialized knowledge of content areas in K-6 mathematics curriculum. NOCK represents a content area (number and operations) that covers a significant portion of the K-6 curriculum, and PFACK represents a newer strand of content (patterns, function, and algebra) in K-6 mathematics curriculum. NOKSC requires specialized teacher knowledge of students' thinking about mathematics (For more detailed information about the instrument see Hill, Schilling, & Ball, 2004). For this study Form A-2001 was used for the pretest and Form B-2001 was used for the posttest to guard against practice effects.

The developers of this measure tested the reliability of their instrument. The constructs, (a) number and operations content knowledge, (b) patterns, function, and algebra content knowledge, and (c) number and operations knowledge of student and content, received a reliability coefficient for Form A of $\propto$ = .80, .72, and .70, respectively, and received a reliability coefficient for Form B of $\propto$ =.83, .80, and .73, respectively. To test the instrument's construct validity, the developers conducted cognitive tracing interviews, where individuals are asked to explain their reasoning for their answers to particular items. If a respondent answers an item correctly, but explains it incorrectly, there is a problem with validity. Ball et al. also tested content validity by comparing their instrument to the NCTM Standards. To further test construct validity, the developers are currently comparing survey results of individual teachers to the way they teach in the actual classroom. All checks for validity supported the validity of the instrument.

Question 4: Reform beliefs. "There is substantial evidence that teachers' beliefs about mathematics impact their teaching of mathematics" (Hart, 2002, p. 4). As novice teachers, the participants' knowledge of the mathematical reform movement and its recommendations for effective teaching was limited. As a regular part of their mathematic methods course work, all of the members of the Master's Cohort were assigned readings and took part in discussions regarding the reform movement in mathematics education, particularly the role of discourse in the mathematics classroom. They also learned to evaluate and create mathematical tasks using The Mathematical Tasks Framework (Stein et al., 2000).

It was hypothesized that teachers' beliefs would change over the course of the semester to be more aligned with reform beliefs, and this change would be more dramatic for the video club group. This was predicted because many teachers have not had many experiences with mathematical reform methods of teaching and learning, and the video club would provide them with both practical experiences with reform methods and a forum to socially reflect on them. Data to test this hypothesis were drawn from the self-report survey *Elementary Teacher's Commitment to Mathematical Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003).

The developers of this survey tested the reliability of their instrument after three implementations. Initially the instrument was deemed reliable with a reliability coefficient of $\propto = .88$. The subsequent administrations resulted in a reliability coefficient of $\propto = .81$, rating $M = 4.48$, $SD = 0.53$, and a reliability coefficient of $\propto = .81$, rating $M = 4.64$, $SD = 0.20$. The developers of the instrument also tested it for validity. They tested for face and content validity by having math specialists and teachers review all items.

They tested for concurrent and construct validity by observing a small number of teachers who scored high at the time the survey was administered to determine if the way they teach correlates with their answers on the survey. Predictive validity was demonstrated by showing that the survey scores correlated with a mandated performance assessment. All tests for validity supported the validity of the instrument.

Results

Question 1: Video club discourse

The focus of this element of the study was video club teacher-to-teacher discourse; thus, each of the video club sessions was videotaped, transcribed, and coded using Transana (2005) software. Table 6 and Figure 4 show the percentage of discourse coded for each coding category for all six video club sessions using Sherin and Han's (2004) modified coding scheme. Based on the percentage of each coding category across all video club sessions, no consistent change in teacher discourse was found over the six video club sessions. Novice teachers' discourse during the video club sessions was consistently coded as focusing on General Pedagogy across all video sessions. In addition, considerable percentage of total discourse was coded as Discourse Pedagogy, Classroom Management Pedagogy, and Student Conception in many of the video club sessions. Generally, the discourse categories of Classroom Discourse, Mathematics, and Other represented relatively lower percentage of discourse across all video sessions, except Video Club 4 which had 13% conversational turns coded as Classroom Discourse, and Video Club 3 which had 19% conversational turns coded as Other.

Table 6

Percentage of Video Club Discourse

Video Club Sessions	Discourse Pedagogy	Classroom Discourse	Student Conception	General Pedagogy	Classroom Management Pedagogy	Mathematics	Other
Video Club 1	15%	9%	25%	32%	2%	7%	10%
Video Club 2	6%	1%	20%	28%	37%	0%	8%
Video Club 3	20%	7%	16%	12%	27%	0%	19%
Video Club 4	19%	13%	6%	30%	22%	3%	7%
Video Club 5	13%	1%	14%	58%	7%	0%	7%
Video Club 6	19%	8%	18%	28%	18%	0%	8%
Total Average	15%	6%	17%	31%	19%	2%	10%

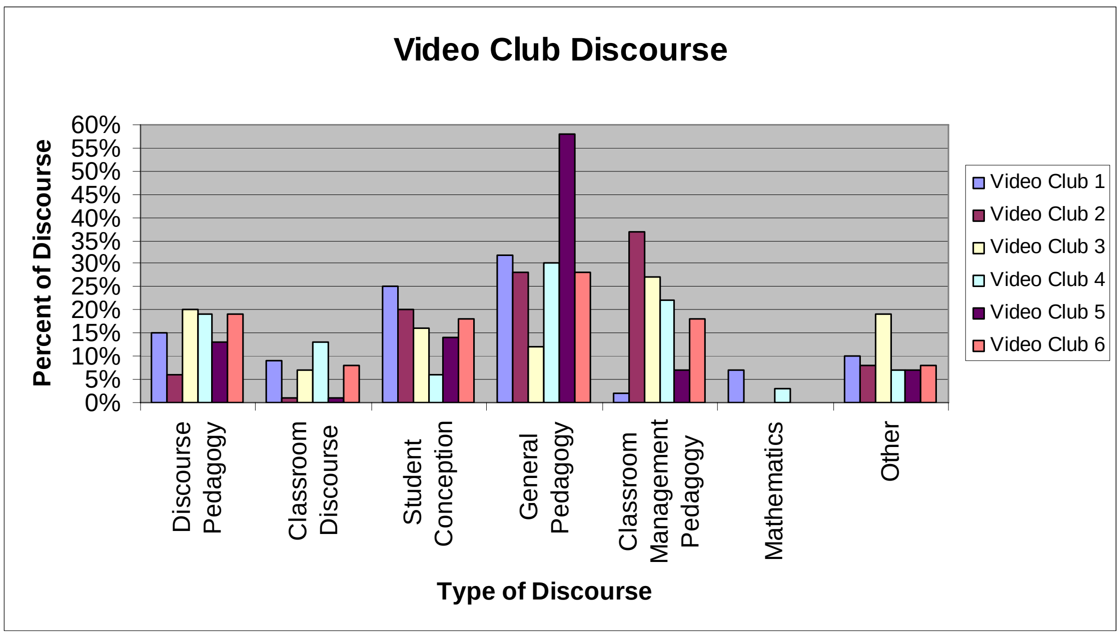

Figure 4. Video club discourse across all coding categories.

Video club discourse underwent further fine-grained analysis using an iterative process that employed constant comparative analysis methods to develop themes from the data. This analysis revealed two trends: (a) although discourse about pedagogy-related topics were the main subject across all video club sessions, *how* novice teachers talked about pedagogy did change; and (b) video clubs offered novice teachers three affordances that may enhance their ability to implement mathematical discourse within their classroom. Pseudonyms were used for all participants reported in this study.

Changes in pedagogy discourse. In the early sessions (Video clubs 1-3), pedagogical discourse (General, Discourse, and Classroom Management) involved teachers struggling with *how* to implement mathematical discourse communities within their classroom. In the later sessions (Video clubs 4-6), that same pedagogy discourse began to include teachers' questioning pedagogical goals, as well as questioning authority. One example of a teacher questioning a pedagogical goal happens during video club session 4:

> (Olivia speaking to the group) Um, yes, so that's one strategy that I've tried that's worked. Um, and, there's another question that I wanted to check in with everybody about and that was the. It seems like the students really, you know, get to talking to each other in like the small groups, like heads together part, you know with three or four people, but I kinda wonder about, um, the purpose of having this whole group discussion. They seem to be or it seems to be easier to get them to talk in the small groups, so I was kind of curious about what our goal is for like the whole group.

In this quote, the teacher questions the value of whole-class discourse when she is able to easily orchestrate small group discussions. In prior video club sessions the effectiveness of whole-class discussions was never questioned, in general; teachers simply described efforts to implement it, described what went well and what did not, and asked for alternative suggestions for improvements. Similarly, later in the same video club session another teacher questioned another goal related to whole-class discourse:

> (Lauren to group) But that's a good point though. I mean especially like, in these charts. I haven't done mine with my class yet, but I don't know. I think you always have to have those people who are just maybe internal thinkers and they might not express out loud very well or might be uncomfortable and as teachers is it our goal to make them public speakers at this point. I don't know.

This quote was in response to a teacher’s frustration with a student who was “shy” and would not participate in whole-class discussions. This statement served as a launching pad for a debate among video club members about whether all students should be forced or trained (depending on your view point) to participate in whole-class discussions. It also served as a catalyst for teachers to formulate and refine their beliefs about whole-class discourse.

Video club discourse also changed to include questioning of authority. In the following two examples from video club session 5 the authority being questioned is that of their school’s administration. The first conversation regards finding the time to do student-centered mathematical activities.

> (Shelly to group) You know you will have a great idea or a great thought of a, um, something and then when you look at it and you say, oh ok we have to be on this by Friday.
>
> (Olivia to Shelly) Or what happens?
>
> (Shelly to Olivia after a long pause) Um, I don't know. I've never not been there by Friday.

Olivia’s question, “Or what happens?”, is not meant as a request for more information, but rather is meant for Shelly to consider if there are real consequences to not staying aligned with the pacing chart, and if there are not consequences, maybe she could do what she felt was best as opposed to faithfully following a mandated pacing chart. Later in the same session, Dorrissa shares that she has decided to reject authority by not following mandated lesson plans:

> (Dorissa to group) It's also what you have to do though because you can't, I mean I know I can't, but I'll probably, you know I would probably get in trouble for what I am doing now. But. I mean we're supposed to be doing right now greater than and less than using, um, place 1s and 10s mats. And we haven't even gone into groups of 10 or place value or anything like

> that. That comes after. So I'm like, wait, stop. I totally stopped them in the middle of my lesson today. I was like this is ridiculous. I was like guys we are gonna go back, where we should be, a chapter. Even though the grade level said to skip that and then come back to it. I'm like I'm sorry if it throws off you know when I'm supposed to give them on their test, but I'm not gonna try to teach them greater than and less than when we haven't even understood groups of 10 yet.

This quote was in response to a discussion about the ways video club members plan and organize their lessons. Whether video club members were making the decision to question authority in their schools during the earlier video club session or not, they did not share this with group members until later video club sessions. Although the frequency of questioning goals and authority did not occur in great quantities in the latter video club sessions (4-6), it did not occur at all in the earlier video club sessions (1-3).

Analysis of discourse themes. In addition to showing how teacher discourse changed over the six video club sessions, the comparative analysis uncovered three themes of the affordances video club have for novice teachers in their attempts to implement reform initiatives. The three themes that emerged from the data are: Noticing, Encouragement, and Alternatives.

Affording Noticing. The video club in this study seemed to afford members the time and tools for noticing aspects of their pedagogy that they otherwise would not have noticed. The third-person stance of viewing oneself on tape affords teachers the facility to examine what is effective and what needs improvement in their teaching. In the following example Shelly views her video in preparation for the video club meeting and notices that one of her students can perform well orally in spite of low achievement on written work. She uses what she noticed to inquire about accommodations for this student.

> (Shelly to group) They allowed me to use his test scores, um, to modify. I found out like, I think it was like Friday after school, I asked about if,

> because he got an F on his report card. If he can take that test and pass it orally can I give him, can I change his grade? Can I like give him a grade based on his oral exam? And they said yes and Ms. Sears gave me a modification sheet. All I have to do is make a note that, um, it was modified, and they even have a spot for that on the report card. He can have some success because if he is starting to get "F"s in first grade, how long before he stops trying? You know, so I just thought that was really neat. And that was something that I don't think, I mean eventually I would have picked it up, but having to do this and go through this just helped me get there faster, and I thought that was really good for him.

In this case, Shelly attributed the process of preparing to facilitate a video club session as aiding her ability to meet a student’s needs, and at a faster rate than she would have been able to accomplish on her own if she had not participated in the video club.

In the following two examples of noticing, the teachers are describing events that they found significant. In both cases, they reported that they didn’t believe that they would have been aware of the situation if it were not for examining video in preparation for the video club. In the first example, Lauren notices a student’s subtle participation.

> (Lauren to group) Yeah. And the first time I watched it, I was like man he's not even doing anything. But then if you go back and watch it a second time the two girls are in the middle saying something, "we just bought this," and he for a second he looks up and he writes down how much they have left, I guess what ever they've said. So he is really involved, which I noticed the second time, but the first time I watched it, I thought he wasn't doing anything. But, I guess for him that's his way.

Although video helps Lauren to notice a student’s reserved participation, this did not occur until she analyzed the video by watching it multiple times in order to prepare for presenting her video as the facilitator. Similarly, Kelly noticed community dynamics that she was not aware of prior to preparing for her video club facilitation.

> (Kelly to group) Yeah, usually they work, um, really well. I don't think I would have caught this unless it had been videotaped. And it, it took me by my 2nd or 3rd watching this, like, I was like wait a minute. I was like, no this didn't just happen. So it was kinda interesting.

After both of these examples, video club members offered alternative ideas and strategies to aid the teachers in their improvement of their pedagogy.

In the following example, Jim's noticing was prompted by diagramming the flow of discourse in his classroom as a part of the video club procedure.

> (Jim to group) Their questions didn't really have to do with math after that, but we kept going on. But um, that brings up an interesting point to me, as you can see there are about three students involved in that discussion and I was able to figure that out after I uh [Jim picks diagram and gestures to group with it and puts it down] mapped it . What do you do, I mean, I was talking to Mary about this earlier, what do you do with the rest or the class when they are just going at this discussion? And nobody else doesn't really care. Everybody is not involved.

Although Jim was aware that he did not have full class participation in his classroom discussions, it was not until he diagrammed it that he realized just how few students were involved in the discussion. Whole-group discussions can mislead teachers because as long as some of the students are involved in a discussion it can appear to be functioning. The video club process in this study seemed to offer teachers tools for noticing and evaluating the effectiveness of classroom discourse.

Affording encouragement. During the video club sessions, the facilitating teacher typically led the teacher-to-teacher discourse by first describing the lesson that was videotaped and explaining pedagogical decisions in the creation and implementation of the lesson. Inevitably, the facilitating teacher would negatively self-critique some aspect of the lesson that he or she noticed. This critique was almost always followed by the other video club members pointing out positive aspects of the lesson which seemed to serve as encouragement. Encouragement means giving teachers affirmations, support, or a positive outlook on their ability to be an effective teacher. This happened frequently across the six video club sessions.

During the first video club session, Jim is encouraged to see positive aspects of his lesson in this exchange:

> (Jim stops video clip and says to the group) As you can see right there they are not exactly doing, getting to the meat of what I wanted. They are not really understanding why, or maybe it's something that's with my teaching.
>
> (Lauren to Jim) I thought it was good [others agreeing].
>
> (Shelly to Jim) Yes they were doing it.
>
> (Lauren to Jim) Yeah
>
> (Jim to group) Yeah but they are saying four without knowing what that four meant.
>
> (Shelly to Jim) But she said we measured this thing over here and that thing over there.
>
> (Jim to group) Well ok, well then alright. I like your ears [laughter].

The positive affirmations by Jim's fellow video club members seemed to serve the purpose of encouraging him not to give up and to prime him for the acceptance of alternative approaches that were offered immediately following this exchange. Throughout all six video club sessions, encouragements like this were usually followed by the video club members offering alternative ideas and strategies to help the facilitating member improve his or her pedagogy. In this way, encouragements did not seem to be a non-critical acceptance of ineffective facets of a teacher's pedagogy, but rather a genuine way to discern effective actions from less effective actions, and at the same time it prepared the recipient of the encouragement to hear alternative approaches without being defensive.

In another example, after Shelly is critical of herself for not having had the paper for the activity folded in thirds prior to the hands-on, problem-solving lesson in which she had time constraints, Lauren responds to Shelly with the following encouragement:

> (Lauren to Shelly) I think that will come with time. I mean look at the one lesson that you. We didn't even say anything, and you were like I noticed this and I noticed this, and this, and the next time you do it, you'll have those 3 folded papers prepared. You'll have all of this and it will be easier. Cause you will be like here's your paper, get to work and they will do it, you know.

Lauren used this encouragement not only to point out Shelly's ability to notice, but as a way to communicate that teaching is a learning process, and you cannot be expected to know all the answers. She then projects that in the future her current negative experience will allow her to be more effective.

Although encouragements most often followed negative self-critiques, this was not always the case. In the following example, Shelly offer encouragement to Dorissa without being prompted:

> (Shelly to group) One thing that I wanted to say about Denise's, um, little diagram. This was so awesome. When I did mine it was like everything was so much teacher talk whole group or to the little mini-groups. And even when, even though they were working in groups, their talk was back to me or back to an adult in the room. Um, I think that if we were to redo that now they probably will be talking more to each other. But, um, I was really surprised when I saw mine and how you know it wasn't all this interaction like this kids are really talking to each other, so that's really good. That mean's that even you thought that this was something that you don't get to do that often there, there is something that they're doing where they've developed some type of classroom community where they feel comfortable talking to each other. So that's really good.

This statement seemed to serve to encourage Dorissa, as well as Shelly herself. In examining Dorissa's discourse flow diagram, Shelly attempts to relieve Dorrisa's concern about not having the time to implement whole-class discussions as often as she would like. She points out that what Dorissa is able to do is still worthwhile, and thus should be continued. She also uses Dorissa’s discourse flow diagram to reflect on her own progress in creating a mathematical discourse community within her classroom. Video club’s affordance of encouragement, as illustrated in these examples, may help teachers to continue to try reform approaches even in the face of difficulties.

Affording alternative ideas and strategies. Finally, the video club examined in this study afforded a space for members to offer alternative ideas and strategies that were contextually relevant to the teachers’ practice. The following example from video club session 5 illustrates a teacher explaining a struggle she was having with implementing a mathematical discourse community in her classroom, followed by the researcher offering encouragement, followed by another teacher offering an alternative strategy through the use of a resource.

> (Olivia to the Group) Um, I'm experimenting again with the seating chart. I've tried the U shape, in chairs, you know for a whole group discussion. It was terrible. I will never do it again. (group laughs) so I am going to try um.
>
> (Researcher to group) But what I like about with what she tried was, she saw where there was a specific, where she had brought them so far with the discussion. Maybe if I tweak it this way ...well every time you tweak it it's not gonna be the perfect tweak.
>
> (Dorissa to Olivia) This book (holds up book) has some really interesting. It's active learning. I particularly, I think I'm gonna try this one (points to page in book). It's like groups, but it's like more for a U shaped group. Like it's has all different kinds of like seating, through it. But I especially like that one. If you want to look at it real quick (hands book to Olivia).

This conversation helped scaffold the teacher’s persistence in trying new tactics. Without such scaffolding, teachers’ options may become limited. This is especially important when trying to implement reform efforts, because most novice teachers neither experienced this approach to learning mathematics as a student nor in their student-teaching field placements.

The next example is in response to Jim requesting ideas from the video club group to help him with engaging more students into whole-class discussion.

> (Kelly to Jim) I found something um that we do in our writing, cause we have authors chair at the end, and after every um author shares their work the students have to say three things, I heard you say, I suggest, no ... I heard you say, I like and I suggest. And you, I mean you could probably do that with math too, um is to get more students involved. Say, like with Mary, like if I'm gonna call on you you need to be ready to say I heard you say, I suggest, I have a question about, why did you do this? I mean something, make it more math, but, so if you see somebody or a group that's kinda going off task, you can just say remember I'm going to call on you, and you have to have some questions ready to ask the group, and then wait a few more seconds, let it go a little bit more, and then call on one of those people, one of those students, and that would be their cue to like get back into the discussion.
>
> (Jim to Kelly) Yeah.
>
> (Olivia to Kelly) That's a good idea. What were the last two things that I heard you say?

Many of the video club members used this alternative strategy as a way to initially train their students to listen and engage in discourse. In later video club sessions, Kelly offered further recommendations about how she helped reduce the structure of this strategy so that students engaged in more natural mathematical discourse free of specific prompts. Video clubs' affordance of alternative ideas and strategies may also help teachers build an identity as professionals capable of solving their own professional dilemmas, as opposed to helpless technicians in need of being fixed by an outside authority.

As illustrated above, qualitative analysis showed that although novice teachers' discourse remained concentrated on pedagogical issues, they did change how they talked about pedagogy by including the questioning of goals and authority in later video club sessions. In addition, this analysis revealed three affordances that being a video club member may offer: noticing, encouragement, and alternative ideas and strategies.

Question 2: Student mathematical discourse community

Discourse between and among the case study teacher and her students was studied by diagramming the flow of classroom discourse during each of the six videotaped lessons. Figure 5 and Figure 6 show the flow of classroom discourse at the beginning of the study and at the end of the study, respectively. Each arrow represents conversational turns (1 to 14 conversational turns in lesson 1 and 1 to 25 conversational turns in lesson 6) in the discourse, with dashed-lined arrows representing 1 to 2 conversational turns, solid thin-lined arrows representing 3 to 5 conversational turns, and thick-lined arrows representing 6 or more conversational turns. Arrows inside the circle represent on-task discourse and arrows outside the circle represent off-task conversational turns. Thus, the figure shows density of turns and directionality. By agreement with the school system in which the case study was conducted, individual student information would not be tracked over time. Thus, the student numbers used in Figure 5 and Figure 6 do not represent the same student each time, but represent different students' contributions for each particular lesson. Table 7 shows the salient features of the discourse across all six videotaped sessions. Because the duration of the student discourse session varied widely (lasting from 6 minutes to 21 minutes) data are reported in this table per minute so that video club sessions can be compared. The trend in mathematical discourse over the six videotaped lessons is reflected by the number of conversational turns per minute (Figure 7), total student turns per minute (Figure 8), student-to-whole class turns per minute (Figure 9), and student initiated turns per minute (Figure 10) increased. Total teacher turns and teacher-to-student turns per minute remained relatively constant, while on-task student-to-student turns per minute fluctuated, and off-task student-to-student turns per minute decreased.

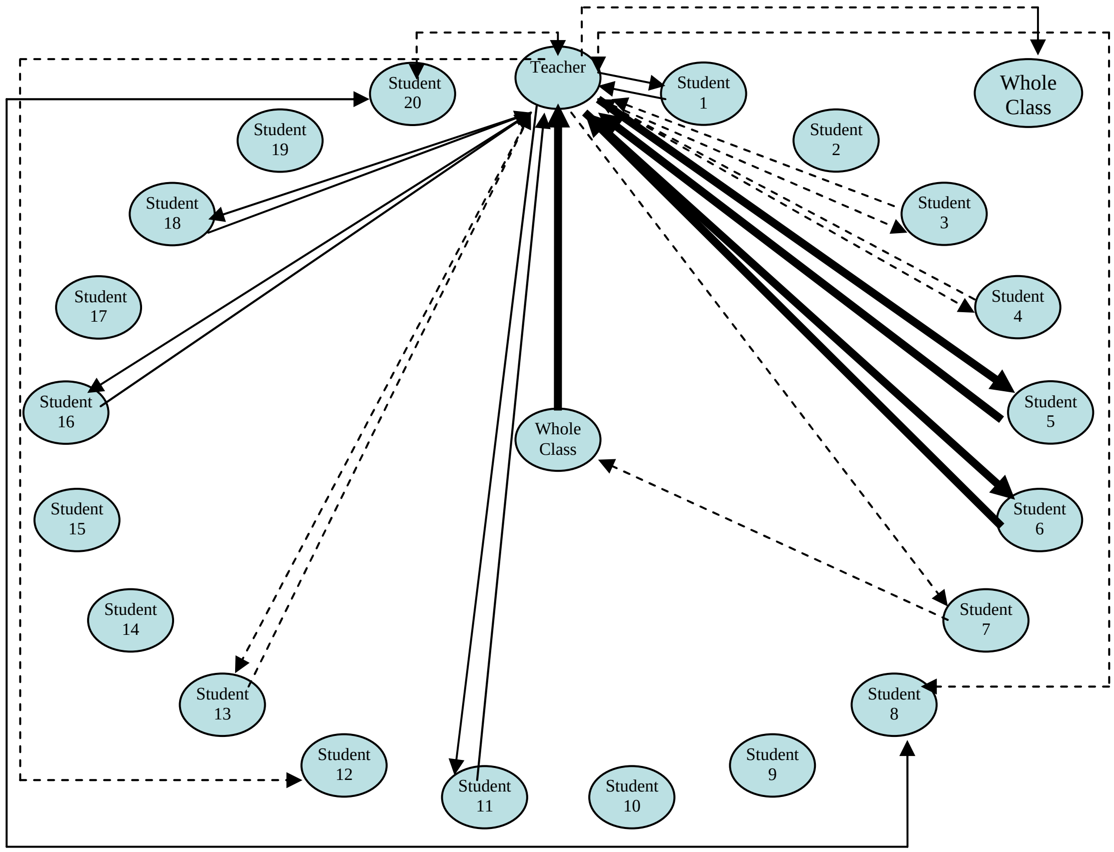

Figure 5. Discourse flow diagram for lesson 1. Each arrow represents 1 to 14 conversational turns, with dashed-lined arrows representing 1 to 2 conversational turns, solid thin-lined arrows representing 3 to 5 conversational turns, and thick-lined arrows representing 6 or more conversational turns. Arrows inside the circle represent on-task discourse and arrows outside the circle represent off-task conversational turns.

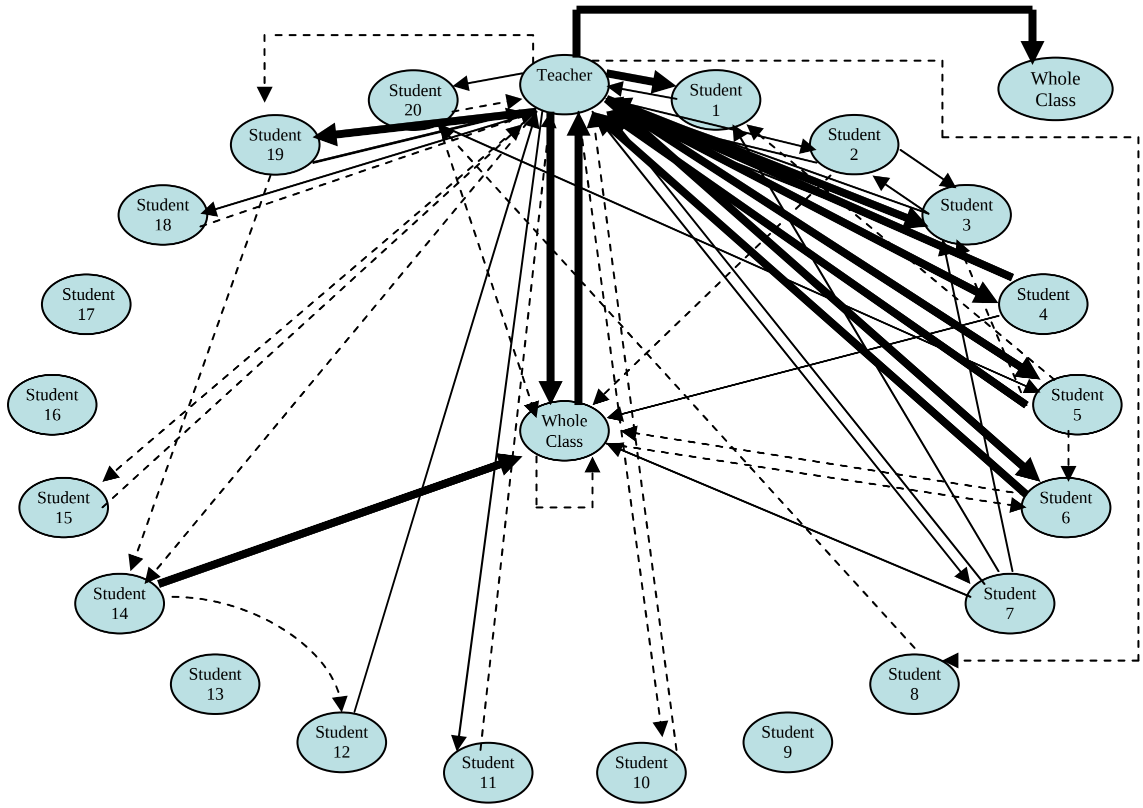

Figure 6. Discourse flow diagram for lesson 6. Each arrow represents 1 to 25 conversational turns, with dashed-lined arrows representing 1 to 2 conversational turns, solid thin-lined arrows representing 3 to 5 conversational turns, and thick-lined arrows representing 6 or more conversational turns. Arrows inside the circle represent on-task discourse and arrows outside the circle represent off-task conversational turns.

Table 7

Classroom Mathematical Discourse Analysis of Flow Diagrams.

Video Lesson	Number of conversational turns	Time Duration in minutes	Number of turns per minute	Total Teacher Turns per minute	Total Student Turns per minute	Teacher to Student Turns per minute	On-Task Student to Student Turns per minute	Off-task Student to Student Turns per minute	Student Initiated Turns per minute	Student to Whole Class per minute
Lesson 1	103	11	9.36	5.18	4.18	8.00	0.00	0.82	0.09	0.09
Lesson 2	114	13	8.77	4.38	4.38	5.77	1.31	0.08	0.46	0.38
Lesson 3	192	21	9.14	5.71	3.43	7.48	0.57	0.00	0.52	0.19
Lesson 4	49	6	8.17	5.00	3.17	6.17	0.00	0.00	0.50	0.17
Lesson 5	181	17	10.65	6.18	4.47	8.18	0.35	0.00	0.94	0.41
Lesson 6	198	16	12.38	6.00	6.38	8.81	0.94	0.00	2.75	1.06

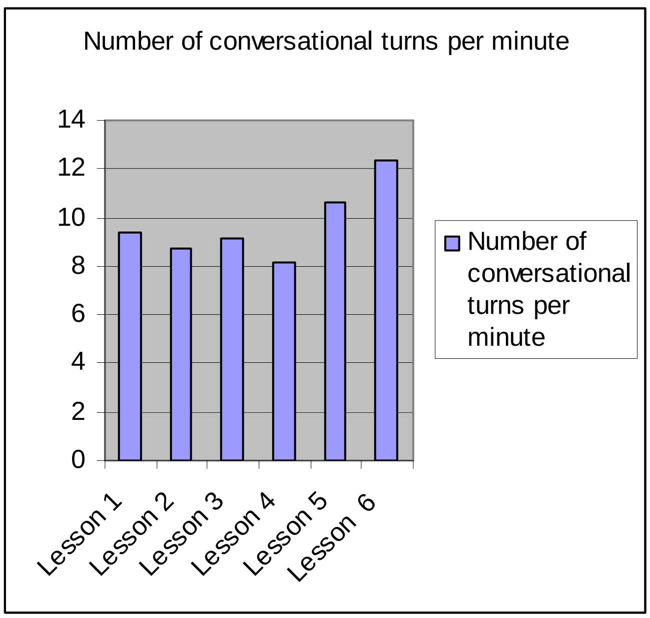

Figure 7. Total conversational turns per minute.

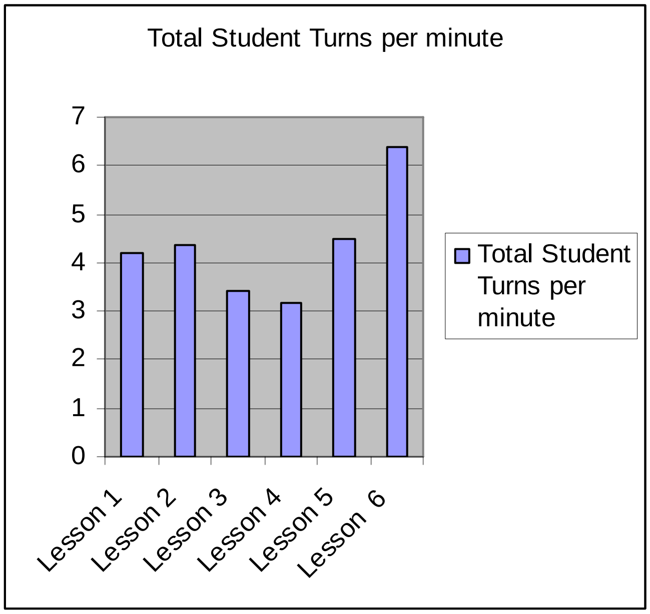

Figure 8. Total student conversational turns per minute.

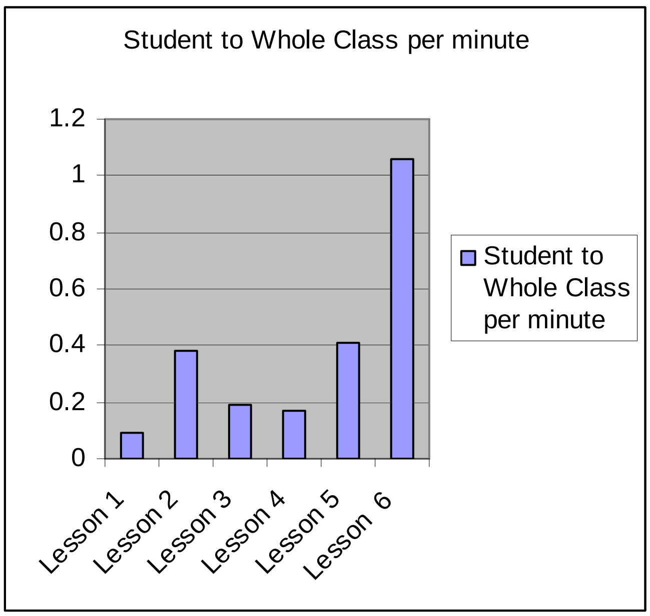

Figure 9. Student-to-whole class conversational turns per minute.

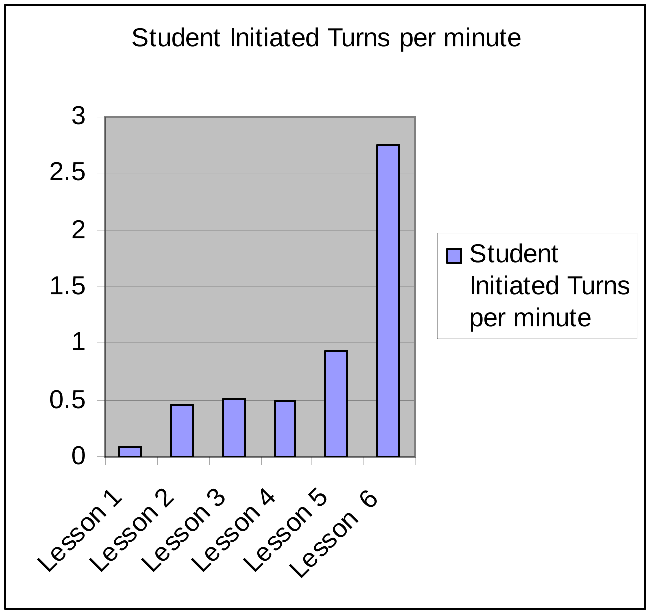

Figure 10. Student initiated conversational turns per minute.

The case study classroom discourse did change over the six lessons. These changes reflected a shift from classroom discourse that was more vertical in nature to one that was increasingly horizontal in nature. In addition, student initiation of discourse increased, particularly in the final lesson.

Question 3: Specialized content knowledge

The difference in pretest-to-posttest change in specialized content knowledge between the cohort members in traditional coaching and the cohort members in the video club was tested using the *Content Knowledge for Teaching Mathematics Survey* (Ball et al., 2002) by first converting individual total raw scores for each construct (number and operations content knowledge (NOCK), patterns, function, and algebra content knowledge (PFACK), and number and operations knowledge of student and content (NOKSC) into IRT scores. Ball et al. provided an IRT conversion table for raw scores. Because IRT equated scale score (which are given in standardized scores with a standard deviation of 1 and a mean of 0) were used, the difference in means between pretest and posttest show the change in standard deviation. Ball et al. (2002) state that "in most moderate sized studies an effect size of .3 standard deviation units will often be significant. Effect sizes of over .5 standard deviations are moderate and almost always significant. And effect sizes of over .75 are substantial and large" (p. 3). Next, the group posttest means were compared using three one-way Analyses of Covariance (ANCOVA), one analysis for each construct (NOCK, PFACK, and NOKSC), controlling for the pretest scores.

As shown in Table 8, there was no statistically significant group difference found for change in number and operations content knowledge (NOCK), $F(1, 13) = .30$, $p = .59$, $eta^2 = .02$; and patterns, function, and algebra content knowledge (PFACK), $F(1, 13) = .45$, $p = .51$, $eta^2 = .03$. However, a marginally significant difference in favor of the video club group was found for change in number and operations knowledge of student and content (NOKSC), $F(1, 13) = 3.54$, $p = .083$, $eta^2 = .21$. Thus, teachers in the video club group showed greater change in specialized teacher knowledge of students' thinking about mathematics to a marginally significant degree compared to teachers in the traditional coaching group.

Table 8.

Analyses of Covariance for Specialized Content Knowledge.

Construct	Group	Pretest IRT *M*	Posttest IRT *M*	SS	df	MS	F	p	Eta Squared
NOCK	Video Club Group	-.035	.300	8.88	1	.68	.30	.594	.02
	Traditional Coaching Group	-.083	.024						
PFACK	Video Club Group	-.524	.134	3.97	1	.31	.45	.513	.03
	Traditional Coaching Group	-.715	-.169						
NOKSC	Video Club Group	-.105	.418	4.74	1	.36	3.54	.083	.21
	Traditional Coaching Group	-.013	-.130						

It was also of interest to examine any change over time in specialized content knowledge for the total sample, that is, based on being a member of the Master's cohort mathematics methods course. To examine this effect, a one-way ANOVA for repeated measures was conducted for the total sample for each of the *Content Knowledge for Teaching Mathematics Survey* constructs (NOCK, PFACK, and NOKSC). The analysis revealed no significant difference for NOCK and NOKSC, $F(1,15) = .96$, $p = .343$, $eta^2 = .06$ and $F(1,15) = .44$, $p = .519$, $eta^2 = .03$ respectively. However, the analysis found significantly different means between pretest ($M = -.64381$, SD = .77) and posttest ($M = -.05544$, SD = .70) for the PFACK construct, $F(1,15) = 14.88$, $p = .002$, $eta^2 = .50$. This indicates that the Master's cohort mathematics methods course was successful at enhancing teachers' understanding of patterns, function, and algebra content knowledge.

In summary, teachers in the video club group showed greater change in specialized teacher knowledge of students' thinking about mathematics to a marginally significant degree compared to teachers in the traditional coaching group, and the cohort group as a whole improved significantly in their understanding of patterns, functions and algebra content knowledge.

Question 4: Reform beliefs

The difference in reform beliefs between the cohort members in traditional coaching and the cohort members in the video club was tested using a one-way Analysis of the Covariance ANCOVA, comparing the posttest scores of the two groups, controlling for their pretest scores using data from the *Elementary Teacher's Commitment to Mathematical Education Reform* (Ross, McDougall, Hogaboam-Gray, & LeSage, 2003). Groups reform beliefs were not significantly different, $F(1,13) = 1.35$, $p = .266$, $eta^2 = .09$.

However, it is also of interest to examine any change in reform beliefs based on being a member of the Master's cohort mathematics methods course. To examine this effect, a one-way ANOVA for repeated measures was conducted on the total sample. Over the course of the mathematics methods course, reform beliefs for the cohort changed significantly, $F(1,15) = 28..187$, $p < .001$, $eta^2 = .65$ from a pretest $M = 4.31$ and $SD = .34$ to a posttest $M = 4.78$ and $SD = .32$ on a six-point scale. This indicates that although there were no group differences, the Master's cohort mathematics methods course was successful in enhancing teachers' beliefs in the direction more consistent with reform initiatives.

Discussion

Given that situated learning theory suggests that reflection, particularly collective reflection, is necessary for professional development (Borko & Putnam, 1998; Lave & Wenger, 1991; Owens, 2002; Schön, 1983), the present study examined the use of teacher video clubs as a space in which novice teachers can publicly and collectively reflect on their pedagogy. Specifically, this study examined how novice teachers talked about teaching and learning in the context of a video club with a focus on the NCTM mathematical reform efforts. In addition, this study explored whether being a video club member was related to one teacher's ability to orchestrate a mathematical discourse community in an elementary classroom. The study also examined the effect of the video club on members' specialized content knowledge and reform beliefs.

Even though video club teacher discourse in the present study did not change in the way discourse did in Sherin and Han's (2004) study (from initial concentration of discourse on teacher action to later concentration of student concepts and discourse), it did change in other ways. This study revealed that although teachers' discourse continued to center on issues of pedagogy throughout all video club sessions, teachers began to question goals and authority in regards to pedagogical issues in later video club sessions. It is reasoned that to be active participants in video clubs requires teachers to collectively reflect on teaching and learning, and as a part of this process teachers moved from questioning *how* to *why*. The *how* came first because teachers addressed their immediate needs for preparing and implementing lessons involving student discourse for the first time. However, by exploring how to implement reform initiatives, teachers began to understand their practice in a way that allowed them to ask *why*.

One possible explanation for the difference between these findings and those of Sherin and Han is the fact that the teachers in the present study were all novice first-year elementary school teachers. Sherin and Han (2004) studied veteran middle school teachers with four to twenty-eight years of experience. As novice teachers in the fall of the first year of teaching, the teachers in this study were negotiating the fundamentals of teachers' practice (Killeavy, 2006). A second explanation for the difference in discourse analysis results may be the relative short timeline of this study. Sherin and Han's video club met ten times over an academic school year, whereas this study's video club met six times over one semester. Examination of teacher-to-teacher discourse of novice teachers involved in video club discourse over a longer period of time may show similar changes in discourse to that of Sherin and Han's study.

In the present study, analysis of teacher-to-teacher discourse revealed that the video club provided teachers the tools for noticing, the support structure for encouragements, and the resources for providing alternative ideas and strategies. This study also showed that noticing, encouraging, and offering alternative ideas and strategies often unfolded in discourse in that order over the discussion of a topic. They worked together to create a safe environment for teachers to share their teaching publicly and receive alternative approaches without feeling defensive. The facilitating teacher typically led the teacher-to-teacher discourse by first describing the lesson that was videotaped and explaining pedagogical decisions in the creation and implementation of the lesson. Inevitably, the facilitating teacher would negatively self-critique some aspect of the lesson that he or she noticed. This critique was almost always followed by the other video club members pointing out positive aspects of the lesson to serve as encouragement, such as the giving of affirmations, support, or a positive outlook on the facilitator's ability to be an effective teacher. This happened frequently across the six video club sessions. In this regard, Dorrisa reflects on the video club experience by stating:

> Just the support of having someone listen without judgment is very comforting. I felt that the video club was a safe place to talk about what was going on. I also felt that if I was having problems, that talking about them not only let me hear ideas from other teachers, but also gave me insight on how to solve problems.

Across all six video club sessions noticing was highly evident, which is similar to the findings of other researchers (Sherin & van Es, 2005; van Es & Sherin, 2002). In this study, noticing was perhaps most valuable for the facilitating teacher for whom it was necessary to micro-analyze her or his teaching and student learning in order to facilitate a video club session. However, all video club members reported in their reflections that the ongoing process of being a video club member helped them improve their pedagogy. For example, Olivia stated in her final reflection:

> Being a member of the video club had many positive effects on my teaching. I always left our meetings with at least one new strategy that I was ready to try out on my class the following day. Over the course of our meetings I took suggestions and advice from all participants.

The affordances of being a video club member seemed to give the teachers the tools and stamina for the ongoing efforts to implement reform initiatives such as student discourse communities.

This study also examined how taking part in a video club may have related to one novice teacher’s classroom discourse. Over the course of the video club sessions, one teacher was followed to see if her classroom discourse changed over the same time period that she was involved in the video club. The result of the mathematical discourse diagram analysis showed that her classroom discourse became more complex over time as shown by the increase in the number of conversational turns per minute, total student turns per minute, on-task student-to-student turns per minute, student initiated turns per minute, and student-to-whole class turns per minute over the six video sessions. The increase in student initiation implies that students are active participants in the discourse community. This can lead to students listening to each other, evaluating each other, and taking responsibility for their own learning. In a reflection about video club participation, this teacher attributes the change in her classroom discourse to strategies she learned from participating in the video club and from ongoing reflection on her pedagogy that being a video club member entailed. In addition, she attributes her success to the support and advice she received from fellow video club members. She states: “I never felt uncomfortable asking for advice or taking advice from my colleagues. I also felt confident trying their suggestions because I knew that they were in the classroom just like me, trying to work on their classroom discourse.”

It also was hypothesized that teachers in the video club group would become more knowledgeable about mathematics and how to teach it compared to other teachers who were a part of the same mathematics methods cohort but were not in the video club. Although the video club group out-performed them on all three constructs, they did not significantly out-perform the traditional coaching group on construct (a) number and operations content knowledge (NOCK) and (b) patterns, function, and algebra content knowledge (PFACK). However, the video club participants’ performance was greater to a marginally significant degree over the traditional coaching group for the construct (c) number and operations knowledge of student and content (NOKSC). This is important because this is the one construct that taps “the knowledge teachers have about students’ learning of content—typical solution strategies, common errors, what problems are easy or difficult etc” (Hill, 2004, p. 1). It is reasoned that this difference is a result of video club members’ collective reflection on student reasoning and ways to improve their pedagogy, as they viewed students engaged in mathematical discourse. The use of video contextualized this conversation, allowing for specific analysis of student action, which may have led to a better understanding of both students and content.

Repeated measures showed that the cohort as a whole significantly improved on construct (c) patterns, function, and algebra content knowledge (PFACK). As novice teachers certified in elementary education, their knowledge of Patterns, Functions and Algebra may be initially limited. These topic areas were often the focus of problem solving activities of the cohort's mathematics methods course, and may have led to a better understanding of this construct.

Reform initiatives like those recommended by NCTM have not been implemented in significant ways in elementary classrooms (National Center for Educational Statistics, 1999; Stigler and Hiebert, 1998; The National Academy of Science, 1997). One possible explanation Stigler and Hiebert (1998) give for this is that "teaching is a cultural activity" where cultural scripts for teaching are both tacit and tenacious. They illustrate how widely shared these scripts are by pointing out that even young children can "play" school before they ever attend any formal schooling. As such, video clubs may offer a space where teachers can collectively reflect on reform initiatives and in doing so question goals of reform and discover methods for implementation. In this way, video clubs may give teachers a space to test out new approaches, collectedly analyze these approaches, and collectively problem solve by developing alternative approaches in order to effectively implement reform efforts. Thus, video clubs may provide the rich interactions necessary to change deeply-held cultural notions about schooling.

Video clubs as a form of professional development may also offer scalability for changing the cultural activity of teaching. Although the researcher was a participant observer, teachers as facilitators had the most influence on the discourse during the video club session. The facilitator chose the video clip based on what she or he noticed, and guided the discourse during the video club session. This study's findings may reflect what would happen if groups of teachers formed their own video club groups in the school setting away from a researcher's control, a situation necessary for scalability of reform efforts.

Although it was not directly analyzed in this study, some of the facilitating video club teachers seemed to engage the rest of the members in more discourse than other facilitators. In an effort to study a scalable approach to video clubs, the present study involved teachers selecting the video clips to share with the group based on what they noticed. In previous studies the researcher selected the video clips to be shown at video club sessions. Since the present study was conducted, Sherin (2006) developed a rubric for clip selection. The rubric is based on research about what elements of a video clip produce the most discourse. This rubric as a guideline may be helpful in future studies that examine teachers choosing their own video clips to share with the group.

Future research is needed to look at the long-term effects of video clubs on teacher practice. The present study examined one video club group over one semester. Change in teacher-to-teacher discourse and classroom mathematical discourse only began to change in important ways at the conclusion of the study. Ongoing analysis is needed to determine whether these changes continued in a positive trajectory. In addition, the current study only examined change in student discourse, not change in student conceptual learning of mathematical concepts. The effects that teacher participation in video clubs have on students' learning of mathematical concepts is needed to advance the full understanding of the effects of teacher video clubs.

Conclusion

In the present study, two innovative educational environments were studied: teacher video clubs and student mathematical discourse communities. The findings of this mixed-methods study contribute to better the understanding of these innovations. First, this study examined a professional development method, video clubs, and the process of collective reflection that emerges from analysis of one's professional practice in a social setting. Specifically, this study showed how novice teachers' discourse during video clubs did and did not change, and what membership in a video club may afford teachers' development. Second, this study showed the effectiveness of video clubs as a professional development method for meeting the Professional Standards for Teaching Mathematics (1991). Specifically, video clubs offer the opportunity for teachers to learn how to create effective mathematical discourse communities within their classrooms by giving teachers their own professional community in which to reflect publicly and grow. This study advances prior research by using teacher video clubs as a tool for enhancing discourse among *novice* teachers who *facilitated* video club sessions in order to increase their ability to create *mathematical discourse communities* among their students. Video clubs have potential for not only aiding teachers in their ability to learn how to implement reform efforts, but they may also be a more scalable approach to training teachers to implement reform approaches to education.

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Appendix A

Elementary Teacher's Commitment to Mathematical Education Reform

(Ross, McDougall, Hogaboam-Gray, & LeSage, 2003)

Directions: Please rate each of the following statements as honestly as possible by circling the number that corresponds to the level of your agreement or disagreement.

Item	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1. I like to use math problems that can be solved in many ways.	1	2	3	4	5	6
2. I regularly have my students work through real-life problems that are of interest to them.	1	2	3	4	5	6
3. When two students solve the same math problem correctly using two different strategies, I have them share the steps they went through with each other.	1	2	3	4	5	6
4. I tend to integrate multiple strands of mathematics within a single unit.	1	2	3	4	5	6
5. I often learn from my students during math time because my students come up with ingenious ways of solving problems that I never thought of.	1	2	3	4	5	6
6. It is not very productive for students to work together during math time.	1	2	3	4	5	6
7. Every child in my room should feel that mathematics is something he/she can do.	1	2	3	4	5	6
8. I integrate math assessment into most math activities.	1	2	3	4	5	6

9. In my classes, students learn math best when they can work together to discover mathematical ideas.	1	2	3	4	5	6
10. I encourage students to use manipulatives to explain their mathematical ideas to other students.	1	2	3	4	5	6
11. When students are working on math problems, I put more emphasis on getting the correct answer than on the process followed.	1	2	3	4	5	6
12. Creating rubrics for math is a worthwhile assessment strategy	1	2	3	4	5	6
13. In my class it is just as important to learn data management and probability as it is to learn multiplication facts.	1	2	3	4	5	6
14. I don’t necessarily answer students’ math questions but rather let them puzzle things out for themselves.	1	2	3	4	5	6
15. A lot of things in math must simply be accepted as true and remembered.	1	2	3	4	5	6
16. I like my students to master basic mathematical operations before they tackle complex problems.	1	2	3	4	5	6
17. I teach students how to explain their mathematical ideas.	1	2	3	4	5	6
18. Using computers to solve math problems distracts students from learning basic math skills.	1	2	3	4	5	6
19. If students use calculators they won’t master the basic math skills they need to know.	1	2	3	4	5	6
20. You have to study math for a long time before you see how useful it is.	1	2	3	4	5	6

Appendix B

Content Knowledge for Teaching Mathematics

STUDY OF INSTRUCTIONAL IMPROVEMENT/ LEARNING MATHEMATICS FOR TEACHING

CONTENT KNOWLEDGE FOR TEACHING MATHEMATICS MEASURES (CKT-M MEASURES)

MATHEMATICS RELEASED ITEMS 2005

University of Michigan, Ann Arbor
610 E. University #1600
Ann Arbor, MI 48109-1259
(734) 647-5233
www.soe.umich.edu/lmt

 Measures development supported by NSF grants REC-9979873, REC- 0207649, EHR-0233456 & EHR 0335411, and by a subcontract to CPRE on Department of Education (DOE), Office of Educational Research and Improvement (OERI) award #R308A960003.

Study of Instructional Improvement/Learning Mathematics for Teaching

Content Knowledge for Teaching Mathematics Measures (CKT-M measures)
Released Items, 2005
ELEMENTARY CONTENT KNOWLEDGE ITEMS

1. Ms. Dominguez was working with a new textbook and she noticed that it gave more attention to the number 0 than her old book. She came across a page that asked students to determine if a few statements about 0 were true or false. Intrigued, she showed them to her sister who is also a teacher, and asked her what she thought.

Which statement(s) should the sisters select as being true? (Mark YES, NO, or I'M NOT SURE for each item below.)

	Yes	No	I'm not sure
a) 0 is an even number.	1	2	3
b) 0 is not really a number. It is a placeholder in writing big numbers.	1	2	3
c) The number 8 can be written as 008.	1	2	3

2. Imagine that you are working with your class on multiplying large numbers. Among your students' papers, you notice that some have displayed their work in the following ways:

Student A	Student B	Student C
35	35	35
x 25	x25	x 25
125	175	25
+75	+700	150
875	875	100
		+600
		875

Which of these students would you judge to be using a method that could be used to multiply any two whole numbers?

	Method would work for all whole numbers	Method would NOT work for all whole numbers	I'm not sure
a) Method A	1	2	3
b) Method B	1	2	3
c) Method C	1	2	3

3. Ms. Harris was working with her class on divisibility rules. She told her class that a number is divisible by 4 if and only if the last two digits of the number are divisible by 4. One of her students asked her why the rule for 4 worked. She asked the other students if they could come up with a reason, and several possible reasons were proposed. Which of the following statements comes closest to explaining the reason for the divisibility rule for 4? (Mark ONE answer.)

a) Four is an even number, and odd numbers are not divisible by even numbers.

b) The number 100 is divisible by 4 (and also 1000, 10,000, etc.).

c) Every other even number is divisible by 4, for example, 24 and 28 but not 26.

d) It only works when the sum of the last two digits is an even number.

4. Ms. Chambreaux's students are working on the following problem:

Is 371 a prime number?

As she walks around the room looking at their papers, she sees many different ways to solve this problem. Which solution method is correct? (Mark ONE answer.)

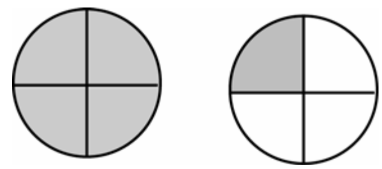
a) Check to see whether 371 is divisible by 2, 3, 4, 5, 6, 7, 8, or 9.

b) Break 371 into 3 and 71; they are both prime, so 371 must also be prime.

c) Check to see whether 371 is divisible by any prime number less than 20.

d) Break 371 into 37 and 1; they are both prime, so 371 must also be prime.

5. Mrs. Johnson thinks it is important to vary the whole when she teaches fractions. For example, she might use five dollars to be the whole, or ten students, or a single rectangle. On one particular day, she uses as the whole a picture of two pizzas. What fraction of the two pizzas is she illustrating below? (Mark ONE answer.)



a) 5/4

b) 5/3

c) 5/8

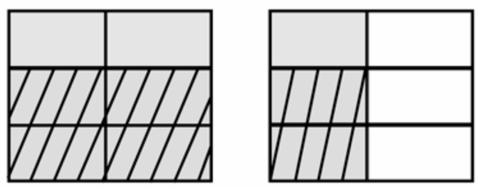
d) 1/4

6. At a professional development workshop, teachers were learning about different ways to represent multiplication of fractions problems. The leader also helped them to become aware of examples that do <u>not</u> represent multiplication of fractions appropriately.

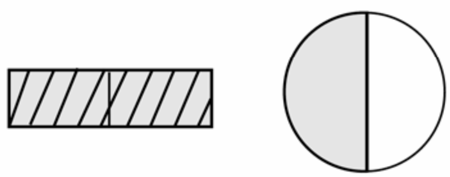
Which model below <u>cannot</u> be used to show that $1\frac{1}{2} \times \frac{2}{3} = 1$? (Mark ONE answer.)

A)

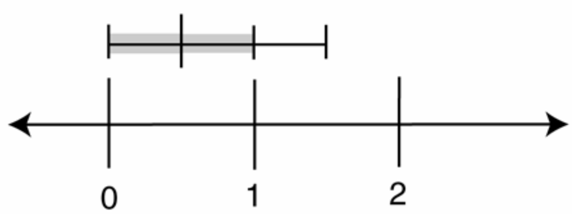
B)



C)



D)



7. Which of the following story problems could be used to illustrate $1\frac{1}{4}$ divided by $\frac{1}{2}$? (Mark YES, NO, or I'M NOT SURE for each possibility.)

	Yes	No	I'm not sure
a) You want to split $1\frac{1}{4}$ pies evenly between two families. How much should each family get?	1	2	3
b) You have $1.25 and may soon double your money. How much money would you end up with?	1	2	3
c) You are making some homemade taffy and the recipe calls for $1\frac{1}{4}$ cups of butter. How many sticks of butter (each stick = $\frac{1}{2}$ cup) will you need?	1	2	3

8. As Mr. Callahan was reviewing his students' work from the day's lesson on multiplication, he noticed that Todd had invented an algorithm that was different from the one taught in class. Todd's work looked like this:

$$\begin{array}{r} 983 \\ \underline{\times\, 6} \\ 488 \\ +\underline{5410} \\ 5898 \end{array}$$

What is Todd doing here? (Mark ONE answer.)

a) Todd is regrouping ("carrying") tens and ones, but his work does not record the regrouping.

b) Todd is using the traditional multiplication algorithm but working from left to right.

c) Todd has developed a method for keeping track of place value in the answer that is different from the conventional algorithm.

d) Todd is not doing anything systematic. He just got lucky – what he has done here will not work in most cases.

ELEMENTARY KNOWLEDGE OF STUDENTS AND CONTENT ITEMS

9. Mr. Garrett's students were working on strategies for finding the answers to multiplication problems. Which of the following strategies would you expect to see some elementary school students using to find the answer to 8 x 8? (Mark YES, NO, or I'M NOT SURE for each strategy.)

	Yes	No	I'm not sure
a) They might multiply 8 x 4 = 32 and then double that by doing 32 x 2 = 64.	1	2	3
b) They might multiply 10 x 10 = 100 and then subtract 36 to get 64.	1	2	3
c) They might multiply 8 x 10 = 80 and then subtract 8 x 2 from 80: 80 – 16 = 64.	1	2	3
d) They might multiply 8 x 5 = 40 and then count up by 8's: 48, 56, 64.	1	2	3

10. Students in Mr. Hayes' class have been working on putting decimals in order. Three students — Andy, Clara, and Keisha — presented 1.1, 12, 48, 102, 31.3, .676 as decimals ordered from least to greatest. What error are these students making? (Mark ONE answer.)

a) They are ignoring place value.

b) They are ignoring the decimal point.

c) They are guessing.

d) They have forgotten their numbers between 0 and 1.

e) They are making all of the above errors.

11. You are working individually with Bonny, and you ask her to count out 23 checkers, which she does successfully. You then ask her to show you how many checkers are represented by the 3 in 23, and she counts out 3 checkers. Then you ask her to show you how many checkers are represented by the 2 in 23, and she counts out 2 checkers. What problem is Bonny having here? (Mark ONE answer.)

a) Bonny doesn't know how large 23 is.

b) Bonny thinks that 2 and 20 are the same.

c) Bonny doesn't understand the meaning of the places in the numeral 23.

d) All of the above.

12. Mrs. Jackson is getting ready for the state assessment, and is planning mini-lessons for students focused on particular difficulties that they are having with adding columns of numbers. To target her instruction more effectively, she wants to work with groups of students who are making the same kind of error, so she looks at a recent quiz to see what they tend to do. She sees the following three student mistakes:

$$\text{I)}\quad \begin{array}{r} {}^{1} \\ 38 \\ 49 \\ +\ 65 \\ \hline 142 \end{array} \qquad\qquad \text{II)}\quad \begin{array}{r} {}^{1} \\ 45 \\ 37 \\ +\ 29 \\ \hline 101 \end{array} \qquad\qquad \text{III)}\quad \begin{array}{r} {}^{1} \\ 32 \\ 14 \\ +\ 19 \\ \hline 64 \end{array}$$

Which have the same kind of error? (Mark ONE answer.)

a) I and II

b) I and III

c) II and III

d) I, II, and III

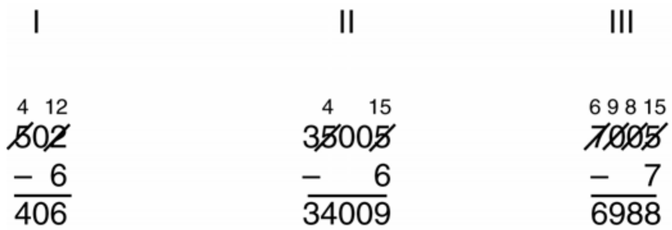
13. Ms. Walker's class was working on finding patterns on the 100's chart. A student, LaShantee, noticed an interesting pattern. She said that if you draw a plus sign like the one shown below, the sum of the numbers in the vertical line of the plus sign equals the sum of the numbers in the horizontal line of the plus sign (i.e., 22 + 32 + 42 = 31 + 32 + 33). Which of the following student explanations shows sufficient understanding of <u>why this is true</u> for all similar plus signs? (Mark YES, NO or I'M NOT SURE for each one.)

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

	Yes	No	I'm not sure
a) The average of the three vertical numbers equals the average of the three horizontal numbers.	1	2	3
b) Both pieces of the plus sign add up to 96.	1	2	3
c) No matter where the plus sign is, both pieces of the plus sign add up to three times the middle number.	1	2	3
d) The vertical numbers are 10 less and 10 more than the middle number.	1	2	3

14. Mrs. Jackson is getting ready for the state assessment, and is planning mini-lessons for students around particular difficulties that they are having with subtracting from large whole numbers. To target her instruction more effectively, she wants to work with groups of students who are making the same kind of

error, so she looks at a recent quiz to see what they tend to do. She sees the following three student mistakes:



Which have the same kind of error? (Mark ONE answer.)

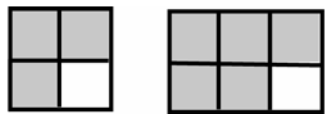
a) I and II

b) I and III

c) II and III

d) I, II, and III

15. Takeem's teacher asks him to make a drawing to compare $\frac{3}{4}$ and $\frac{5}{6}$. He draws the following:



and claims that $\frac{3}{4}$ and $\frac{5}{6}$ are the same amount. What is the <u>most likely</u> explanation for Takeem's answer? (Mark ONE answer.)

a) Takeem is noticing that each figure leaves one square unshaded.

b) Takeem has not yet learned the procedure for finding common denominators.

c) Takeem is adding 2 to both the numerator and denominator of $\frac{3}{4}$, and he sees that that equals $\frac{5}{6}$.

d) All of the above are equally likely.

16. A number is called “abundant” if the sum of its proper factors exceeds the number. For example, 12 is abundant because 1 + 2 + 3 + 4 + 6 > 12. On a homework assignment, a student incorrectly recorded that the numbers 9 and 25 were abundant. What are the most likely reason(s) for this student’s confusion? (Mark YES, NO or I’M NOT SURE for each.)

	Yes	No	I’m not sure
a) The student may be adding incorrectly.	1	2	3
b) The student may be reversing the definition, thinking that a number is “abundant” if the number exceeds the sum of its proper factors.	1	2	3
c) The student may be including the number itself in the list of factors, confusing proper factors with factors.	1	2	3
d) The student may think that “abundant” is another name for square numbers.	1	2	3

MIDDLE SCHOOL CONTENT KNOWLEDGE ITEMS

17. Students sometimes remember only part of a rule. They might say, for instance, “two negatives make a positive.” For each operation listed, decide whether the statement “two negatives make a positive” sometimes works, always works, or never works. (Mark SOMETIMES, ALWAYS, NEVER, or I’M NOT SURE)

	Sometimes works	Always works	Never works	I’m not sure
a) Addition	1	2	3	4
b) Subtraction	1	2	3	4
c) Multiplication	1	2	3	4
d) Division	1	2	3	4

18. Mrs. Smith is looking through her textbook for problems and solution methods that draw on the distributive property as their primary justification. Which of these familiar situations could she use to demonstrate the distributive property of multiplication over addition [i.e., a (b + c) = ab + ac]? (Mark APPLIES, DOES NOT APPLY, or I’M NOT SURE for each.)

	Applies	Does not apply	I’m not sure
a) Adding $\frac{3}{4}+\frac{5}{4}$	1	2	3
b) Solving $2x - 5 = 8$ for x	1	2	3
c) Combining like terms in the expression $3x^2 + 4y + 2x^2 - 6y$	1	2	3
d) Adding 34 + 25 using this method: $\begin{array}{r} 34 \\ \underline{+25} \\ 59 \end{array}$	1	2	3

19. Students in Mr. Carson's class were learning to verify the equivalence of expressions. He asked his class to explain why the expressions a – (b + c) and a – b – c are equivalent. Some of the answers given by students are listed below.

Which of the following statements comes <u>closest</u> to explaining why a – (b + c) and a – b – c are equivalent? (Mark ONE answer.)

a) They're the same because we know that a – (b + c) doesn't equal a – b + c, so it must equal a – b – c.

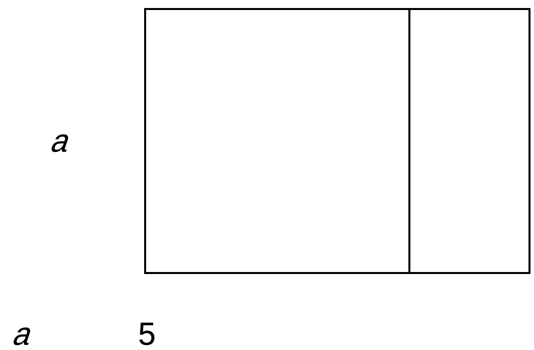
b) They're equivalent because if you substitute in numbers, like a=10, b=2, and c=5, then you get 3 for both expressions.

c) They're equal because of the associative property. We know that a – (b + c) equals (a – b) – c which equals a – b – c.

d) They're equivalent because what you do to one side you must always do to the other.

e) They're the same because of the distributive property. Multiplying (b + c) by –1 produces –b – c.

20. Ms. Whitley was surprised when her students wrote many different expressions to represent the area of the figure below. She wanted to make sure that she did not mark as incorrect any that were actually right. For each of the following expressions, decide whether the expression <u>correctly represents</u> or <u>does not correctly represent</u> the area of the figure. (Mark REPRESENTS, DOES NOT REPRESENT, or I'M NOT SURE for each.)



		Correctly represents	Does not correctly represent	I'm not sure
a)	$a^2 + 5$	1	2	3
b)	$(a + 5)^2$	1	2	3
c)	$a^2 + 5a$	1	2	3
d)	$(a + 5)a$	1	2	3
e)	$2a + 5$	1	2	3
f)	$4a + 10$	1	2	3

21. Ms. Hurlburt was teaching a lesson on solving problems with an inequality in them. She assigned the following problem.

$$-x < 9$$

Marcie solved this problem by reversing the inequality sign when dividing by – 1, so that $x > -9$. Another student asked why one reverses the inequality when dividing by a negative number; Ms. Hurlburt asked the other students to explain. Which student gave the <u>best explanation</u> of why this method works? (Mark ONE answer.)

a) Because the opposite of x is less than 9.

b) Because to solve this, you add a positive x to both sides of the inequality.

c) Because $-x < 9$ cannot be graphed on a number line, we divide by the negative sign and reverse the inequality.

d) Because this method is a shortcut for moving both the x and 9 across the inequality. This gives the same answer as Marcie's, but in different form: $-9 < x$.

Appendix C

Video Club Facilitator's Directions

You will need to:

1. create a "Doing Mathematics" Lesson Plan that incorporates:
    a. directions
    b. a small group activity
    c. a whole-class discussion
    d. an assessment activity similar to the small group activity but done independently to determine what the students learned.

    (All of this (a-c) will be videotaped)
2. grade both activities
3. edit video with researcher
4. diagram classroom discourse
5. facilitate video club
    a. show video
    b. lead discussion (possibly strengths, concerns, questions, interesting points, suggestions, etc.)
    c. report the results of the activity and the diagram of discourse

After the video club meeting, everyone will write a one-page reflection based on the video club meeting.