The Development of Education Quality Performance Standards in Grade 9-10 Mathematics Teaching

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Project Objectives

1. To develop procedures to use education quality performance standards in teacher self-assessment.
2. To pilot test the effectiveness of the standards in improving mathematics teaching.

The project focused on Transfer Grant Priority #1, Impact of Secondary School Reform, part B Accountability, subsection “education quality performance indicators (key performance indicators)”.

Review of the Literature

Mathematics Education Reform

The mathematics classrooms of today are not dramatically different than the classrooms of the past, despite repeated calls for substantial change. Since the publication of the Standards by the National Council of Teachers of Mathematics (NCTM) in 1989, evidence has accumulated that implementation of the Standards leads to higher achievement. For example, problem solving and conceptual understanding improve (Boaler, 1998; Brenner, et al., 1997; Cardelle-Elawar, 1995; Hickey, Moore, & Pellegrino, 2001; Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000; Schoen, Fey, Hirsch, & Coxford, 1999) without any loss of computational mastery (Mayer, 1999; Reys, Reys, & Koyama, 1996; Riordan & Noyce, 2001; Romberg, 1997; Villasenor & Kepner, 1993; Wood & Sellers, 1997). These findings suggest that increasing implementation of Standards-based teaching in Ontario would contribute to higher student achievement, including grade 9 EQAO scores.

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1 Final report of Transfer Grant project to the Ministry of Education and Training. The views expressed in this report to not necessarily reflect those of the Ministry. The research team for the project included Sonia Ben Jafaar, Cathy Bruce, Anne Hogaboam-Gray, Jane Lee, and Caroline Rosenbloom. Comments about the report should be sent to Dr. John A. Ross, Professor & Field Centre Head, OISE/UT Trent Valley Centre, Box 719, Peterborough, ON K9J 7A1.
The same body of research (reviewed in Ross, McDougall, & Hogaboam-Gray, 2002) suggests that change in mathematics classrooms is a rare and fragile event. Even teachers chosen as exemplars of reform depart from the ideal, displaying the height of innovation one day but regressing to traditional methods the next (Senger, 1998). The catalogue of barriers to reform is a lengthy one. The most important are the enduring effects of prior experiences on the expectations of teachers, administrators, students and parents. The central dilemma is that teachers must be agents of a change they did not experience as students (Anderson & Piazza, 1996).

There are well-documented strategies for reducing these barriers. The most promising interventions involve in-service that simultaneously focuses on teachers’ practice, their cognitions about mathematics teaching, and their knowledge of mathematics (Bitter & Hatfield, 1994; Borko, Davinroy, Bliem, & Cumbo, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Grant, Peterson, & Shoigreen-Downer, 1996). A major goal of our project was to extend this research by examining the impact of self-assessment on change in mathematics teachers’ beliefs and practices.

Dimensions of Mathematics Teaching

The chief characteristics of Standards-based mathematics teaching emerging from our review of math education research (Ross et al., 2002) and NCTM policy statements (1989; 1991; 2000) are (i) broader scope (e.g., multiple math strands with increased attention on those less commonly taught such as probability, rather than an exclusive focus on numeration and operations). (ii) All students have access to all forms of mathematics, including teaching complex mathematical ideas to less able students. (iii) Teachers in reform settings make the development of student self-confidence in mathematics as important as achievement. (iv) Student tasks are complex, open-ended problems embedded in real-life contexts; many of these problems do not afford a single solution. In traditional math, students work on routine applications of basic operations in decontextualized, single solution problems. (v) Instruction in reform classes focuses on the construction of mathematical ideas through student talk rather than transmission through presentation, practice, feedback, and remediation. (vi) The teacher’s role in reform settings is that of co-learner and creator of a mathematical community rather than sole knowledge expert. (vii) Mathematical problems are undertaken in reform classes with the aid of manipulatives and with ready access to mathematical tools (calculators and computers), support not present in traditional programs. (viii) In reform teaching the classroom is organized to encourage student-student interaction as a key learning mechanism, rather than to discourage it as an off task distraction. (ix) Assessment in the reform class is authentic (i.e., analogous to tasks undertaken by professional mathematicians), integrated with everyday events, and taps a wide variety of abilities, in contrast with end of week and unit tests of near transfer that characterize assessment in traditional programs. (x) The teacher’s conception of mathematics in the reform class is that of a dynamic (i.e., changing) discipline rather than a fixed body of knowledge.

The intended curriculum in Ontario includes all ten of these features, while omitting some elements often included in reform initiatives such as having students invent algorithms (e.g., Ball, 1993; Carroll, 1996). The Ontario curriculum also includes a feature not usually associated with math reform—detailed grade level expectations.

How Self-Assessment Influences Teacher Practice

The model in Figure 1 is heavily influenced by social cognition theory (Bandura, 1997) and by our work on student self-assessment (particularly Ross, Rolheiser, & Hogaboam-Gray, 2002). It assumes that teacher efficacy beliefs mediate the influence of self-assessment on teacher practice and that inputs from peers and supervisors moderate teacher cognitions about their work.
At the centre of Figure 1 are teacher cognitions about their practice, particularly their perceptions of its effectiveness in bringing about student learning. The model represents self-assessment as the integration of three processes that self-regulating professionals use to observe and interpret their behavior. First, teachers produce self-observations, deliberately focusing on specific aspects of their instruction relevant to their subjective standards of success. Second, teachers make self-judgments in which they determine how well their general and specific goals were met. The primary data for judgments about the effects of instructional efforts are teacher perceptions of changes in student performance that are gleaned from student utterances, work on classroom assignments, homework, and formal assessments. Third, are self-reactions, interpretations of the degree of goal attainment that express how satisfied teachers are with the result of their actions. Causal attributions, e.g., whether teachers attribute success and failure to their own actions or to factors beyond their control, play a critical role in forming these reactions.

![Diagram of Teacher Practice Model](image)

**Figure 1: How teacher self-assessment influences teacher practice**


Teacher self-assessment contributes to the development of beliefs about their ability to do the job. Teacher efficacy is a constellation of beliefs about a teacher’s ability to bring about student learning. It is particularized to teaching specific content, to specific students, in specific instructional contexts. Teacher efficacy is an expectancy about future performance that is based on past experience. Teachers who perceive themselves to have been successful in the past, regardless of the accuracy of their judgment, expect to be successful in the future. Of the four sources of teacher efficacy information identified by Bandura (1997), the most powerful is mastery experience. Teachers become confident about their future performance when they believe that through their own actions, and in the face of formidable obstacles, they have helped children learn.
Teacher efficacy influences goal setting and effort expenditure. Teachers who anticipate that they will be successful set higher goals for themselves and their students. Teacher efficacy consistently predicts willingness to try out new teaching ideas, particularly techniques that are difficult to implement and involve risks such as sharing control with students (Czerniak & Schriver-Waldon, 1991; Dutton, 1990; Hani, Czerniak, & Lumpe, 1996; Riggs & Enochs, 1990; Ross, 1992). High expectations of success motivate classroom experimentation because teachers anticipate they will be able to achieve the benefits of innovation and overcome obstacles that might arise. Teachers with high expectations about their ability to teach produce higher student achievement in core academic subjects (Anderson, Greene, & Loewen, 1988; Ashton & Webb, 1986; Cancro, 1992; Herman, Meece, & McCombs, 2000; Moore & Esselman, 1994; Muijs & Reynolds, 2001; Ross, 1992; Ross & Cousins, 1993; Watson, 1991) and on affective goals like self-esteem (Borton, 1991), self-direction (Rose & Medway, 1981), motivation (Roeser, Arbreton, & Anderman, 1993) and attitudes to school (Miskel, McDonald, & Bloom, 1983). Teacher efficacy contributes to achievement because high efficacy teachers try harder, use management strategies that stimulate student autonomy, attend more closely to low ability student needs, and modify students’ ability perceptions (evidence reviewed in Ross, 1998).

Teacher efficacy also influences effort. Teachers with high teacher efficacy have fewer absences (Imants & Van Zoelen, 1995), are more willing to handle difficult to teach students themselves than to refer them to special classes (Soodak & Podell, 1998), and are less likely to leave the profession (Brouwers & Tomic, 2000). Confident teachers persist. They are not depressed by failure but respond to setbacks with renewed effort. For example, individuals with high self-efficacy interpret a gap between aspiration and outcome as a stimulus while those with low self-efficacy see such a gap as debilitating evidence that they are incapable of completing the task (Bandura, 1997.)

Goals and effort are also linked: For example, individuals are more likely to persist if they adopt goals that have unambiguous outcomes, that are achievable in the near future, and that are moderately difficult to achieve (Schunk, 1981). High teacher efficacy also contributes to other positive motivations. Individuals with high self-efficacy are more likely to attribute success to their ability and failure to insufficient effort, to adopt learning rather than performance goals when faced with a professional learning task, and are more likely to be guided by intrinsic rather than extrinsic motivations (Bandura, 1997).

The combination of goals and effort affect teacher practice. Teachers who are willing to try new instructional ideas and who persist through obstacles are more likely to implement new approaches, experience success with them, and internalize the innovations into their practice. There may also be benefits for professional learning. Research with children suggests that positive self-evaluations play a key role in fostering an upward cycle of learning in which the child sets higher goals and commits more personal resources to learning tasks. Negative self-evaluations lead students to adopt social rather than academic self-images (Anderman, Anderman, & Griesinger, 1999), embrace goal orientations that conflict with learning, select personal goals that are unrealistic, adopt learning strategies which are ineffective, exert low effort, and make excuses for performance (Stipek, Recchia, & McClintic, 1992).

The Influence of Peers on Self-Assessment

Self-assessment is an individual enterprise that can be informed by the actions of teachers’ colleagues. Peer feedback can influence the first process (self-observation) by directing teacher attention to particular dimensions of practice. The influence would be stronger if there were a shared understanding of criteria communicated through rubrics and exemplars. Peer feedback might also influence teacher judgments about the degree of their goal attainment (the second process). The influence would be stronger if colleagues interpreted student outcomes and teacher practice in terms of overt standards for students and teachers. Peers might influence teacher satisfaction with the outcomes of their instruction (the third process), particularly if colleagues
gave praise explicitly linked to the quality of the performance (Cameron & Pierce, 1994) but not if the praise were linked to effort without regard to the worth of the outcome (Lepper & Hodell, 1989).

Bandura (1997) proposed that teacher efficacy develops as teachers process four sources of information: enactive mastery experiences (perceiving that one’s teaching has been successful), vicarious experience (observing others being successful or thinking about being successful oneself), social persuasion (being told that one is capable of performing the task), and physiological and emotional states (teacher efficacy is strengthened when positive feelings arising from teaching are enhanced and interpreted as indicative of teaching ability or when negative feelings arising from teaching, such as stress, are reduced). The information provided needs to be interpreted as meaningful by the teacher for it to have an impact on that teacher’s efficacy beliefs. The most powerful of these sources of teacher efficacy information is mastery experience. The teacher’s assessment of whether a given teaching act was successful can be steered by those around the teacher through the processes outlined above. Peer feedback is weighed against the observations, judgments and reactions the teacher generates during and after the lesson. Peer input may complement or compete with these self-responses depending upon the teacher’s perceptions of the credibility of their colleagues.

Figure 1 also provides for influence on self-assessment by supervisors. However, this project focused exclusively on teacher-teacher interactions and did not examine the role of supervisors.

**Design and Methodology**

The research design was a series of nested case studies (Merriam, 1990; Yin, 1994). Each pair of teachers constituted a case. The pair was the unit of data collection, analysis, and reporting.

**Sample**

We used existing networks of the research team to recruit a convenience sample of ten teachers for the project. Eight of these teachers were teaching grade 9 mathematics in the first semester. The ninth and tenth teachers were grade 7 and 8 teachers selected from a feeder school of one of the secondary schools that provided a secondary school teacher team. Our purpose was to ensure a divisional contrast that would highlight features of the change process in the secondary panel. The teachers varied in their experience and in their commitment to mathematics education reform (see case reports).

**Treatment Design**

Previous research indicates that teaching self-assessment procedures to students contributes to more accurate self-assessment and to higher student achievement (Arter, Spandel, Culham, & Pollard, 1994; Ross et al., 1999; 2002a), although it should be noted that we have observed conditions in which increased attention to self-assessment depressed performance in a mathematics classroom (Ross et al., 2002b). Four features distinguished our treatment:

1. Peer conferencing. In peer coaching, pairs of teachers of relatively equal experience and competence observe each other teach, negotiate improvement goals, devise strategies to implement the goals, observe the improved teaching, and provide each other with feedback. Although the technique can be difficult to learn (Perkins, 1998), positive effects are likely to be obtained when the appropriate climate, involving mutual trust, genuine voluntarism, encouragement of reflective thinking, and principal support (McLymont & da Costa, 1998) is developed. Previous research indicates that peer coaching increases teacher implementation of sought-after teaching practices and contributes to higher teacher efficacy (Edwards, Green, Lyons, Rogers, & Swords, 1998; Kohler, Ezell, & Paluselli, 1999; Licklider, 1995; Wineburg, 1995). Our initial design was modified somewhat during the sample selection. Two of the five pairs were mentor-teacher (i.e, a department head with an inexperienced teacher); the other three
pairs were made up of pairs of teachers with relatively equal experience. Consequently we labeled these phase of the treatment, peer conferencing rather than peer coaching.

2. Rubric for implementing Standards-based Mathematics Teaching. In our previous research we conducted observations and interviews with mathematics teachers who ranged from traditional teachers to high fidelity implementers of Standards-based teaching (McDouggall et al., 2000; Ross et al., 2000; 2001-02). We used these data, MET curriculum documents, and feedback from expert math teachers, to construct a rubric for Standards-based teaching. For each of our 10 dimensions, we described four levels of implementation, arranged in a hierarchy of increasing fidelity to NCTM Standards. We anticipated that use of this rubric would focus teachers’ peer observations and their improvement goals on the dimensions of mathematics teaching of highest priority to subject experts. The gulf between traditional and constructivist teaching is huge and daunting. The rubric describes much finer distinctions, increasing the ability of teachers to generate the type of improvement goals associated with persistence in past research; i.e., goals that have unambiguous outcomes, that are achievable in the near future, and that are moderately difficult to achieve (Schunk, 1981).

Appendix 1 contains the rubric. We provided 29 mathematics education experts (consultants attending the November 2002 Ontario Mathematics Coordinators Association Conference) with a task sheet in which descriptions of teacher practice copied from the self-assessment survey were displayed in random order. Each consultant was asked to arrange the descriptions for each dimension so that their response constituted a hierarchy ranging from least to best approximation of Standards-based teaching. Immediately following the individual task, the consultants met in groups of 6 to discuss their responses to three dimensions. They were asked to reach consensus on a single hierarchy and to share their reasoning. The consultants made 1798 individual decisions with 1612 of them matching the level placements in our model; i.e., 90% perfect agreement. The chance-adjusted agreement was $\kappa = .86$ (Cohen, 1960). All the groups reached consensus relatively easy. There was a perfect correlation between the rankings of each group (N=17 dimensions) and the rank order within the rubric. These results provide evidence of the face validity of the hierarchy of levels in the rubric.

3. Self-assessment tools. We devised a self-assessment consisting of four short descriptions (derived from the rubric) for each of the 10 dimensions of Standards-based mathematics teaching. It will be accessed through an interactive website that provides immediate feedback. The website provides teachers with an overall score in terms of four categories ranging from “procedures focus”, corresponding to traditional mathematics instruction, to “constructivist focus”, corresponding to Standards-based mathematics teaching. We anticipated that teachers who completed the self-assessment would have a deeper understanding of the Standards and that scores from these tools would help teachers set improvement goals that contribute to implementation of mathematics education reform.

4. Information about Standards-based teaching. As noted earlier, implementation of the Standards is a difficult task. The treatment provided information about how to implement the Standards in particular grades and courses through three half-day interactive in-service sessions. The procedures were based on those used in Impact Math (McDouggall et al., 2000) and confirmed in other research (e.g., Garet et al., 2001); i.e., ample supply of student learning materials, input from subject experts, collegial interaction to explore classroom applications, attention to beliefs about mathematics, and alignment with Standards.

The treatment will consist of 1) self-assessment using an interactive website that provides an interpretation of teachers’ self-reported practice in terms of the rubric for implementing Standards-based mathematics teaching, 2) in-service A (how to observe a mathematics classroom and setting observation priorities by the teacher and peer), 3) peer observation of teaching, 4) in-service B (identification of strengths of the peer teaching team, access to additional learning resources for specific Standards, and development of action plans for professional growth), 5) classroom experimentation over a 4-week period, 6) classroom
observation by the peer, and 7) peer debriefing. Each step will be matched with a parallel set of data collection activities.

Sources of Data (Events in the Project)

1. In early October, 2002 we observed each teacher teaching one section of a grade 9-10 mathematics course. Each pair of teachers was partnered with one member of the research team for the duration of the project. The site visits followed procedures established by Simon and Tzur (1999). We visited each classroom in September on two consecutive days during their math period (75-80 minutes per day). We interviewed teachers before, during, and after each math lesson to elicit the teacher’s intentions and reflections on the lessons we observed. We recorded the appearance of the room (e.g., location of computers, display of math posters) and noted events that occurred when students were learning mathematics, with and without computers. The purposes of the second day of observations were: a) to ensure that as many dimensions of teaching as possible were observed - in previous studies we found that there was considerable uncertainty after the first day and less the second; b) to determine the consistency of the teacher; c) to guard against demonstration lessons. We anticipated that all teachers would be in transition, manifesting some aspects of traditional math teaching as well as reform elements. (Frykholm, 1996 and Spillane & Zeuli, 1999 have demonstrated that self-reports exaggerate the degree of math reform implementation). The template for classroom observations is in Appendix 2. Observations of mathematics teaching (self, peer, and external observers) were coded using the categories of the rubric (4 levels X 10 dimensions of Standards-based mathematics teaching).

2. Each teacher completed the 30-minute on-line self-assessment. Appendix 3 displays examples of the probes that the site offered. Participants received feedback on their responses in the form of summaries of their self-reported teaching practices, as well as their responses to each item. The first summary score was a mean implementation score ranging from level 1 to level 4, based on dimensions 1, 2, and 3. We should the language of implementation fidelity because the Ontario curriculum prescribes teacher practice on these dimensions. The second summary provided the percentage of their responses in four categories: procedures focus (“The teacher typically focuses on developing and reinforcing key mathematical facts and algorithms.”), modified procedures focus (“The teacher, more often than not, focuses on developing and reinforcing key mathematical facts and algorithms.”), modified exploration focus (“The teacher, more often than not, focuses on exploring student ideas about mathematics.”), and exploration focus (“The teacher typically focuses on exploring student ideas about mathematics.”). These categories corresponded to levels 1-4 of the rubric in Appendix 2. We referred to these as categories of practice because the Ontario curriculum leaves these decisions to the classroom teacher.

3. Teachers participated in a half-day in-service session on how to observe a mathematics classroom and set observation priorities for peer observation. The in-service outlined the purposes and procedures of the project, including the role of researchers, as shown in Appendix 4. Each of the dimensions of Standards-based mathematics teaching were described and teachers selected two dimensions they planned to focus on in the project. Research team members provided strategies for observing a peer’s teaching and a template for recording observations. Teachers viewed a short film and practiced their observational skills using the template. Each teacher received a review of the literature on Standards-based teaching. We observed teacher behaviour and recorded their comments.

4. Teachers observed a peer teaching and were observed by that peer teaching one period in one section of a grade 9-10 mathematics course on one day. The researcher partnered with that pair also observed the lesson. The researcher briefly interviewed the teachers before and after the observations.

5. Teachers attended a second half-day in-service session on Standards-based mathematics teaching. The in-service focused on the dimensions that had been selected by most teachers: assessment (transparency and variety) and tasks. For assessment, researchers demonstrated the difference between traditional and reform approaches to student assessment, distributed short articles (Fischer, & King, 1996; McLean & Lockwood,
1996), and provided examples of Standards-based assessment for specific mathematics topics. For tasks, researchers provided examples of rich tasks from the topics of exploring angle sums in polygons, trigonometry, and others. Teachers set priorities for improving their mathematics teaching and planned with a peer how they would implement the change over a 4-week period. We observed the interactions between each teacher pair and recorded their comments.

6. Teachers implemented self-selected changes in mathematics teaching for four continuous weeks. A researcher observed each teacher for one period per week for each of the four weeks. Researchers continued to use the template for recording observations. The priorities in these observations were the two dimensions that each teacher identified, but we were also alert to data on other dimensions. Our goal in doing so was to record any unplanned changes in the teachers’ practice, either movements toward greater implementation of Standards-based teaching or regressions to traditional practice. In one of the five pairs (Paul and Christine) only three of the four observations were made due to scheduling conflicts of the two teachers.

7. In the fourth week, each teacher observed a peer teaching and was observed by that peer teaching in one period.

8. Teachers attended a half-day in-service session on how to analyze classroom observation data and decided with a peer what changes occurred during the field test. This session was a semi-structured interview in which each teacher narrated his/her experience in the project. The researcher assigned to the pair moderated the conversation and probed for specific evidence of the claims teachers made. Teachers and their researcher partners met in small groups to identify factors that might have contributed to change or lack of it in the practice of the teachers. The final activity consisted of researchers meeting with their teacher pair to identify semester 2 activities in which teachers would continue to work on their practice in a self-directed way. We observed the interactions between each teacher pair and recorded their comments. The researchers participated in the teachers’ conversations by suggesting evidence from our observations but we did not challenge any of the assertions that teachers made.

9. We prepared initial case reports on each teacher. The reports were based on our initial reading of the files during the coding process. The purpose was to develop an initial interpretation of how the intervention influenced the teacher (if it did) and to obtain feedback from the teacher on the accuracy of our interpretations. These 2000-2500 word reports were the initial outline for the full case study reports. The format for the short reports consisted of (a) Vignette (i.e., a one paragraph description of a lesson from the first observation that described the essence of the teacher’s instructional style, followed by a very brief description of the teacher); (b) the rubric dimensions chosen by the teacher and what the teacher did to change his/her practice with respect to those dimensions; (c) progress made by the teacher in changing his/her practice with respect to the chosen dimensions (this section included positive and negative changes in other dimensions of mathematics teaching and referenced the teacher’s perception of whether change occurred); (d) factors that supported or impeded change in mathematics teaching in directions specified by the rubric. We invited teachers to comment on the short case reports. We recorded their comments and incorporated them into the final reports. One pair (Paul and Christine) did not respond to our invitation to participate in the member checks.

Data Analysis

The unit of coding was the thought. A particular chunk could be as short as a phrase or as long as several paragraphs. The coding scheme was driven by the research questions of the study.

Research Question 1: In what ways did teachers think they changed? The main data sources were the interviews with the teachers, especially the December 3 (third in-service) interviews. Also relevant were the teachers’ self-assessments and their responses to our case reports in the member checks.
Research Question 2: In what ways did the researchers’ observations indicate that the teachers had changed? The main data sources were the observations made throughout the project; these were compared to teachers’ self-reports.

The coding scheme for these two questions was driven by our rubric; i.e., our theoretical framework for representing variation in mathematics teaching. Each chunk was identified as one of the following 18 codes. Since the dimensions of our rubric overlap, we also assigned additional codes to the same chunk if the additional code was one of the target dimensions for that teacher.

- D1 Scope
- D2 Opportunity to Learn
- D3 Confidence
- D4a Tasks – Strategies
- D4b Tasks – Representations
- D5 Constructing Knowledge
- D6 Teacher’s Role
- D7a Tools – Manipulative Use
- D7b Tools – Technology Use
- D8a Student Interaction – Instruction
- D8b Student Interaction – Tasks
- D8c Student Interaction – Communication
- D9a Assessment - Purpose
- D9b Assessment - Transparency
- D9c Assessment – Variety
- D10a Disciplinary Knowledge - Dynamic
- D10b Disciplinary Knowledge - Connections
- D11 – used for other important dimensions of mathematics programs that were not included in our rubric, e.g., classroom management

Research Question 3: What factors contributed to and/or impeded teacher change?

The coding scheme was driven by the elements of our treatment design. The first seven factors identify elements of our intervention that might influence teacher practice (particularly a change). The last three factors identify variables other than the elements of our intervention that might influence teacher practice.

Intervention elements:
- TREAT the treatment as a whole, without differentiating elements of it
- PC peer conferencing
- RU rubric for implementing Standards-Based teaching
- SA self-assessment tools
- INF information about Standards-based teaching, i.e., workshops and interaction with individual researchers
- RES being observed or interviewed by the researcher
- OI other aspects of our intervention that were not part of our design, e.g., teachers might believe they were chosen for their excellence and now want to live up to it

Elements Unrelated to the Intervention:
- PERS personological factors such as the teacher’s prior experience, family life
- SCHL school-related factors
• OTH other factors such as Ministry curriculum materials, district policy, etc.

We used NUD*IST to organize the data. Themes were developed through constant comparison. Credibility of the findings of the study was enhanced by 1) triangulating between data collection times and interpreters; 2) maintaining an audit trail by creating charts of relationships and counting instances (Miles & Hubberman, 1994); 3) searching for negative instances (Seale, 1999); 4) using member checks (i.e., teacher feedback on the short case reports).

Case Reports

Case Reports for Alex & Deborah

By Jane Lee

Case Report for Alex

Introduction

Alex has been an educator for 12 years. For the first five years, Alex was a guidance counselor and he taught co-op courses. Alex has also taught grade 9 science and grade 11 biology. In Mathematics, Alex has experience teaching the former grade 9 and 10 curriculum and he is currently teaching the new curriculum for grades 10 and 11. Prior to his teaching career, Alex worked in the health and health administration field. This case report is based on Alex's teaching experience with a grade 10 enriched Mathematics class.

In the Mathematics classroom, Alex draws on many effective organizational and managerial skills he developed when he was in health administration. Alex organizes his lessons from beginning to end so that he is rarely caught off guard by any surprises that arise during the class. He is very detailed and records all his lesson plans in writing in his teacher's planner; Alex usually goes through two planners during the school year (Oct 15, In-Service Session).

When you enter a classroom that Alex is about to teach in, you notice that he has already laid out his entire lesson on the blackboards. Each of the topics that the students will be covering is included, along with the homework that will be assigned for the following class. As well, Alex writes on the blackboard the sample questions that he will use to illustrate the lesson for the day (Oct 10, Obs Field Notes).

As in most secondary schools, the classroom is set up with the desks (chairs attached) arranged in rows. However, typically Alex has the class rearrange themselves in pairs or small groups, so that the students feel at ease moving their desks into the arrangement necessary for that day. Alex's students are accustomed to choosing their own pairs or small groups, just as they are accustomed to having Alex select pairs or small groups for them (Oct 11, Obs Field Notes).

Almost as soon as the bell rings to signify the start of the period, Alex takes roll call and all the students answer with "here". When a student walks in late, Alex immediately asks the student where he or she was and what his or her excuse is, reminding the student of his or her obligation to be on time. When he has completed taking attendance and all students are accounted for, Alex begins the lesson by taking up homework he assigned in the previous class. Alex has almost the entire class participate in taking up homework by assigning one student to each of the homework questions. Students are required to write out full solutions on the blackboards. To ensure that all students partake equally in the homework write-up, Alex starts with a different section of the classroom each time. For example, one day he will start assigning questions from the left of the classroom, the next day he will start with the middle of the classroom. Alex's students also help keep track of what section will start next in terms of putting up the homework questions (Oct 10 & 11, Obs Field Notes).
While students are writing out their solutions, Alex asks the class to check their own work to see if there are any discrepancies between their answers and the answers that are being written on the board. When discrepancies are found, Alex has the students participate in determining who has made the mistake, either the student that has put his or her solution on the board or another student that has called attention to the solution on the board. The students involved then come to an agreement as to which answer is correct. If no one in the class has any questions about the homework, Alex then draws attention to questions that he believes should be highlighted, whether for the intricacy of the solution or a possible misconception that the students may have had that would have led to an incorrect answer (Oct 21, Obs Field Notes).

The lesson for the day is usually teacher-led, with students helping to illustrate the key points using the questions laid out on the board. When Alex feels that the students have grasped the major ideas of the lesson, he assigns them questions to try from their textbook or from photocopied handouts. Alex usually leaves enough time at the end of the period so that the students can work individually, in pairs, or in small groups to try some of the questions that are to be completed for homework (Oct 10 & 11, Obs Field Notes).

Alex provides positive verbal feedback when students respond correctly to a question, and he will also ask more from the student when he feels the student has not fully explained him- or herself. Along with providing positive verbal feedback as positive reinforcement, Alex rewards students with stickers on their quizzes and tests. He has an intricate system of rewarding students with a certain number of stickers based on the grades they achieve. Alex believes that students of all grades appreciate the stickers as rewards (Oct 30, In-Service Session).

Teacher's Action Plan

Alex chose to focus on Dimension 4, Student Tasks, and Dimension 9, Student Assessment, for his grade 10 enriched Mathematics class.

Alex and his teaching partner, Deborah, wanted to choose dimensions that they could work on together. The reason that Alex and Deborah chose Dimensions 4 and 9 was that they wanted to gain more experience with the different types of assessment methods that the new curriculum demands of them. They agreed that having chosen Dimension 9, Student Assessment, it made sense to also choose Dimension 4, Student Tasks, because they would also need to work on the student assignments in order to be able to assess them.

For the four-week observation period, Alex and Deborah planned on creating two new student tasks, along with the rubrics for the student tasks.

Implementation of the Teacher's Action Plan

Dimension 9, Student Assessment

Alex's knowledge and experience with Dimension 9, Student Assessment, grew considerably during the four-week period. Although Alex was apprehensive about creating and using rubrics in the beginning, Alex realized he was familiar with generating student tasks that required group work. Alex did not have any prior experience with rubrics and he had never created a test with questions that were divided into the four categorizes (Knowledge and Understanding; Application; Thinking/Inquiry/Problem Solving; and Communication). But he created two different rubrics for two different student assignments. He had an easier time with the allocation of questions than with the rubric. When he looked over a test he had created previously without the categories, Alex realized that he had already included questions covering all four categories. All Alex had to do was rearrange the questions so that they were grouped under the appropriate category. As well, he was able to divide questions on his next test into the four categories to be assessed in the new curriculum.
At the outset, Alex had no experience using or creating rubrics and so he was very interested in what other people, including his students, thought about using rubrics:

Teacher: "Do you get rubrics in other courses? How useful do you find this?"
Student: "Very useful."
Teacher: "Why?"
Student: "Because it lets us know what we have to do."
Teacher: "We'll use this rubric for this activity, but I'll ask you after how you might change the rubric to assess this activity better" (Nov 7, Obs Field Notes).

To help him create his first rubric, Alex was given a general Mathematics rubric template by the researcher. After he created his first rubric using the general criteria provided by the template, Alex was able to create a second rubric using criteria he believed more closely reflected what he wanted to assess in the student task. Alex became confident enough in his abilities to generate criteria for rubrics to share his knowledge with his other colleagues.

Alex demonstrated that he gained experience with Student Assessment by creating rubrics with the input of his students. While Alex was learning about different varieties of assessment, he was also willing to negotiate with his students in terms of how the rubric could best reflect the activity.

In addition to having no prior experience creating or using rubrics for assessment, Alex had never divided up questions into the four categories expressed by the Achievement Chart in the Ontario curriculum. However, by the end of the four-week period, Alex was writing up his Mathematics tests according to the four categories.

While Alex asked his students for feedback on the use of rubrics in his classes, he also wanted student feedback on the four categories that the students were tested on. He explained to his students his rationale for why the questions on tests were now being categorized and how this would help students determine which areas they needed to improve on:

Teacher also expresses that he later wants feedback on how the test they recently had was put together, in terms of writing up the test in the four categories.

Teacher asks the class why people do better on the knowledge and understanding category than the other three. A student responds that they are more knowledgeable, and teacher replies with they may know more facts.

Teacher explains what is required from the other three categories. In the communication questions, he expects students to answer using sentences, and that they need to be able to describe their answers. He also says he is looking for how they explain their answers using English correctly.

Teacher expresses that he wants the class to be able to read for comprehension, and he wants them to interpret the questions correctly, as well as express their solutions effectively.

Teacher comment that the class did not do so well in the application part of the test compared to the knowledge and understanding section. Teacher explains the difference between a thinking/inquiry/problem solving question and an application question.
A student asks how to a specific question on the test needed to be answered. Teacher takes up the question on the board.

Teacher stresses the importance of drawing a diagram, and asks, "Why are application questions difficult for some of you?

No one responds, so teacher answers own question - maybe they have problems with synthesizing, and gives suggestions to how students can improve, such as trying more different types of problems so that they can build up their strategies.

Teacher comments that their tests from now on will be broken down into the four categories, and that they will be doing more work with rubrics (Nov 21, Obs Field Notes).

By creating a test using the four categories, Alex was able to discuss with his class why students would perform better in the category of Knowledge and Understanding, than the Application category. Alex was also able to specify the differences in the types of questioning between the categories. This exercise proved to be helpful to his students as well as himself. Moreover, Alex grew confident enough in his skills at generating rubrics and categorizing test questions that he began helping his colleagues in the Mathematics department with their queries.

Prior to his experience with the rubrics, Alex would informally assess students and their participation in their groups. Now, he creates rubrics to help him and his students assess themselves in their group work. Alex is also comfortable now with asking his students to help generate and provide feedback on the questions on tests that are categorized and on the rubrics that are created.

The rubrics Alex created allowed a portion of the task to be assessed by him, and a portion to be assessed by the students. The students were required to assess each other in the role they played at completing the task.

Teacher instructs students that they need to now assess each other using the rubric given to them on the "Working with others" criteria. There are four criteria on the rubric in total, but the students are only assessing each other on one of them. The teacher announces that he will assess the groups on the other criteria, based on the activity pages (Nov 14, Obs Field Notes).

By having his students mark one another using the rubrics, Alex was able to include their views in the assessment of the activity so that his students were also involved in the learning process. By incorporating the views of his class, Alex demonstrates that he values input not just from his colleagues, but from his students as well.

**Dimension 4, Student Tasks**

Alex also grew in relation to Dimension 4, Student Tasks. The first task he generated required students to work together on an activity where they would each hand in their own solution set. The rationale that Alex gave the students for why they were working together was that the students could check each other's answers and discuss their solutions before writing up their individual reports.

Teacher asks class if they find working in small groups useful. A student comments that they don't have to work in groups, but it is better for communication and listening skills - how he believes girls listen better than boys, and by working in small groups, the guys can develop better listening skills (Nov 21, Obs Field Notes).
Alex values the opinions of his students. While he justifies to his students why he believes they need to work together, he is also interested in whether they also believe if working in groups is helpful.

The second task Alex generated also required students to work together, but this time the group had to collaborate in order to reach the solution. Each part of the solution required the effort of each member of the group.

Teacher clarifies that each student has his or her own question to complete within the group, but the group must combine the individual results and come to a conclusion. Then each student is responsible for handing in his or her own report of the activity.

Teacher gives the rationale that everyone must produce an assignment, but they have to rely on each other to get the results.

All students are on task at getting the assignment completed - they realize they are restricted in terms of the amount of time. Students are asking each other questions within their groups, but they are also asking the teacher.

There is discussion between students from all groups observed. Teacher is circulating room with a checklist.

A student has asked the teacher a specific question; the teacher clarifies the answer with the entire group. Teacher reiterates that students may ask for clarification of instructions, but not content (Nov 7, Obs Field Notes).

Alex wants his students to rely on each other as a source for answers, rather than just relying on him. While he comments that the individual component of the solution is important, Alex also stresses the importance of the entire group's effort to complete the task.

**Dimension 8, Student-Student Interaction**

A dimension that Alex did not focus on, but that was also clearly present, was Dimension 8, Student-Student Interaction. Alex ensures that his students are communicating constantly with him and with each other.

Teacher asks another student to explain her solution.

Student reads out the question from the text and begins her explanation. As the student is going through her steps, most of her peers are following along with her explanation by looking over their own work. A classmate asks the student explaining the question why it could not be solved using another method, and student gives an explanation.

Teacher chooses another student to explain his solution and he also goes through his method. Teacher asks for clarification of a specific step and student responds.

All three students that have shared their solutions are reciting the steps that have been put up on the board by themselves.

Teacher asks if there are any questions from the class, and comments that he notices some people had not completed their homework, and if this was the case, that they should finish it up on the weekend.
Teacher asks one more student to explain a question from the board. Teacher comments on how students need to be careful about dealing with signs when doing operations with Polynomials, and how students should not rush in order to avoid making mistakes (Nov 29, Obs Field Notes).

Whether his students are giving explanations to the class as a whole, or giving explanations to each other, Alex demands that they focus on their communication skills. When the teacher-led classroom instruction is taking place, there is teacher-student interaction as well as student-student interaction.

Students putting up answers to questions on linear inequalities (homework from last day)

Teacher explaining terminology that students need to be using, along with rules to dealing with inequalities, i.e. when multiplying or dividing with inequalities, to change the signs; uses "hollow" and "clear" dots and "solid" dots when illustrating solutions on the number line (instead of open and closed dots)

After students have written all their solutions on the board, teacher chooses five students to go up to the board to explain their answers.

All five students are reiterating what they have written on the board. Teacher continuously giving positive reinforcement to the students, while clarifying/emphasizing concept areas that he feels needs to be stressed.

Teacher asks if there are any questions from the class - there are none (Nov 21, Obs Field Notes).

When students are working in pairs or small groups, Alex facilitates student-student interaction by circulating throughout the classroom to make sure the conversations that are taking place are task-related.

Teacher divides students into groups of three, and has students move their desks so that they face each other. Teacher comments that the homework will be written on the board and that students are allowed to use whatever strategy they want to get the questions completed. For example, having students do different questions and then comparing their solutions afterwards, or doing the same question together so they can immediately check their answers.

Teacher gives multiple strategies on how homework can be completed by next day, and comments that each individual is responsible for all the questions. A student then asks about what the point is of working in groups, and teacher responds that they can utilize the mind of a group rather than individual know-how (Nov 29, Obs Field Notes).

When students ask him a question, Alex guides the questioning so that the questioner can talk about possible solution strategies with his or her group members. When Alex has his students working in-groups, he prefers to have solutions arise from the group's effort rather than having his students rely on him for answers.

Teacher Perceptions of Professional Change

Alex believes the project helped him change his teaching practices in regards to the dimensions he chose to work on, Student Tasks (Dimension 4) and Student Assessment (Dimension 9). Alex's main goals were to develop student tasks that would challenge and engage his enriched grade 10 Mathematics students,
individually and in small groups. As well, Alex devised rubrics that helped him assess his students on the tasks that he had created.

Alex commented that an obstacle the project helped him overcome was having people other than his students watching him teach. He realized that he needed to overcome his initial perception that we (Deborah and the researcher) were in his classroom to evaluate him (Oct 7, Interview). Alex admitted that he spent a great deal of time "preparing" for the lesson that Deborah was going to observe. He felt a bit more pressure when both the researcher and Deborah were in his classroom (Oct 18, Interview). However, after having observed Deborah, Alex realized his role, as an observer, was not to evaluate his teaching partner, but to gain insight into her teaching strategies so that he could discuss and share teaching techniques. As well, after the first couple of observation sessions with the researcher in his classroom, Alex commented he became much more comfortable with someone else watching him teach (Dec 3, Interview).

Overall, Alex was positive about the entire experience because he became much more comfortable with creating tasks and using rubrics and assessing students using the achievement chart and the four categories. Alex enjoyed the time he was able to spend gaining insights from the researchers at OISE/UT and the opportunity to collaborate with his teaching partner, Deborah (Dec 3, Interview).

**Case Report for Deborah**

**Introduction**

Deborah has been teaching for the past 24 years. She has taught the former science curriculum from grades 9 through to OAC biology. Deborah's has experience being both department head and an associate head for science. In Mathematics, Deborah has experience teaching the former grades 9 through 12 curriculum, and she is currently teaching the new curriculum for grades 10 and 11. This case report is based on Deborah's teaching experience with a grade 10 enriched Mathematics class.

Deborah is a veteran teacher who practices successful teaching and classroom management strategies. She is experienced in peer coaching and mentoring situations and her colleagues find her invaluable for her knowledge and insight in the content area of mathematics. While she is an experienced teacher, Deborah is always open to learning about the most recent developments in education, which made her an excellent candidate for this project. Deborah wanted to update her knowledge and skills in the areas of assessment and develop different student tasks, as reflected in the dimensions that she chose to work on (Oct 15, In-Service Session).

When you enter a classroom that Deborah is about to teach in, you notice that the date is always written in exactly the same location on the blackboard, with the agenda for the lesson found underneath. This routine that Deborah has established allows her students to always know what they can expect for the lesson, as well as identify the homework assigned for the next day, which Deborah writes in at the end of the period (Oct 7, Obs Field Notes).

Deborah has her students sit in an assigned seat according to a seating plan. She regularly changes this seating plan so that all students learn to work with other people in the class, as well as to maintain discipline and attention. As in most secondary schools, the classroom is arranged with the desks (chairs attached) set up in rows. Deborah has her students fill up the seats starting at the front (Oct 7 & 9, Obs Field Notes).

Deborah demands punctuality from her students, and most of the time all of her students are already in their seats as the bell rings to signify the start of the period. Deborah will complete her lesson and have her students working before she checks attendance.
Deborah usually dispenses with "housekeeping" duties at the beginning of class, reminding her class of any due dates for quizzes, tests or assignments along with any other administrative details. Deborah then starts her class by taking up the homework from the day before. Instead of taking up all the homework questions, she asks her class if they had difficulty with any specific questions. If no one volunteers any such difficulties, Deborah will highlight specific questions that she believes capture the more difficult concepts of the topic. Sometimes Deborah asks for volunteers and sometimes she chooses specific people to write the full solutions to the homework questions on the board. While students are writing out their solutions, Deborah asks the class to check their own work to see if there are any discrepancies between their answers and the answers that are being written on the board. When discrepancies are found, Deborah holds a conversation with the student that has written the solution on the board and the student that has a different answer, and the three of them come to a conclusion as to who has the correct solution (Oct 9, Obs Field Notes).

If Deborah is returning a quiz or test that day, she will verbally go through the solutions to questions she believes her students had difficulty with (Oct 23, Obs Field Notes).

Deborah organizes her lesson plans so that the level of difficulty gradually increases throughout the lesson in order that her students do not feel overwhelmed or unprepared with respect to the content they are expected to understand for the day. She offers her students a fair opportunity to demonstrate their knowledge and skills, while demanding that they be fully focused for the entire duration of the class (Oct 30, In-Service Session).

The lesson for the day is teacher-led. Deborah introduces her class to the new concept and goes through the mathematics terminology that is required for the concept. She then illustrates the concept with several sample questions. Each question is placed on the blackboard and the entire class is given time to try out the question themselves before the solution is taken up. Deborah either asks for a volunteer or she chooses someone to offer a solution to the problem. When a student faces difficulty with a specific part of the problem, Deborah will help guide the student to the solution. If a student gives a solution without offering the intermediate steps, Deborah will ask questions to get the student to explain how she or he reached the answer. When the class has covered enough sample questions, Deborah will assign questions from the textbook or from photocopied handouts. Deborah usually leaves enough time at the end of the period so that the students can work individually to try some of the questions that are to be completed for homework (Oct 23, Obs Field Notes).

**Teacher's Action Plan**

Deborah chose to focus on Dimension 4, Student Tasks, and Dimension 9, Student Assessment, for her grade 10 enriched Mathematics class.

Deborah and her teaching partner, Alex, wanted to choose dimensions that they could work on together for this project. The reason that Deborah and Alex chose Dimensions 4 and 9 was that they wanted to gain more experience with the different types of assessment methods that the new curriculum demands of them. They agreed that after choosing Dimension 9, Student Assessment, it made sense to also choose Dimension 4, Student Tasks, because they would also need to work on the student assignments in order to be able to assess them.

For the four-week observation period, Alex and Deborah planned on creating two new student tasks, along with the rubrics for the student tasks.

**Implementation of the Teacher's Action Plan**
Deborah's knowledge and experience with Dimension 9, Student Assessment, grew considerably during the four-week period.

The teacher explains the marking scheme for the assignment using the rubric she has created. The teacher mentioned to me before class that this is the first time the teacher has used a rubric to assess student's work (Nov 6, Obs Field Notes).

Deborah was eager to learn about creating and using rubrics and recording the levels into marks. She created one rubric on her own for a student assignment and she created one rubric with her students for a student task completed in class. Deborah had never created a test with questions that were grouped according to the four different categories in the Achievement Chart (Knowledge and Understanding; Application; Thinking/Inquiry/Problem Solving; and Communication). However, when she looked over a test she had created before without the categories, Deborah realized that she already had questions that covered the four required categories. All Deborah had to do was rearrange the questions under the appropriate headings. Deborah was able to categorize questions on her next test into the four categories to be assessed in the new curriculum.

For the second week, instead of having an observation period for the teacher participant, we held a couple of meetings to discuss how she would implement the dimension, Student Assessment (D9), she was working on.

At the first meeting, the teacher showed me a test that she had used last year on Coordinate Geometry. This test had 9 questions, marked out of 44 marks. The teacher said this year she wanted to give her students a test that addressed the four categories for student learning: knowledge and understanding, application, thinking/inquiry/problem solving and communication.

The teacher then showed me a test on Coordinate Geometry that had questions falling under the headings mentioned above. This test was out of 43 marks. The first five questions were Knowledge questions, which carried 15 of the total marks. The next question was a Communication question that was worth 3 marks. The remainder of the questions addressed the Application category. We discussed the definitions for each of the categories and the teacher decided that she wanted to change where some of the questions on her test would appear.

When we met again, she showed me a test out of 38 marks. The first 6 questions fell under the Knowledge category, and were worth 17 marks. The next question was a Communication question worth 4 marks. The next three questions were Application questions worth 11 marks, and the last question was a Thinking/Inquiry/Problem Solving question (Nov 13, Obs Field Notes).

Deborah went from not having any experience at all using or creating rubrics, as well as not ever having categorized questions into the four different categories, to doing both within the four-week period. Although Deborah struggled with generating her first rubric, she was comfortable enough with the experience the first time that she was confident in generating her second rubric with her class. At the end of the month, Deborah grew confident enough in her skills at generating rubrics and categorizing test questions that she began helping her colleagues in the mathematics department with their queries.
The first rubric Deborah created allowed a portion of the task to be assessed by her and a portion to be assessed by the students. The students were required to assess each other in the role they played at completing the task.

Teacher moves on to the application questions and comments that "There was not one new question" in this section. She goes through the questions and the steps that the students needed to do.

Teacher gives an overview of the differences between the four categories and defines what is required from each one. She wants students to reflect on which categories they scored well on and which ones they could improve on. She provides rationale on why the questions are split into these categories and suggests ways that students can improve.

Teacher asks students to put test away and begins to talk about the group assignment (observed in Observation 1).

Teacher asks the students to move back into the groups they worked in, to determine their own level under the heading "group interaction" on the rubric. Teacher puts down the requirement for each of the four levels under this heading on the board to help students put themselves on the rubric. Each group is given a blank piece of paper so each student can write down the level he or she achieved during the group assignment.

A student asks for clarification of what he is supposed to do. The teacher responds by saying that they just have to write the level they feel they are at, but that they are to discuss it amongst themselves (Nov 18, Obs, Field Notes).

Deborah created the second rubric with her class. After her students had completed a task given in class, Deborah had them brainstorm to create a rubric to assess their performance.

Students have moved their desks back to the original seating plan. Teacher wants to know how she should mark this activity using a rubric. Teacher wants the class to brainstorm and come up with rubric categories to mark the pair task that was just completed by the students.

A student offers "teamwork" as one of the categories.

Another student offers "neatness" - there is a chorus of no's.

Other categories that are offered: Accuracy and Showing Steps.

Teacher: "Okay, we have four categories - why did the neatness category bother you?"
Students respond it was hard to keep their solutions "neat".
Teacher: "Okay, can you think of another category then?"
Student: "How about Organization?"
Teacher: "Good."

A student comments that Teamwork should not be a category because the task could have been done individually. The teacher agrees that the task is capable of being performed individually, but reminds the student that one of the stipulations at the beginning of the assignment was that the students had to work in pairs.
Teacher wanted only three categories, but now there are four. Teacher asks which one they can cut - no response, so they will keep all four categories on the rubric. Teacher creates a chart on the board and goes through the levels required for each category with the students. Teacher wants everyone to make a copy of the rubric on the back of their assignment to be handed in (Nov 27, Obs Field Notes).

Even though Deborah had a specific layout in mind for the rubric, she was willing to compromise with her students and extend the number of headings on the rubric from three to four. Deborah felt confident as a teacher to share with her students the assessment development process.

Deborah also makes it clear to her students the purpose of using a rubric for the activity. Deborah believes that not all forms of assessment have to be translated directly to a mark, and she feels comfortable explaining that the rubric will help her review and give feedback about a person's learning skills.

A student asks if the rubrics count as actual marks. Teacher responds that the rubric scores will not translate out to an actual mark, but will be used for the learning skills and for when parents come in for Parent Interview Night so feedback can be given back on the student.

The teacher begins to fill in the rubric, and a student asks, "What is highly organized?"

Teacher responds with, "Good question", and explains that the assignment should have a date and name.

Teacher continues discussion with the class on how the levels are to be filled in on the rubric. However, before the rubric is completely finished, the announcements come on over the intercom system.

Teacher collects the assignment from each pair and comments that the assignment and rubric will be discussed next class (Nov 27, Obs Field Notes).

Deborah charted the basic layout of the rubric, with the columns for the four levels and rows for the criteria. Together, Deborah and her class decided the criteria for the rubric and the appropriate requirements for the levels were filled in. Deborah not only became comfortable at creating rubrics, she also became comfortable with sharing the assessment with her students.

*Dimension 4, Student Tasks*

Deborah also grew considerably in relation to Dimension 4, Student Tasks. The first task she generated required students to work together on an activity where they would each hand in their own solution set. This task required the students to arrange themselves in groups of three instead of their traditional row seating.

Teacher instructs the class that they will be divided into groups of three and will be asked to find the median and right bisectors. The students will be required to do individual work but then they will have to share their answers to combine their work and hand in the assignment as a group (Nov 6, Obs Field Notes).

By having her students rearrange their seating order to better accommodate group work, Deborah was able to facilitate easier communication between her students.
Another task Deborah created allowed her students to pose different possible strategies to reach the same solution.

Teacher explains the use for Pascal's triangle: how binomials can be expanded by not expanding everything. Teacher begins to develop Pascal's triangle by expanding binomials, starting from degree zero, and continuing to degree three.

Teacher stops at the binomial with the third degree and asks the class how this could be expanded.

A particularly bright student (had her in my grade 9 class), responds by breaking down the 3rd degree binomial to a second degree and a first degree, and uses what was expanded previously by the teacher, to expand the third degree. Student was going to give the final answer, but teacher asks her to go through entire expansion using the distributive law.

Teacher: "How do we get the next line?" (Pointing at the binomial to the forth degree.) A student responds by giving the next line of coefficients and gives reasons how he got the numbers.

Teacher asks if the rest of the class understands what is happening; class responds with affirmatives.

Teacher asks a student to expand the next line, the binomial to the fifth degree. Student expands correctly - what is not mentioned is how the degree of each term is the same as the overall degree of the entire polynomials.

Teacher mentions that these examples are not "real" examples (binomials of only a and b, so puts up another example, (5x - 3y) to the 4th degree. Teacher writes how now 5x is really the "a" term and that -3y is the "b" term and that students should now be able to expand using the same method used to develop Pascal's Triangle (Nov 27, Obs Field Notes).

*Dimension 8, Student-Student Interaction*

A dimension that Deborah did not focus on, but that was developed with the other two dimensions was Dimension 8, Student-Student Interaction. Most of the interaction that took place in Deborah's class was between the teacher and the student. Questions would be posed by Deborah and then answered individually by the students. When Deborah chose to work on Dimension 4, Student Tasks, Deborah also increased student-student interaction. Instead of her students sitting in rows and working on the questions individually, the tasks that Deborah created had her students working in small groups. Deborah now required her students to arrange their desks to facilitate small group interaction, which greatly increased the student-student interaction.

Students move around the room to form the groups they have been assigned to. There are eight groups of three students in each group.

Within each group, the students number themselves off so that the workload is divided up among themselves. Desks are arranged to accommodate optimal student interaction (Nov 6, Obs Field Notes).

Teacher wants everyone in the class to get paired up so that they can work on a question together that they must hand in. Students begin moving desks around (Nov 27, Obs Field Notes).
Deborah was able to further facilitate student interaction by moving around the room during these tasks to help groups with their questions. Deborah ensured that the groups were on-task by guiding their discussions back to the appropriate topics when the groups got off track.

Teacher walking around and observing student interaction. Students aware that teacher is circulating and consciously involve themselves in-group conversation.

Teacher mentions that students don't have to be talking all the time, but that they can ask each other for clarification, or even her, if it's about an instruction.

A student mentions that they don't have anything to talk about. Teacher answers comment by saying you can ask each other for clarification when a question arises.

Teacher, "Are you sure?" And asks when they come to a specific point in the assignment. Student, "well then….", and doesn't finish her sentence.

Teacher mentions she has good comments (Nov 6, Obs Field Notes).

**Teacher Perceptions of Professional Change**

Expressing the same sentiments as her teaching partner, Deborah believes the project helped her change her teaching practices in regards to the dimensions she chose to work on: Student Tasks (Dimension 4) and Student Assessment (Dimension 9). Deborah's main goals, consistent with Alex's, were to develop student tasks that would challenge and engage her enriched grade 10 Mathematics students, individually and in small groups. As well, Deborah devised rubrics that helped her assess her students on the tasks that she had created.

Deborah mentioned that, before the project, she would never have thought to use a rubric to assess her students. But after having gained experience over the weeks of the project, Deborah commented that she suddenly came up with the idea for using a rubric to assess an enriched activity she had engaged her students in.

Prior to class, the teacher mentioned that nothing special was going to take place and that group activities were difficult to schedule in all the time, since time is lost for covering the curriculum. Both teachers were stressed this final week of observations - possibly due to many factors, i.e. a staff meeting scheduled for beginning of week, report cards went out the week before, and Parent Interview Night scheduled for later this week. Teacher mentioned the enriched activity that she was planning to do, but also commented after the class that she came up with the idea of the students coming up with the categories and levels for the rubric in class. Teacher was wondering how she was going to mark this enriched activity, and came up with the rubric idea (Nov 27, Obs Field Notes).

Deborah's experience with using rubrics gave her the confidence to try it on an activity that she would have not previously thought about using it on. Deborah's positive experience with the project continued after the initial four observation sessions, when she and Alex decided to try and work on a different dimension. An activity Deborah devised with her teaching partner allowed them to work on Student Tasks, Dimension 4, as well as Student-Student Interaction, Dimension 8.

Both Alex and I felt that our teaching had changed. We realized the importance of getting out of the classroom and of using our environment to the students' advantage. Our field trip did not really extend much beyond the field, but it didn't need to be exotic for the students to enjoy a practical, hands-on experience. After the activity Alex and I discussed aspects of the activity that we never really expected; how students who had been paired together and didn't like it learned to use each others' strengths and how students given explicit instructions set about approaching the
activity in a completely different manner because they saw their method as being more accurate (May 16, Record of Activity).

Deborah and Alex felt their time working on Dimensions 4 and 9, Student Tasks and Student Assessment was successful, so they began working on their own on another dimension: Student-Student Interaction, Dimension 8.

Overall, Deborah also felt positive about the entire experience because she became much more comfortable with using rubrics and assessing students using the achievement chart and the four categories (Dec 3, Interview). More importantly, the project allowed Deborah to collaborate with her teaching partner in order to gain insight into their teaching efforts.

We need to make Math come alive more often. As always, a major drawback is time and the opportunity to brainstorm with other teachers. Alex and I had a rare opportunity to do just this and I think we both realize how important it is to have someone to bounce ideas off, share the workload and commiserate when things don't work out as planned (May 16, Record of Activity).

Enablers and Sources of Tension/Obstacles

Alex and Deborah really appreciated the opportunity to come to OISE to listen to the researchers and to share experiences with the other teacher pairs. Alex and Deborah felt that discussing what they were doing in their classes outside of the school environment enabled them to step back and reflect on their actions. Although Alex was uncomfortable in the beginning with a researcher in his classroom observing his teaching practices, he believed that the presence of the researcher prompted him to reflect more on his teaching practices, which helped him question the motives for his lessons. Deborah really appreciated the opportunity that this project gave her to update her knowledge on organizing questions into the four categories on tests as well as practicing creating rubrics.

Although Alex and Deborah were already discussing and sharing teaching strategies with each other, they both commented that their weekly goals intensified the dialogue and relationship. Alex and Deborah noted that the weekly meetings kept them on-track with respect to the dimensions they were working on. However, Alex and Deborah also commented that having to implementing new student tasks and assessment strategies was a bit too much, and they would prefer a much more lenient timeline.

Both Alex and Deborah experienced separate negative incidents during the process instigated by their department head. At one point, Alex's department head told him that she would never have someone else observe her in the classroom and that one of the student tasks that he was going to use was pointless. Deborah's negative incident took place when she was photocopying the first rubric she had created for a student task she planned on using the following week. The department head came into the room and when she saw a copy of the rubric commented that the activity that Deborah had planned was a complete waste of time. Deborah said that she felt really discouraged at her department head's comment, especially after she had put so much effort into creating the rubric. Although Deborah felt discouraged at first, she had enough conviction in her own teaching abilities to believe that the rubric she had created held merit and that what she was doing was worthwhile.

On the positive side, these negative messages from their department head were counter-balanced by their school's strong administrative support. The school's administration helped contribute to the success of the project by allowing Alex and Deborah every opportunity to have release time when they needed to observe each other's classes or when they needed to attend in-service sessions at OISE/UT. Both Alex and Deborah commented that this administrative support made them feel as if their efforts to broaden their teaching practices were validated. Alex and Deborah commented that they would still be committed to any future studies and
suggested that bringing in more administrative support, such as an administrator being another observer in the classroom, might help sway the department head to change her opinion of the project.

Alex and Deborah were asked if there was anything else that the project could provide for them so that they could successfully continue to work on implementing the dimensions. Both Alex and Deborah answered that they would have liked more time off from their classes so that they could spend more time in conference with their teaching partner or more instructive time at OISE. Both teachers believed they were given valuable tools when they attended the in-service sessions. They also believe that their entire Mathematics department would benefit if in-service sessions were offered at the school. Deborah and Alex commented that their colleagues developed an interest in the project and said that they would also like to have the opportunity to be involved in any future projects.

Summary of the Case Reports

Alex and Deborah both believed the project enabled them to collaborate to further develop their experiences with Student Tasks and Student Assessment. The project gave Alex and Deborah an opportunity to provide and receive feedback on each other's teaching practices by acting as sounding boards for each other. As well as having the time to discuss their teaching practices, Alex and Deborah were able to create time for each other by sharing resources and techniques. Ideas for student tasks and assessment strategies were shared between the two teachers so that neither of them had to waste time doing redundant chores. Alex and Deborah believed the project helped intensify their communication and collegial sharing with each other. Weekly meetings helped both teachers keep track of what they wanted to develop in terms of their teaching practices.

Case Reports for Barry & Mark

By Cathy Bruce

As an extension of the secondary study, the case of two intermediate teachers was also included. The pair consisted of one Grade 7 math teacher, Mark Jones, and one Grade 8 math teacher, Barry Smith. These two teachers taught at an intermediate school directly facing the secondary school that their students would eventually attend. The teachers had been attempting to make links to the secondary school math department in order to facilitate common approaches and smooth transitions for students entering Grade 9.

The Case of Barry, Grade 8 Teacher

Introduction

During the initial observation at the beginning of the project, Barry sat on a stool at the front of the room. His Grade 8 students were working on a set of cross stranded short answer questions which served as a warm-up to the math class. The walls were plastered with student work samples and charts with instructions to students. Barry encouraged students to stay focused and rewarded on task behaviours with verbal praise. After Barry observed that most students had completed the tasks, he asked one student to come forward to ‘take the stool’. This student then led the class in taking up the warm-up answers. For some questions, a student provided the correct answer and there was no discussion. For other questions, particularly when students had a variety of answers or asked for further explanation, Barry discussed the method and solution with students for clarification. This warm up took less than 10 minutes in total. Students were then directed to work in pairs or threes on a data management task which involved preparing chart paper displays of graphs and solution strategies. The students worked in their small groups for 40 minutes preparing their charts and their presentations (which were to be approximately two minutes in length) to the class. Barry circulated during the work period discussing student work. His focus was on multiple representations and depth of understanding. When asked a
question, Barry frequently suggested that students ask other students for assistance. The students were busy and active with free wandering in the room. They were on-task and highly engaged. Before the class was over, Barry explained to students that they would begin presenting their data and charts during the following math class. (Obs, Sept 30, Field notes)

Barry referred to his classroom as being a class with “high traffic with noise and interruptions and high needs students” (Nov. 28, Interview) and the observations concur. It should be noted, however, that Barry’s students were focused and although free to roam the room as needed, were purposeful about their activity (Obs. Oct. 1, Field notes). His classroom was also partially open to the room next door which was another Grade 8 classroom. Barry taught 5 math classes but also had a homeroom class. He had been working at this Intermediate school with a total of ten Grade 7 and 8 classes for ten years. He was a seasoned mathematics teacher who has been recognized both at the school level and the district level for his expertise in this area. Barry had taken on a leadership role within the school, often acting as the Principal when the principal was out of the building, and had been involved in a number of district wide math and transition years initiatives over the years. Barry was respected among his peers and always welcomed and encouraged dialogue and team planning both within his own school and at the district level. Barry worked hard to develop a strong math program that encouraged problem solving and integration of the strands using rich learning tasks. “The teacher likes to have a focus strand at all times, but weaves other strands into the tasks. As an example, the teacher described and provided a written handout of a ‘camp design’ project, where students applied measurement, geometry and number concepts and skills to design a camp.” (Obs. Sept. 30, Field notes) Barry also attempted to deepen understanding through multiple and varied opportunities to explore specific concepts and skills. For example, after conducting surveys and participating in a whole group data management task, students were given a series of statements to explore. Examples of the statements were: “40% of M & M’s are brown. On average, Canadians open their refrigerators 22 times a day.” Students had to create a mathematical rationale as to whether they thought each statement was reasonable or unreasonable.

When asked about his rating on the self assessment tool, Barry indicated that he knew where he would ‘come out’ overall on the profile: “The kids explore, but mostly on my terms. I’m at a level 3 (modified exploration focus) with some signs of level 4 (exploration focus)” (Dec. 3, Interview). Initial observations matched with Barry’s self-assessment.

**Teacher’s Action Plan**

Barry chose to focus on the dimensions of Student-Student Interaction (Dimension 8) and Student Assessment (Dimension 9). These two dimensions interested Barry as he saw them as relative weaknesses in his program. He said that the descriptions on the self assessment tool and the researchers’ first days of observations made him think that there was room to grow in these two areas. In particular, Barry was interested in the transparency of assessment (for Dimension 9) and in the level of student engagement during discussions (for Dimension 8).

Barry agreed with initial discussions that described focused student-student interaction (Dimension 8) as not easily sustained without teacher intervention. Interactions during whole group discussions and presentations were sequenced in a linear pattern from student to teacher and teacher to student, without direct student to student discourse (Obs. Sept 30, Field notes). During the independent work periods, students were observed working on their own but were organized into small groups for the sharing of supplies. They were encouraged to ask questions and clarify ideas with one another. During individual presentations, the students were placed in the expert role and were given considerable (over 5 minutes) airtime to explain their displays of data and analysis. The students observed presenting in the initial observations used rich mathematical language to describe their survey data including information about limits of the survey and used comparative language when describing results and problems encountered. The teacher had modeled this language during whole group data collection activities leading up to the presentations. In discussion with Barry, he recognized that his students
were communicating mathematically, but he wanted the level of student to student interaction to increase (Oct. 15, Interview).

During initial observations (Obs Sept 30, Oct 1, Field notes) Barry used a range of assessment strategies. Each student had a work folder. The folders included rubrics that had been used for assessing specific tasks, anecdotal comments made by the teacher on student work, end of unit student reflections (self-assessment) and end of unit culminating tasks, such as “The Strawberry Farm” which was a district wide instrument, developed by a group of teachers including Barry, used for assessing student achievement in Grade 8 mathematics. Written comments from the teacher on one student self-reflection selected at random included the following statements: “I’m glad you’re enjoying math so far. You need a more complete write-up of the hummingbird experiment” (Obs. Sept. 30, Field notes). The teacher was also observed using a rubric while students presented their data displays in class. Students were placed in the expert role both physically (positioned in front of the class) and verbally (significant presentation time) during oral presentations. The range of assessments was exemplary and reflected several years of development and refinement by Barry. As with student-student interaction, Barry had already developed a solid base of skills. His goal was to further refine his skills by developing more transparent and shared tools and strategies for and with students. Barry wanted to shift from a teacher-directed assessment approach to a more student-directed assessment approach.

Implementation of the Teacher’s Action Plan

In order to work on these two dimensions, Barry embarked on a Fermi Problem Solving unit. “As you know, the unit is being built around the idea of increasing transparency, promoting student-student interaction, and continuing to build on the idea that students can take responsibility for selecting/providing evidence of their learning.” (written note from Barry Nov. 18). Fermi problems are characterized as being open-ended with multiple solution strategies and solutions. Barry wanted to heighten student awareness and skills with open-ended problem solving tasks and increase student team work (student-student interaction). He also wanted to negotiate a new rubric with students for problem solving at the beginning of the unit in order to develop more transparent, negotiated means of assessment. This strategy of negotiating the assessment was explained in a group workshop (October 15, minutes) to support the teachers in the project. Significant discussion during the workshop included a brainstorming of ways to involve students in negotiating criteria for assessment. A Fermi problem generally requires estimation of physical quantities to arrive at an answer. These problems challenge students to ask more questions, define the parameters of their solution and determine reasonableness, not just provide "an answer".

Evidence of Implementation

Barry began the year as a very capable mathematics teacher with a modified exploration focus in many areas of his program and an exploration focus in dimensions 4, 5 and 10 (Student tasks, Construction of knowledge, and Conceptions of math as a discipline). He embarked on the study with enthusiasm and saw this as an opportunity to move his teaching along further. Barry focused on Student-Student Interaction and on Student Assessment. In both of these areas, Barry demonstrated a shift in his practice toward an exploration focus.

a) Student assessment

From the first observations, Barry demonstrated an exploration focus for Purpose of assessment and Variety of assessment, but there was no evidence of transparency. Barry identified the sub-dimension of transparency as the area he needed to address. In order to develop transparency in his assessment strategies, Barry had students participate (Obs. Nov. 12, Field notes) in a graffiti board exercise (adapted from the text Tribes: A New Way of Learning and Being Together -p. 300, by Jeanne Gibbs) where students had to brainstorm answers to questions/prompts about problem solving such as:
- The hardest type of problem to solve in Math is...
- When I am solving problems in Math, it is helpful when...
- If our class was problem solving in small groups, an observer would hear...
- If our class was problem solving in small groups, an observer would see...

Students worked independently while writing on the graffiti charts, each with their own marker. Students were organized into seven small groups where the groups of 3 or 4 were writing all at once. When the graffiti boards were completed, each group took one chart and had to summarize what they read on the chart. This required group decision making about how to organize the information and what criteria they would use for selection of ideas for the summary. Students discussed ways of organizing the information with no direction about how to do so from the teacher. Some groups used t charts that organized information into ‘good behaviours’ and ‘bad behaviours’, some groups sorted by frequency (the number of times an idea was written), others used cloud bursts with lines to webbed ideas, some made linear lists. (Obs. Nov. 12, Field notes). Once Barry was confident that students had a clear understanding of what problem solving involved, he had them work in small groups to try out a problem. The ‘Bicycle Problem’ took approximately 75 minutes to complete and four students were selected to make observations about the groups as they were problem solving. These four students reported their observations to the class in the organization of a T-Chart with the following headings: “What I hear in the problem solving setting” and “What I see in the problem solving setting”. At this point, Barry shared a set of five criteria for assessing student problem solving. These criteria were posted on large paper. (Stays on task, Shares ideas and builds on ideas, Listens and encourages others, Appropriate use of mathematical vocabulary, and Develops a solution/Defends a solution). In small groups, the students then created the descriptors for each of the 5 criteria (one criterion per class) in order to make a giant chart with the rubric on it. Students used vocabulary from the graffiti charts to help them with their descriptions. The final rubric was posted across one full wall in the classroom. Barry told students that they would be evaluated based on these descriptions that students had negotiated in class (Obs. Nov. 12, and 20, Field notes). The chart became the foundation for a student-teacher negotiated rubric of what problem solving should look like and sound like for the Patterns and Problems unit (Obs. Nov. 12, Field notes).

On the fourth day of observation during interventions (Obs. Nov. 20, Field notes), Barry opened the period by reviewing the criteria for evaluation of problem solving activity.

T: What will I be looking for today?
St: On task, quiet work.
T: What kind of work?
Sts: Various students referred to specific components of the rubric on the side wall to describe the kinds of work the teacher would be looking for.
T: So I will be looking to see how you work with your partner. I’ll be doing that on my tracker.

After this class, the teacher wrote a note to each small group about his observations of their interactions and related the observations to the class rubric. Example:

Jessica and Soroya (level 3 – solution write up)
You were both very focused during my observation and were sharing ideas and building on the ideas of others. 6 solutions was quite a good number for the time allotted.

Students were observed reviewing comments from the teacher very carefully.

On the fifth observation (Obs Nov 20, Field notes) Barry told students at the beginning of class which items from the student negotiated rubric he would focus on during his observations of group work. There was a one minute review of the rubric on the wall with students before they began their work period. During this
observation, once again, student assessment was made explicit, transparent, and was based on student negotiated criteria.

\[ \text{b) Student-student interaction} \]

Barry also focused on student-student interaction in a variety of ways. His area of emphasis was group work which included mathematical discourse amongst peers. Just prior to the intervention stage of the project, Barry did an analysis of student interaction in the classroom. On November 1st, with ten minutes left in the class, students were asked to make notes about the types of math conversations they had had during the work period. Barry then made a table which illustrated categories of discussion (giving advice, showing how to use a protractor, using formulas for perimeter, organizing a chart, calculating PST and GST, etc.) and who used each of the categories. He shared the information back with the students. Barry described this as a useful tool in guiding students toward helping one another and having mathematics related discussions. During the intervention stage, Barry placed the students in groups of four for the Fermi math problem unit. They worked within the group of four, in pairs, to develop solutions to challenging open-ended problems. During this unit, students were encouraged to share and talk and defend their ideas. Students were therefore moved from a single desk seating arrangement to groups of four. Barry described this as “a risk to go to groups of four, but it worked.” Students were highly engaged in the Fermi problems and spent work periods talking in their groups, defending their mathematical ideas and solution strategies, determining reasonableness of solutions and preparing presentation format cards with their solutions to share with peers (both small group and whole class). On the second week of observations, students shared their cards with peers with a range of levels of success: Pair A and B came together. One member of Pair B looked at the card that Pair A had created and stated: ‘You only picked TV’. Pair A member stated: ‘I can fix that. We can’t be wrong, this is a Fermi question. The students parted and made changes to their solutions and their cue cards. After several observations of this nature, I observed a pair of students sharing very effectively. The first person read over the other pair’s card organized by assumptions, strategy, and solution. The asked specific questions about how they came up with their totals: ‘How did you get 3 months?’ The pair clarified. Then Barry and I discussed how the groups were sharing their solutions and he decided to have one group model positive sharing for the class, to illustrate effective sharing strategies. (Obs. Nov 12, Field notes) Over the next week, Barry did a second analysis of student-student interaction and shared this with students along with a group rating based on the student negotiated rubric.

On the third week of interventions (Obs. Nov. 20, Field notes), Barry asked the class to reflect on Fermi problems:

T: If somebody said that compared to other problems, Fermi type problems are easier, what would you say?
St: They’re harder – there’s too many things to work out.
St: They’re harder because you have a bunch of information. It’s hard to get the right information. One person hardly watches TV and the next watches a lot.
St: They’re easy, you just have to get on a role.
St: They’re easier because any answer could be right.
St: It’s easier to estimate.
T: Okay so 43 songs – that’s my answer.
St: But that’s not reasonable. That’s not probable. Is it a lifetime or what?
St: You have to find a probable way. Your 43 is not probable.
St: You have to find out the properties of it. You have to figure out the details.
T: Should I allow you to do these types of problems?
St’s: Yes!, They are interesting.
St: They require a lot of vertical thinking, hard deep thinking.
T: Vertical thinking I like that. Okay let’s get started.
Remarkably, during this whole group discussion, the pattern of interaction had changed from previous observed discourse. Barry supplied a prompt at beginning of the discussion which led to five student responses without additional intervention. The teacher then added a clarifying statement which led to three more student responses. The final student who speaks in the discourse summarizes student beliefs about engaging with Fermi problems when he states: “They require a lot of vertical thinking, hard deep thinking.”

During the final observation of the intervention stage (Obs Nov 28) students worked in pairs to develop solutions to a complex scheduling problem at a health clinic. Students were expected to share and defend their solution strategies to their classmates toward the end of the period. A range of solution strategies were applied including diagrammatic, series of calculations, charts, written steps and solutions. In most pairs, one person did most of the writing and the other person used a calculator or made calculations. Interestingly, in the pairs observed, the roles were exchanged back and forth within the one session. The pairs discussed the details of how to solve the problem and how the calculations should be made. Students also discussed whether there was any missing information and whether estimates would be acceptable in a solution for this problem. The teacher did not provide answers to these considerations and students worked together to determine how to approach the problem in such a way that indicated a high level of confidence in their abilities (e.g., students did not ask the teacher to determine whether estimates would be acceptable, the pairs decided and justified their decision) (Obs Nov 28, Field Notes).

During observations of the four week intervention stage, conversations amongst students were noted and showed increasingly that students engaged in mathematical discourse in small groups. Students had to develop joint solutions and strategies. Students had to explain their thinking for organization of information and support their ideas to small group peers. Some struggled with the sharing element (did not share effectively – mumbling, no eye contact, not listening without interrupting, not asking clarifying questions) as they did not naturally have effective sharing strategies. When this was discussed between the observer and the teacher, the teacher then decided to have one student from each class and himself demonstrate the sharing process in front of the class in order to model what it ‘looks like’ and what it ‘sounds like’. The quality of student sharing and discussion increased through practice, reflection and growing confidence by the students. Observations also indicate a distinct shift in the pattern of whole group interaction to an increased number of statements made among students without teacher intervention.

**Teacher Perceptions of Professional Change**

Barry indicated (Dec. 3, Interview) that his “focused attention on assessment and student-student interaction allowed [him] to grow in [his] teaching practice”. Within two and a half months of the introduction to the project, Barry remarked on an improvement in the level of student-student interaction: “There is no doubt that Math talk has increased substantially in all classes. I am pleased with the way in which students asked me a lot less questions and tried to seek the answers/support/reassurance from their peers. I was pleased with the degree to which students tried to build on the suggestions of their peers and to come to ‘common ground’ when trying to come up with assumptions/strategies, etc.” (Written note from Barry, Nov. 18). When asked about his own progress at the final interview stage, Barry said he thought there had been specific positive shifts in his program. Barry made a list of outcomes that indicated growth (Dec. 3, Interview) related to student-student interaction:

- Student write-ups on cards improved
- Reflective journals by students describing interactions improved
- Students gained and used new vocabulary such as the word “assumptions”
- The level of student engagement increased
- Students demonstrated increased persistence for those in the middle and lower range of achievement
When asked if he would maintain the changes in student-student interaction strategies in his mathematics program, Barry said that now, he could “not go back”. He wanted to maintain the level of small group student-student interaction, but also wanted to move to examining whole group interaction more closely. “I was very focused on student-student interaction and I saw good growth there. Increased student level of interaction is my evidence of success. My next step will be to work on whole class student-student interaction which is spontaneous, not teacher driven” (Dec 3, Interview).

When asked (Dec. 3, Interview) about his shifts in practice related to transparency of student assessment, Barry said “Over the four weeks [of intervention and observations], I opened things up. In May, the survey would change again. For example, I think there will be more transparency.” He listed several specific types of evidence of improvement:

- Providing students with individual written and verbal feedback led to specific areas of improvement for those students
- Individual student results in problem solving increased from the previous unit
- Write ups on cards improved
- Students were faster getting on task (actually recorded by the teacher)

This list actually addresses the results of increased transparency which indicate that the changes in Barry’s practice were of benefit to students and student learning.

Barry indicated a strong interest in further exploring transparency of assessment in his program in the months to come. In April, for example, student work was scored on a student negotiated rubric for a unit based on the theme of the human body (written note from Brain, May 14). In a reflection written in June, Barry wrote: “Over the summer, I hope to refine some of the tasks that we used in the earlier phases of the project and use them right at the start of September (i.e., Patterns and Problems) so that the message to the students is clear that I value transparency and a sharing of learning on the mathematical road”.

Over the course of the year, Barry wrote extensive notes about his activities focused on student-student interaction and assessment. He shared these notes with the researcher regularly as a form of communication about his sustained interest in and work on the dimensions selected for his journey toward improved mathematics teaching and learning. Barry began the project working at a modified procedures focus level for student-student interaction and at a modified exploration focus level for student assessment (sub-dimension of transparency). After implementation of a variety of enabling strategies to enhance these areas of his program, Barry was able to shift his program to an exploration focus in both dimensions.

The Case of Mark, Grade 7 Teacher

Introduction

As students walked into Mark’s class they were presented with a warm-up activity that asked them to place the numbers 1-9 into a triangular shaped diagram so that each side added to 20. The teacher set the timer for seven minutes. No students had a solution within seven minutes. He added another minute to the timer. By this time, one student had a solution. The solution was taken up and the strategies students used were also solicited. Mark told the students that there were at least three different solutions to the one problem. The following discussion occurred:

T: What could help you solve this problem?
St: A list of numbers that you can cross out as you use them.
St: When you place the numbers in the corners, you’re using them twice.
T: What about the placement of large and small numbers? How should you decide?
St: You need to balance them out.
T: Okay, I don’t have a lock step suggestion for how to solve this problem other than trying out numbers. It’s trial and error. Let’s look at a solution.
Student volunteers a solution.

Mark then organized the students into three rotating groups. One group worked with Mark at the front of the room. A second group worked on a student tracked software program called “Math Trek” (Ministry licensed trademark software) at eleven computer stations on the perimeter of the class. The third group worked independently in the middle of the room on posters demonstrating their breadth and depth of understanding of graphs and displays of data. They were encouraged to use a range of resources (textbooks, glossaries, calculators, other student work samples) to help them with their posters. Mark then taught a probability lesson to the group at the front of the class, introducing the lesson with a candy jar full of different coloured Kerr candies to demonstrate the differences between ‘outcome’ and ‘probability’.

Mark taught three Grade 7 math classes but also had a homeroom class. He had been working at this medium sized Intermediate school for ten years. Mark was a seasoned mathematics teacher who had participated in a range of training and in-service programs (such as the ETFO Summer Institute for Learning in Kingston, Ontario with Trevor Brown) and demonstrated local expertise in this area. Mark had taken on a leadership role in partnership with his colleague Barry within the school. Mark described his goals in mathematics as having a common approach (with Barry’s): “Our goal is to reach out to every kid. When you see a structured lesson, you lose things. What we do is pose a problem and see what happens. We struggle with what we have to do versus what we need to do” (Nov. 28, Interview).

Mark’s program began the year with an atypical strand focused unit on Data Management and Probability. In his long range plan, the other units included cross-stranded tasks for the most part. (Obs Sept 30, Field notes). The teacher indicated using investigations based on resources such as the OAME document “Linking Assessment and Instruction in Mathematics: Middle Years”. Mark referred to these as “woven tasks” (Obs Sept 30, Field notes). The activities students explored in the initial observations involved multi-styles of learning: use of the computer, kinesthetic learning with paper folding, consolidation with pen and paper workbook tasks, visual and written representations on poster displays.

At the beginning of the school year, Mark liked to show the students a film entitled “Contact” because it had a wide range of math concepts used in it including use of prime numbers, math as a tool for communication, time travel, problem solving, etc. He described this as a jump off point for discussions about ‘how big math is’. (Obs Sept 30, Field notes) Mark perceived mathematics as a useful, dynamic body of knowledge which he personally enjoyed exploring with his students. Mark stated “Math is everywhere, everything. There are people who don’t know how the world ticks because they aren’t interested in math.” Mark also mentioned a personal interest in reading math related books for pleasure. (Obs Oct 1, Field notes) When asked about his use of the self assessment tool, Mark said that conducting the self-assessment gave him the urge to “step out of what we are doing and SEE what it is” (Dec 3, Interview). Mark clearly perceived a need for self-reflection as a positive component of personal professional growth as a mathematics teacher.

Mark began the year as a very capable mathematics teacher with a modified exploration focus in many areas of his program, an exploration focus in dimensions 4 and 10 (Student tasks and Conceptions of math as a discipline) and a modified procedures focus in dimensions 6 and 8 (Teacher’s role and Student-student interaction). He embarked on the study with enthusiasm and saw this as an opportunity to move his teaching along further. 

Teacher’s Action Plan
Mark chose to focus on the dimensions of Student-Student Interaction (Dimension 8) and Student Tasks (Dimension 4). These two dimensions interested Mark because he perceived them to be weaknesses in his program. He rated them both relatively lower than other dimensions on the self-assessment tool. In practical terms, Mark focused on Dimension 4: Student tasks and Dimension 8, student-student interaction became a secondary outcome when exposing students to rich tasks. He said that his quest to find interesting, workable, cross-stranded, rich investigations was an on-going pursuit. In particular, Mark was working on student tasks; Sub-dimension solution strategies. He was interested in searching for, using and/or creating tasks that allowed students to use multiple solution strategies and that included multiple solutions.

In order to improve student tasks, Mark decided to find and use a variety of tasks with students and evaluate their effectiveness based on student responses and his own observations. Mark wanted to increase engagement in mathematical thinking and discussion with open-ended problem solving tasks. Mark did not have a detailed plan but he began examining and collecting a broader range of resources and materials. His heightened awareness to the quality of tasks and the activity of gathering tasks led to trials of using those student tasks which were more open-ended than previously used: “They were more open and I just had a better selection of tasks.” (Dec 3, Interview)

Implementation of the Teacher’s Action Plan

In the area of Student Tasks, Mark demonstrated a shift in his practice toward an exploration focus. The changes in student-student interaction were directly connected to the fact that students were more engaged in the tasks, and thus engaged in more detailed and sophisticated mathematical discussion.

a) Student tasks

During the first two weeks of the intervention stage, students were introduced as a whole group to a project on making a travel-sized mathematics game. Students were very interested in the project and asked many questions during the introductory lesson (Obs. Nov. 15, Field notes). They were also interested in looking at similar projects completed by students the year previous. The project itself was cross-stranded and engaged students in both problem solving and in reviewing areas of mathematics that they found most difficult. The game was to have a theme, a rule booklet, a variety of Grade 7 math questions and answers across multiple strands, a storage container, a mechanism for moving through the game (dice, spinner, point cards, etc) and game pieces (Obs Nov 15, Field notes). On the back of the student guide sheet, Mark had generated a rubric for scoring the games. The criteria for assessment were shared during this introductory session. Students were given the option of working in pairs or independently. Almost all students observed decided to work with a partner. This task became the focus for the group that was working independently in the classroom while the others worked at the computers or at the front with Mr. Jones. Students working on their games worked together to brainstorm ideas. One pair was observed making a list of what they could do. They listed their ideas on paper. One of these pairs came up with the idea of a shopping game where you have to add on taxes and look at prices of items on sale. This pair commented on how it was harder to come up with a good idea than they thought it would be. A second pair wanted to focus on Algebra and have chance cards, but had not come up with a theme (Obs Nov 15, Field notes). Two other pairs discussed ideas but did no recording of ideas. The game project was a departure from the Ontario Workbook which was used more regularly with the group whose rotation was at the independent work area.

During these first two weeks of intervention, the students demonstrated more un-settled and off task behaviours than during observations of the pre-intervention stage. By the third week of interventions however, (Obs Nov 20 and 28, Field notes), students and the teacher settled back into the non-disruptive patterns noted during initial observations. This temporary unsettled environment is not unusual when teachers implement changes in their programs. The shift in student tasks became more directly evident later in the implementation stage (Obs Nov 20 and 28, Field notes).
Students at the front of the room were given challenging open-ended tasks which they worked on independently, and then as a small group. The students observed were very focused on the tasks and engaged by the challenging nature of the problems (Obs Nov. 20 and Nov. 28, Field notes). The problems led students to further discussions beyond finding a solution to concepts. For example, students explored the dimensions of increasingly long and narrow rectangles with the same (fixed) area using a strategic list. This led to a discussion of use of decimals in solutions and the infinite possible dimensions of a rectangle with a given area.

T: How is this problem different from the first (a closed problem presented to students earlier)?
St: There was only one answer in the first one.
T: Because there was only one variable open. This problem has two variables. If we keep going with this list (a list of possible lengths and widths for the rectangle with a fixed area), what will the rectangle turn into?
St: A line.
St: Infinity
T: Mathematicians think about these things all the time.
St: What is infinity?
This led to further discussion on the notion of infinity as a construct.
(Obs Nov 20, Field notes)

The teacher built student confidence during this class with individual students who were reluctant to participate. He had the students speak quietly to him and then when they were sure of their answer, the teacher would say “Now in a loud voice so others can hear” (Obs. Nov 20, Field notes).

The use of Geometer’s Sketchpad on Nov. 28th to examine the properties of a trapezoid led to questioning by students about what they believed to be ‘actual trapezoids’. The lesson on trapezoids was intended to be review but due to lack of background knowledge of the students, ended up becoming a full blown lesson. Because the problem was open ended, Mark was able to shift the activity around and “level the playing field” by reviewing basic properties of trapezoids. Students began the lesson with a lack of confidence and with misunderstandings about the concepts and procedures related to area of triangles and trapezoids. The students did not know the sum of the angles of a triangle or square. This made the teacher stop and return to some basic properties of simple 2D figures. He did this by asking the students what they knew about triangles. Students described what they knew but did not include the sum of the angles. The teacher probed further and then explained that they sum to 180 degrees. Students then solved the problem in various ways, with little problem. The teacher did not get upset, he simply started to work backward and the students gained more confidence in their abilities (more hands raised, more elaborate responses, more questions asked) (Obs Nov 28, Field notes). Mark felt that the use of Geometer’s Sketchpad was a critical tool in making that work effectively. This format of open problems that allow students to explore from a basic level to a sophisticated level was what excited Mark the most about his work over the course of the project. (Dec 3, Interview)

At the end of this class, students were assigned a task related to multiple strategies for finding the area of a trapezoid: The problem showed three students each solving the problem differently but none of the students had completed their work. The task was to complete each method and solution and find a related algebraic expression to match the method.

Both Barry (the other teacher participant in the pair) and the observer agreed that the tasks provided for students were richer and more engaging for the students. As a product of the quality of the tasks, students became more engaged and the level of discussion and questioning improved (Dec 3, Group interview).

b) Student-Student Interaction

Mark did not have a specific plan for addressing student-student interaction. He used this dimension as an indicator of quality tasks. In other words, if the tasks were rich enough and allowed for both multiple
solutions and multiple strategies, then the students would engage in more meaningful and animated discussion. During the first observations (prior to the intervention stage) Mark worked with a small group using the Ontario Math Workbook. The teacher provided instruction on tasks that required students to work independently and then share their solutions in the small group to check for accuracy. This exemplifies a modified procedures focus. The interactions that occurred were in a consistent pattern of teacher-student-teacher-student (Obs Sept 30 and Oct 1).

During the intervention stage, Mark maintained this pattern for the first two weeks. Then in the third week of the intervention stage, Mark shifted the lesson so that there was a modified exploration focus. Students were expected to work in small groups and to defend their thinking. They independently shared solutions with peers and the teacher. An example of Mark’s use of this approach was highlighted when students explored the concept of infinite length and width dimensions for a rectangle with a fixed area. As a result of open-ended task exploration in groups, students engaged more eagerly in extended discussions about mathematical concepts and therefore the level of student-student interaction increased in amount of time and in the quality of the discourse. The nature of the communication with the teacher’s small group was gaining some features of a looser ‘conversation’ about their thinking and problem solving strategies as well as making connections to larger math issues (Obs, Nov 20, Field notes). This shift was sustained in the final week of observations.

**Teacher Perceptions of Professional Change**

When asked about his own progress, Mark said that he thought his teaching style had not changed but that the tasks he found/developed and used were more effective. He described this as a “heightened awareness of the quality of the tasks” (Dec.3, Interview). “The way that I teach didn’t change. I thought more about how (Mark’s emphasis) I was presenting things to the students. I wanted multi-stranded student tasks” (Nov 28, Interview). Mark made reference to some specific consequences the changes he implemented and of growth in his teaching practice:

Students in small group with the teacher became more focused;
Students in small group with the teacher were more engaged with the tasks;
There was a higher level of participation and contributions made to mathematical discussions;
Increase in the number of student questions;
Improved level of questions (more “I wonder if” type questions were posed by students);
Students came more quickly to task;
Improved richness in the problems given to the class.

When asked if he would maintain the changes in student tasks in the program Mark talked about his own drive to continue to find rich tasks. He also indicated a desire to meet with other Grade 7 and 8 teachers to pursue rich tasks collectively and pool ideas and resources.

Mark’s list also highlights how student-student interaction became a measure of success with the tasks assigned. Three of Mark’s indicators of student benefit from the changes in tasks were directly linked to student-student interaction. In particular:

- There was a higher level of participation and contributions to mathematical discussions;
- Increase in the number of student questions;
- Improved level of questioning.

Mark indicated a high interest in further exploring, developing, sharing and trying out rich tasks in his program in the months to come. He wanted to expand his pursuit of rich tasks to working with other intermediate mathematics teachers with the same goal.
Mark began with an exploration focus in the area of student tasks and a modified procedures focus in the dimension of student-student interaction. After implementation of increasingly rich tasks, Mark demonstrated a higher degree of exploration focus for student tasks, and a modified exploration focus for student-student interaction.

Enablers and Sources of Tension/Obstacles

Barry was a very positive, motivated and experienced math teacher. He had a history of engaging in personal professional development and continued to do so during this study. His very conception of mathematics was that of an ever changing dynamic construct and it allowed him to explore mathematics teaching in new ways continuously. Mark was a very reflective teacher who was committed to continuous improvement in his practice in order to better meet the needs of students in his math classes. His love of mathematics and his extensive experience teaching mathematics at the Intermediate level, allowed him to expand his skills confidently. Mark needed time to think about what he was doing and introduced change slowly. Together, Mark and Barry developed a community of practice over three years of working on developing a comprehensive Grade 7 and 8 mathematics program. The partnership was furthered by this case study research. In fact, Mark, Barry and the researcher for this case presented their findings and their successes at a federation sponsored workshop. They prepared a detailed handout and CD for participants which included tried and successful tasks and strategies related to the project. Through the interaction during this case study, a community of practice was developed. “We have a common approach. We’re all learners on a journey. What we really enjoy is the incidental teaching – those teachable moments.” (Nov 28, Interview)

Mark and Barry attributed their growth to several specific components of the project.

Professional Relationships: Mark and Barry had already established a solid content knowledge base about the discipline and the curriculum. Using this base, they enhanced their pedagogical strategies. They believed that the professional partnership between one another as teachers enabled growth during the study. When asked if they wanted to continue with this work they stated that they wanted a longer term project that included other Grade 7 and 8 teachers, more workshops to learn about peer coaching and looser timelines that were more teacher driven. Barry stressed his desire to spend time talking to colleagues at the school in order to inform them of the work they had done and would like to continue. Mark and Barry saw implications of this model for their own school and beyond the school in their local district school board. They said that they were very eager to establish a group within their district that would meet regularly, but would also have time to observe one another and work on common goals and planning strategies. They explained that it was difficult to find people with the internal drive to do this type of work and that by combining it with the peer coaching model and with release time, it would be of enormous benefit to the participants. (Dec 3, Interview)

Barry and Mark made specific reference to several other areas of the treatment that also enabled their practice to shift during an interview (December 3):

Self assessment tool: The self assessment tool allowed Barry and Mark to focus their attention on the details of specific dimensions and sub-dimensions. They both found the fixed four levels in the self-assessment tool to be too rigid and suggested that a sliding scale within each of the levels would allow them to pinpoint a more valid measure of where they saw themselves.

Information about Standards-based Teaching: The workshop allowed for sharing of ideas and discussion. At the same time, because of the level of expertise in the workshop, Mark and Barry felt a sense of inadequacy “because the other teachers [meaning presenters] were so good” (Dec 3 Interview). Mark noted that the opportunity to discuss ideas at the workshop was useful, and that there was a need to meet with others more regularly.
Peer observations: The peer observations gave the teachers a sense of reassurance that they were ‘on the right track’. Both teachers wanted to observe other classrooms as well. They believed that by watching others teach mathematics, it informed them of different strategies to use and ways to approach the discipline.

Being Observed by a Researcher: Barry noted a positive effect of being observed by a researcher in the way that students wanted to “perform somewhat” for the researcher. “But I didn’t worry about you being there too much because you are a teacher and you know about the reality of the classroom. There was an incidental spin-off of you being there as kids wanted to talk to you and work with you, like Kyle today” (Nov 28, Interview). This allowed the teacher to observe some of the students’ specific talents and areas of strength. He also indicated that our on-going discussions were a model for professional development: “There was an actual impact because we (the researcher and teacher) talked together right there in the classroom.” (Dec. 3, Interview)

Barry and Mark also identified one particular aspect of the project that was problematic. The short timeline made it difficult to measure growth using the self-assessment tool. Barry found the four week intervention stage far too short with not enough time to plan and implement the changes that he wanted to make. He saw the need for a longer intervention period with more opportunities for the participants and the researcher to meet and plan together. Mark also found the timelines for this project too short. “The timelines were really too tight. I didn’t have any specific planning time set aside for this during the four week observation block… I did pay more attention because someone was watching me. But it reaffirms what I am doing to have someone else there. It heightened my awareness. I’d like to change this so that you (the researcher) come and observe, and then we have a planning session, and then you observe again and so on” (Nov. 28, Interview). The short timeline for measuring growth was difficult to meet, Barry and Mark didn’t have enough time to give feedback to one another after observations, and they wanted more direct feedback immediately following lessons observed: “I did find that it was too long between each observation period. I would like tighter blocks of observations and discussions.” (Int. Nov. 28). Mark also wanted more training and in-service in his focus dimensions and he wanted more time to plan throughout the process. They both expressed concern about stopping at this point and said that “the project was really just a beginning to a much larger process of teacher professional development” (Dec 3, Interview).

Summary of the Cases

Mark and Barry had established a good working relationship before the project began. They worked well together and shared a common understanding of the value of mathematics learning both for themselves and their students. They held a personal professional stance that encouraged the trying on of new strategies to improve student learning. Mark and Barry had a shared understanding of math teaching that was dynamic and professionally enabling. They marveled at moments of inspiration students had in their classrooms. They pushed their colleagues to do the same both within the school and beyond. In April, Barry and Mark conducted a workshop for their peers in the district entitled “Communicating Mathematics” which relied significantly on the results of their work in mathematics during this project. The workshop was very well received. Barry and Mark were both satisfied with the presentation, although there was not as much time to present as they would have liked. “I am happy with the way our in-service for other Math teachers went. We still need, as a profession, to look for vehicles to enhance the spread of ‘best practices’” (note from Barry June 20, 2003). Mark and Barry felt that they had learned so much from the project and their own experiences, that they took advantage of the opportunity provided by the workshop to share their understandings, strategies and their excitement.

In summary, the growth of Mark and Barry’s practices in this project can be attributed to a number of factors including:
A prior disposition to change and trying new strategies as professional goals that would enhance student learning which was in agreement with the aims of the project (moving teacher practice toward increased reformist practices);

Opportunities to meet and talk about their programs together with the case study researcher;

Use of the self-assessment rubric to focus on and illustrate specific sub-dimensions of effective teaching practices for mathematics;

A supportive professional partnership;

Opportunities to observe one another’s classrooms and discuss what they observed.

Case Reports for Don and Cheryl

By Sonia Ben Jafaar

Cheryl’s Report

Introduction

When Cheryl arrived in class, she would generally find a couple of students sitting at their desks. As the students entered the classroom, they talked to one another and asked the teacher what they would be doing in the lesson? The class had a casual atmosphere as evidenced by the informal conversations the students had with the teacher around their appreciation for mathematics, the topic they were learning, or the activity they were going to do. The students enjoyed the challenges set forth by the program of study even when they found the work “hard.” As one student explained to her peer when asked if she did not “get it,” she understood it, but it took her a long time, but she ‘loves it’ [T5 Observation].

At the start of each class, Cheryl would call the class to attention while writing the agenda on the board [T1-4 Observations]. On cue, a student would go to the side board and write the solution for the problem of the day [T1 Observation] as the rest of the class went over a problem on the board relating to their homework. When the homework question was resolved, the student at the side board presented her solution to the class by explaining what she did and how she came up with her strategy [T1 Observation]. A couple of questions would arise from the class, and the student at the board answered.

Topics would be presented with a discussion or an activity. Cheryl was willing to take risks with the class and share her concerns about the situation. Additionally, she invited student input to determine if the new activity was worthwhile [T1 Observation]. One activity consisted of the students using the formula for circumference that they already knew and manipulated it with the different radii, to investigate the circumference ratios [T1 Observation]. In another class, Cheryl introduced the concept of parallel slopes through a whole class exploration of the properties of a line within the context of plotting three points and searching for the fourth point that would construct a parallelogram. Cheryl went through one problem with the students on the overhead, and then allowed them to continue on their own while she circulated [T7 Observation].

Cheryl would manage a variety of understandings from the individual students in the class. Some students would complete exercises in their heads, while others struggled to understand links. Cheryl consistently probed for understanding when interacting with students in the class. When they offered answers, she would inquire as to how they knew their answers, what their solution strategies entailed, and what relationship did the solutions have with the problem posed? Some illustrative examples were:
During an activity where the students were determining the ratio of the radius to the circumference of a circle, a group of students announced that they determined that the ratio was 6.5. Cheryl asked them why 6.5? What relation does it to the formula? The students looked at the data they had recorded on the board, and the formula they had written, and then were silent and pointing to the items on the board. They appeared to be pondering the link as very shortly afterwards; they explained it to the teacher [T1 Observation].

Moreover, Cheryl encouraged students to work beyond the boundaries of first solutions. “When students would check their answers with the teacher to open-ended questions, she would look at their answers and encourage them to try and come up with some more solutions” [T3 Observation]. Alternatively, she would encourage various solutions in her comments while circulating through the class and calling out that the students had “very interesting solutions” to the problem of the day [T7 Observation].

Cheryl’s focus on formative assessments was matched with her interest in ensuring her summative assessments were valid and transparent. She additionally prioritized assessment above evaluation and worked to enhance student confidence with respect to testing. One example that evidenced Cheryl’s concern for assessment validly was when a quiz was scheduled for a given class. Cheryl stated she had not seen the students since the last week, and did not feel that they were prepared for their scheduled factoring quiz. Yet, the departmental constraints and culture made her feel she needed to administer the quiz regardless of her uncertainty. To circumvent potential problems, she offered the students a practice quiz in the form of a worksheet that they worked on in pairs prior to completing the quiz [T4 Observation]. Her decision reflected her use of assessment as a tool for increasing student learning as opposed to pure evaluation. Her belief regarding the purpose of assessment permeated her practice and was adopted by students who internalized assessments as opportunities to learn:

While working on a problem set, students were debating the division that they had done in the solution, and one student told another that they divided it wrong and then proceeded to show his partner something on a paper [T1 Observation]

While students were working on problems, some talking aloud to themselves, others to their neighbors, they often checked their work and answers with one another. When a student got a different answer than his neighbor, he looked at her peer’s paper and identified his error as dividing wrong [T6 Observation].

A student asked about starting the problem of the day and the teacher answers by asking him what he can do with the 2 expressions?

S: put them together
T. how
Two more students join the conversation and start to discuss how to solve the problem
S: ooooh I did it all wrong
(End of class)
T: time to go
The three students don’t move and continue to talk about the problem in the group while the others remain at their desks working [T7 Observation].

The culture of understanding that Cheryl has fostered in her class through her use of assessment as a learning tool was evidenced by the high student average she showed me in the grade book [T5 Observation]. Additionally, students would often continue their mathematical discussions even after Cheryl would announce the end of the lesson. On one occasion, she repeated herself and encouraged them to leave for their next class. Although some students did leave, a group of four students remained at the board trying to recall the proof for the Pythagorean theorem [T5 Observation].
Teacher Action Plan

Cheryl decided that she wanted to focus her attention and energies on the dimensions of Technology and Assessment.

In terms of Technology, Cheryl self-evaluated at a level 2 and reported wanting to progress to a level 3 on the rubric. She clarified that her rating would vary with the topic and availability of the technology at that time. Her plan to attain her goal involved the use of the laptop computers in the class with the software Zapgraph. She made it clear that the use of this software was better suited for the students’ learning than graphing calculators. When Don insisted that the use of graphing calculators was mandatory in the new curriculum guide, she reported that the mandate would be sufficient incentive for her to make an effort to include graphing calculator use in her class.

In terms of Assessment, Cheryl self-evaluated at a level 2 and reported wanting to progress to a higher level 2 on the rubric. At that time she clarified her goal to learn how to find an open-ended question that would relate directly to the course to which a rubric could be created. She believed that it was a moot point to develop a rubric unless it is appropriately linked to an activity. Hence, her goal was to search out appropriate student tasks that would lend themselves to rubric-based assessments. The criteria for her good assignment were effective, curriculum-linked, and doable. Additionally, she wanted to find them from the limited resources at the school. At the same time as her search, she would also ask a group of students in to assess their group work on their portfolio with a rubric that she would create for that aspect of the assignment. It is noteworthy that Cheryl verbally self-evaluated at a level 2, on the online self-assessment, she checked off a level 3 for transparency in the assessment dimension.

Implementation of Action Plan

Technology

Cheryl reported spending time on the Internet searching for good technology-based activities for her class. She found that it was a fruitless endeavor that frustrated her because it was a waste of time. She did find the book she borrowed on geometer sketchpad from the in-service session to be useful, and she did copy some activities from it. However, Cheryl felt that the introduction of technology-based activities should correspond with the topic in the curriculum being taught and not be a superimposition. As such, Cheryl did not find any activities that she felt could be introduced during the time period of the study, although she did report that she would be keeping the ideas in mind for different units. She gave considerable thought prior to introducing any new dynamic into her practice with particular consideration to the ability of the technology to enhance the mathematics learning rather than usurp it. The following examples evidence Cheryl’s measured approach to introducing technology:

Cheryl wanted to bring in the Zap-graph to demonstrate to students what the roots in a quadratic equation that they would be finding would translate into on the graph. She voiced concern at the appropriateness of it because she feels that it may confuse students who have not yet learned what an ordered pair is. So she decided to think about it and decide the following week [T4 Follow-up discussion].

Today she would have them apply the concepts of perpendicular and parallel lines on a graph. She wanted to incorporate the use of the graphing calculators today and she thought about how to do that, and decided that it was really not an appropriate place to introduce them – so that this activity was better without their use in this situation [T7 Follow-up discussion].
Although the examples during the period of observation did not evidence any changes in practice, there was ample evidence that Cheryl was taking her time thinking about the different ways she could appropriately integrate the technology in her classroom. She made a point of searching online for resources, and was disappointed in the fruitlessness of the endeavor [T9 Interview]. However, she did appreciate the use of a resource book on different uses of Geometer sketchpad that she borrowed during the in-service of the project. Cheryl kept the book for three weeks, and when she returned it, she informed me that she had copied a couple of lessons she found interesting [T4 Observation].

Assessment

For Assessment, the initial observation supported the self-assessment of a modified exploration focus. In class she was explicit about informing the students what it was that she was looking for in her assessments. Additionally, in the observations during the study time frame, Cheryl had reported creating a checklist rubric for the students’ binder-check, which she orally relayed to the students, and she followed through on her idea of having the students self-assess their group work in a different class [T9 Interview]. Hence, she did fall into the category of level 3 as evidenced by the disclosure of predetermined criteria for assessment prior to the administration of the assessment. Moreover, the purpose of assessment for Cheryl was clearly to improve student learning. Although the initial observations evidenced questioning that required students to explain their thinking.

As students were working at their seats on worksheet problems, the teacher spoke to a student about the first step when another student overheard the conversation and called out “rearrange?” Cheryl returned to the board and asked the students how they would rearrange the terms in the question? When a student called out the answer, the following conversation was recorded:

T: Why would he put it in that order?
S1: easier to find the trinomial pattern.
S2 calls out procedure while Cheryl writes on the board the steps being called out. She stops writing when the student stops talking allowing the student to decide on the next step without her help. She finally asks the class what they need to do next and there is only a low murmur from the students. Cheryl waits. After a while, a student calls out that they need a difference of squares and Cheryl agrees and continues to write out the rest of the solution that the student calls out. The student pauses and asks if he needs to keep the brackets?
T: You need to make that decision
S1: It never hurts to keep the brackets [T5 Observation].

When a student offers the answer to the problem as slope = 3, Cheryl questions the class about the answer by asking what the slope of 3 really means? A student answers that it is the rise of 3 and then over right one [T7 Observation].

She was more aware of not answering the questions with a solution but responding with a question that would redirect the student’s attention to finding their own solution to the problem [T9 Interview]. Additionally, she used the results on quizzes to determine if the students’ needed more practice in a given topic, and emphasized to the students that their marks were an indicator of where they needed to focus their attention and not a reflection of their ability [T5 Observation]. Hence, the observational data support Cheryl’s online self-assessment of having an exploration focus regarding the purpose of assessment.

Additionally, Cheryl worked on making her expectations clearer by making them explicit to the students [T9 Interview]. She told the students exactly what was on the test and what her expectations were regarding marks distribution for potential solutions. She knew that she had achieved her goal when the students asked her if they could get a 9/10 when they got an answer wrong, or a 3/10 with the right answer [T9 Interview, T6
Observation]. Specifically, Cheryl worked on creating two rubrics for her students to convey her expectations to them. The first rubric addressed assessing homework in her Grade nine class. As she thought through the protocol, she informed the students that she would give them more forewarning when she was going to collect the homework, and that she will be giving them details of what she wants to see [T6 Observation]. The second rubric addressed peer-evaluations of cooperative work for her Grade ten students that had to work in groups for their portfolio project [T7 Observation].

Teacher Perception of Professional Change

For both the introduction of rubrics and technology in her class, Cheryl felt very strongly about the need for the activity or tool to fit in with the timing and curricular context of the class for her to try it in her class. She does not want to introduce new items for the sake of change, especially with the time and curricular constraints that she has in class. Consequently, she thinks that the reflection that she started regarding the dimensions of assessment, technology and student task would continue, and that she would make changes in her practice as they became appropriate while planning units. However, the short timeline of the project would not permit for the observation of these changes.

Technology

There were no observations that evidenced any changes in the use of technology in the classroom. The lack of evidence for student use of technology falls under the category of a procedural focus in the rubric, which differed substantially from Cheryl’s online self-assessment of a modified exploration focus. However, Cheryl reported wanting to change and was working through how to do so in a way that was appropriate to the topic and student needs. In talking about her progress, she felt that she was in the same category. At the moment, she is “leaving things” because it was really too soon to tell. However, she indicated that it would be much easier for her to be able to complete an exercise in self-assessing her progress in incorporating technology in the classroom by the end of the year [T9 Interview]. As Cheryl did not continue to participate in the project after December, there were no observations or formal interviews that would evidence any more changes in her practice. However, in an informal meeting with me, Cheryl enthusiastically informed me that she had finally tried Geometer Sketchpad and she appreciated the benefits of the program with respect to the students’ mathematics learning. She also indicated that she wished I had been there to observe the class and how far she had come with the incorporation of technology.

Assessment

Cheryl reported that her classroom practices did not change very much but that her awareness of how she was teaching and assessing students increased as a result of her participation in the project. She did feel that she addressed some of the uncertainty surrounding the new provincial guidelines and felt that she reflected those expectations better. She is confident that with more time to reflect on the assessment process and in planning units she would find appropriate matches between the new assessment requirements and the program [T9 Interview].

It is noteworthy that I never saw the rubrics because Cheryl was developing them throughout the time period of the project. She felt that she needed more time to go from thinking about them to doing something about them. The use of rubrics in class was “at the back of her head” when thinking about assessment issues and while she reportedly sat down to start a checklist of what she would like included in a rubric for homework completion, it would take time before she implemented it [T9 Interview].

Don’s Report
Introduction

Generally, Don would walk into the classroom to find his students mostly seated at their desks [T1 Observation]. He would place his materials on his desk at the front of the room and takes out the materials for the day’s lesson. Don would start his classes with an agenda written on the board outlining a homework question, a problem of the day, a lesson, and their homework from the textbook in that order [All Observations].

Don would engage his students in thinking starting with the problem of the day at the board. These questions are layered and intended to promote student thinking [T1 Observation]. A student... While a student presents her solution for the problem of the day from the last class, Don confirms her solution with nodding [T1 Observation]. Don follows this presentation with a new problem of the day to which he offers the students a couple of examples to get them started on developing their solutions. He gives them 7 minutes to work on the problem in groups of two to four at their desks. He calls time and instructs the student who will be presenting the solution next class [T1 Observation].

Don’s regard for informal assessment was linked to his teaching practice as he relied on the student feedback to proceed with the lesson. He already had established a classroom dynamic where students would offer their process as well as their solution. This was evidenced when the class was going over the answers to a quiz and the problem of the day. When Don would call on a student, the student would start their answer with the problem and articulate the steps in the process that led to the answer [T1 Observation]. Additionally, when Don delivered lessons at the board, he would call on students to offer procedural answers. One illustrative example is when he guided the students to derive the formula for the midpoint of a line and as they answered he would ask “how do you know?” [T3 Observation]. Additionally, Don ensured that when students asked questions, they had thought through the process to finding the solution.

Student: Do you know what number 13 is?
Don: That is not a question!” [T3 Observation].

Don’s approach permeated all of learning. When the class would complete taking up the homework, Don wrote out a higher-level question from the same section in the textbook from which the homework was taken. When students would call out the answers, they would offer step by step solutions as Don wrote out what they said using mathematical symbols. When a student would call out something that was incorrect, Don stops and questions the student on their understanding of what they called out. When the student has the right answer, he proceeds to write on the board. Illustrating how Don emphasized the importance of procedure and demonstrating thinking was when he discussed answers to quiz questions with a student during corrections:

“Don: #3 asks you to do a little more, in words without computations what do. I need to find…
Student calls out the procedure and then offers calculation on request of teacher who
Writes it out on the board.
Same for the second part with another student offering the solution and he makes an mistake.
T: oh, careful
s: oops, sorry
T: that’s ok
The student corrected herself and Don resumed writing the solution on the board. Once the solution was done, one student remarked that the question “gave such perfect numbers that you could work it out in your head.”
T: You could, but it is the process that is important” [T5 Observation].

Don’s classes would spend considerable time working and talking through problems. The other component
of the course became evident when Don was introducing a new topic. He would offer the class notes on new topic on the blackboard. The note-taking time was very much like his problem solving time where he would engage the students by asking them questions regarding the possible steps. During a lesson on graphing lines, the following dialogue was recorded:

Don: what is an x-intercept?
Student: point
Don: where?
Student: x=0
Don: why do you say that?
Student: point on the x-axis
Don: so?
Student: y-coordinate” [T7 Observation]

Don equally offered students time to do homework questions in class. While the class was working on the problems, he would circulate and listen to the conversations between the group members. Noteworthy was Don’s silence in this case [T1 Observation]. He would not intervene in the discussion and only offered advice, strategies, or explanations when asked specifically for help [T1 Observation]. He did take time to stop and re-explain concepts to students individually who were struggling [T1 Observation].

Although there was no observation of the use of technology with the exception of calculator use in the first classes, it is noteworthy that Don had mentioned his website to the class to inform the students that the mathematics portfolio rubric was available online [T1 Observation]. There was evidence that the students were accustomed to the URL as Don also informed the students that he would post the rubric they constructed in class on the website prior to handing them back to the students at the end of the week [T5 Observation].

Teacher Action Plan

Don wanted to work on the dimensions of Technology and Assessment, and outlined specific objectives within each dimension.

In terms of technology, Don initially self-evaluated at a level 4 because at his previous school he claimed that he integrated technology in the coursework. He explained that the only reason that this was not the case at UTS was because of the limited access to the technology. This factor lowered his rating [T4 Interview]. I probed Don on how he used to use technology, such as asking him if he used to use the laptop as a demonstration tool at his previous school? Don looked over the rubric for the technology dimension again and concluded that perhaps he was working at a level 3 or higher at his previous school.[T4 Interview]. He re-emphasized the limitations of UTS created a situation where he was working at a level 2 and would aim for a level three for the purpose of this project. Although he expressed those levels in words, his facial expression and tone of voice indicated that he was uncomfortable with that low rating. Notwithstanding, he wanted to devise a plan to familiarize the Grade nine students with the graphing calculators to comfortably manipulate the graph window appropriately and graph a line from the equation of the line [T4 Observation]. Don decided to develop a project or activity that would encompass the use of graphing calculators. Although he was enthusiastic about the project, he knew, from his past experience teaching with calculators, that he would need to take time as a front-end investment that would not have to be reproduced down the line. He recognized that once he demonstrated the use of the calculators and the students learned how to use them, it would facilitate the inclusion of graphing calculators in future units.

In terms of Assessment, Don self evaluated at a level 3 with a goal of a level 4. He felt that he was at a level three because he had already introduced a portfolio assessment into the course [T4 Interview]. The criteria for the portfolio was on his school website and required students to develop a solution for an open-ended
question or mini-project. For the purpose of this project, he wanted to try and negotiate a rubric with his class as demonstrated in the in-service session [October 30 in-service session]. He first thought it would be important to devise an assignment for the Analytical Geometry unit for which the students would create the assessment criteria. He hoped to include a performance component to the rubric that would be related to the graphing calculator portion of the course so that he would link the two dimensions he was working on together [T4 interview].

Implementation of Action Plan

Don was very technical about the implementation of his plan. He thoughtfully developed specific strategies to progress in each dimension selected. The specificity of his plan facilitated the implementation of changes in his practice. Although there was sufficient evidence to demonstrate a change in practice, there was substantial evidence demonstrating Don did not change his beliefs with respect to his approach to teaching, which undermined the implementation and minimized the importance of the changes.

Technology

Don successfully introduced the use of graphing calculators and Geometer sketchpad to his Grade nine class. He embedded the introduction of both technologies within a unit on linear relationships that pivoted on an investigation he developed and called “The Triangle Assignment.” When Don introduced the assignment to the class, he went through the requirements and highlighted that he wanted “exact answers,” which implied the use of Geometer Sketchpad. He explained to the class that although they could use the compass and ruler method, they may not be able to get a very accurate answer, and would receive part marks [T4 Observation]. Attaching points to the use of technology to find the solution reflected Don’s desire to encourage the students to use the technology as he believed that they were all high achievers [T7 Observation] and would subsequently want the better grade. He then proceeded to explain that the assignment would be done in groups and that he would be booking computer lab time for the class [T4 Observation]. Although the assignment’s introduction focused on the use of Geometer Sketchpad, Davis also highlighted the importance of the graphing calculators in helping students find exact answers.

In the case of the Graphing calculators, Don brought in the class set of TI-83 graphing calculators for the unit on graphing lines and understanding their properties. In the first class introducing the use of graphing calculators, Don offered the students a handout that categorized the different functions on the calculator related to graphing lines [T4 Observation]. In the next lesson introducing the use of the graphing calculators, Don grouped the students together to learn how to use the graphing calculators. When this part of the lesson started, the following communication occurred:

Student: what do we type in?
Don: I will show you.

Don (up at the front of the class) tell the class to refer to the TI-83 graph sheet he gave out last class and tells the students that they will be learn how to
1. plot points
2. graph lines
3. how to find the intersection of 2 lines.
Don: Turn the calculator on.
Don starts to instruct the students on how to graph a line and the functions available on their calculators that they need to graph a line.
The students are following along, occasionally interjecting to ask questions.
Student: how do we get the coordinates?
Don explains the procedure on the calculator to get y with a given x, after he tells them about the trace function [T5 Observation].
The didactic approach illustrated in the excerpt above was sustained throughout this unit. In another lesson, Don started at the board recapping the equations of the line they had already covered, and the ones that they would be covering while the students were writing in their notebooks. The students were then given a worksheet on linear equations and told to work on in groups. Although the students were working at different paces with different levels of comfort with the graphing calculators, Don maintained full control of the pace and the progress students made with the graphing calculators. For example, when a student had completed the first part of the worksheet that encompassed collecting data on the different linear equations (i.e., recording the slope, the x-intercept, and the y-intercept), he asked if he was permitted to go on to the second part of the worksheet. The next section required the students to find the association between the linear equation and the data collected in the first portion of the worksheet.

Don’s response was the following:

Don announces that if they are done they can start the back of sheet one and they are not to continue on to the next sheet because the class is going to do that together.
Three students in the same group are done the backside of the first page and one asks what to do next.
Don: Just relax.
Student: Can I go on to the next page?
Don: Just relax for a minute [T7 Observation].

Don’s control over activities related to learning technology extended to the introductory lesson on Geometer Sketchpad in the computer lab. Don brought the class over to a large well-equipped room. Each student had their own computer along a bench all facing the front projector screen with the exception of the back-wall computers. The projector screen was illuminated with the instructor’s computer screen so that the students were able to see what Don was doing on his ‘master screen’ the entire time. While the students faced him behind their computers, Don proceeded with his lesson on Geometer Sketchpad.

Don opens the software Geometer Sketchpad and instructs the students to do the same. The students move their mice in response. Don then proceeds to demonstrate the basic function toolbar at the side of the screen and as he clicks on each box, he tells the students what they do and what they are used for. For example, Don clicks on the textbook function and types in “This is a textbox.” He changes the font, and attempts to change the background color. He then looks up at the class and calls out “Let’s draw a triangle.” Don then proceeds to call out the steps as he demonstrates how to draw a triangle on the computer.

Don: Display preferences to check defaults, autoshow labels, so each time you create a point, the program will label it for you. Distance, leave it in inches, it does not matter. Precision on to the 1000th because this will give you all the decimal points that you need… [T6 Observation]

Don’s direct approach to teaching the technology was coupled with a sense of time urgency that did not allow for student discovery of the program and its functions.

Don: Let’s construct a midpoint
Student: It’s not working
Don continues to demonstrate the program and tells the students that they will construct a median, find the area of the triangle.
Don then interrupts to announce that he sees people plotting points. He pauses, “Anyway”
Student: How do you find the median?
Don walks to the student’s desk and starts to tell him to drag the line at the same time another student states the same instruction.
Don then looks around the room and says, “What are you all doing?”
He continues to look around and tells the class that he does not want to have to explain this again as he walks to the front of the room to finish his lesson [T6 Observation].

When Don did give the students the opportunity to interact with his lesson, he would question concepts that he had already gone over in the previous lesson. Again, there was limited opportunity for the students to interact with the technology independently.

Don tells the student not to worry about the angle bisector, and tells the class to start a new screen. He draws a triangle and asks the students that to construct the orthocenter, Don: What is intersecting?
Student: The altitudes
Don: Do you need all three?
Student : No
Don: Why not X?
Student: Because two will give the point of intersection where the third will intersect with them.

Don nods approval and constructs the orthocenter on the screen while calling out the steps as he demonstrates them [T6 Observation].

Assessment

There were two components to Don’s attempted changes regarding the assessment dimension. The first reflected his conscious intention to negotiate a rubric with the class. The second was an unintended consequence of the Triangle activity. As evidenced below, Don perceived the technology-based activity as a superimposition of a supplementary activity for the class. Throughout the process, Don reflected on the additional expectation on his students and consequently felt it necessary to re-evaluate the degree of equity across the Grade nine classes. In order to address the issue of equity in his mind, Don offered some choices to the students with respect to the activity’s grade value.

Intended consequence

In the case of the negotiated rubric, Don implemented his plan successfully. I was invited to observe the lesson where Don decided to negotiate the rubric, and the following format was recorded:

Don gave the students a rubric template the previous lesson and asked them to think about what would fill in the box for homework. He asks students to get the rubric template out, and puts students into four groups to work on a different section each: Quantity, Quality, Presentation, and Work ethics. Each group is responsible for coming up with the criteria for levels 2-4.

Don: In the next 10 minutes, think about what would be meeting, approaching, and exceeding expectations. What would that look like to the teacher [T5 Observation]?

During the activity, Don circulated and negotiated the meanings of what he wanted in each of the cells in the rubric. Additionally, at the end of the activity, he collected all the matrices from each group and read out the contents of the cells. He informed the students that he would refine the rubric and post it on his website by the end of the week [T5 Observation].

Once the rubric was completed, Don evaluated the process and the product as successful because he believed the rubric turned out the way that he would have developed it himself. He recognized the benefits of the process because it was “an issue of ownership and power” [T5 Observation]. Moreover, Don’s thoughts regarding the student-constructed rubric was that “these kids have high expectations of themselves, and that they see this as a vacation from those expectations which is good for them to see that with slightly lower expectations they can still achieve excellence” [T5 Observation]. Don’s belief that this was a “break” from
those high expectations may have been true as he cultivated the dismissive attitude towards the activity throughout the process.

The ‘low’ expectations associated with the rubric and the activity were a product of Don’s attitude towards the negotiated rubric. During the rubric development, the four member of a group were “debating the question of how many questions needed to be completed for a level 3 versus a level 4. One student felt that 4 questions out of the 5 needed to be answered for a level 3, and another one indicated that was unreasonable because there were a lot of students in the class who would be unable to get all of the questions, and maybe not even be able to get 4 out of them done” [T5 Observation]. The conversation was significant in achieving the goals of student-negotiated rubrics, as it demonstrated the students were considering the various possibilities and what they meant in terms of evaluation. However, the students did recognize that Don did not think that this was of import.

As the conversation continued, one of the students stated Don’s expectations were low, so that it would be ok to have just 3 questions for a level 4.

Student 2: “yeah, his expectations are low because he thinks we are idiots!”
Student 3: “no, look he shaded out level 1” [T5 Observation].

Unintended Consequence

Don struggled with the notion that he was being unfair to the Grade nine class in increasing their workload with the additional project. He did not offer the Triangle activity to his other Grade nine classes, and he informed his class of the experimental nature of the activity when he introduced it to the students.

Don negotiated the issue with himself and decided that it would be fair to offer the students the option to accept their grade on the Triangle Activity instead of taking the unit test. The week of the test, Don reminded the students that the test on Friday was optional, but if they did write it then they would receive the better grade from the test and the triangle project for the record. Don asked the students to show, by raising their hands, how many students would be taking the test on Friday. When all the students raised their hands, Don responded with “Good, because you have nothing to lose” [T7 Observation].

Don also made a conscious effort to allow the students the necessary time to complete the project well. During the same lesson when he checked how many students would be sitting the unit test, he also asked the students to indicate, on a scale of 1-5, how many of them were almost finished, because he did not mind postponing the deadline. The students raised their hands to indicate a one, two, or three. Don decided to postpone the deadline [T7 Observation].

Teacher’s Perception of Professional Change

Don firmly believed that he had accomplished his goals. He knew his because he worked on what he wanted to work on and made the change he had planned to make. He indicated that it was not difficult because the targets were very achievable because they were small [T9 Interview]. Although Don attributed observable changes in his strategies over this time period, he did articulate that the project was only an opportunity to enact changes that he already believed should happen [T9 Interview].

Don made a point of attributing change to his own initiatives and knowledge. He felt that although the in-service session offered in this project may have been appropriate for teachers not familiar with current mathematics education reforms, this was not the case for him [T9 Interview]. Additionally, he informed me that he did not think that he changes he made affected his overall practice. Although Don articulated that the study
lacked challenge for a teacher that was already implementing reform strategies, he also made statements that lead the researcher to interpret the situation differently. Don stated the October 30 in-service did not contain anything of value for him because he was already aware of all the new strategies, yet he decided to try a negotiated rubric in response to having one displayed at the in-service [October 30 In-service & T9 Interview]. Additionally, although Don clearly stated that he did not want to continue the study because he already had ideas he wanted to implement, he did attribute the study with a safe place to take risks. He explained that the project afforded him a good opportunity to try new and completely different instructional strategies at his school to change some of the dynamics of the class, and he would like to do more of both the changes that he made regarding assessment and technology use [T9 Interview].

**Enablers and Sources of Tension/Obstacles**

Both Don and Cheryl were eager to be a part of this project. They felt the principal and their department head both supported the idea of working closely with a peer at the school as a form of professional development [T7 Post-observation interview]. Both were experienced teachers teaching their first year at UTS and believed the courses were run in a traditional manner coupled with traditional assessment procedures. Additionally, as both noted, they appreciated joining the study because it matched their personalities and belief in working with colleagues [T7 Interview].

**Reflection & Time**

Cheryl indicated that she reflected more on her practice, for example she thought more about her assessment practices as a result of engaging in this study. Although she believed she was informally assessing students well, she did not feel certain about the expectations in the new curriculum and she reflected on those more [T9 Interview]. However, because of the reflection she believed was necessary, Cheryl felt more time was needed to actually implement the new ideas. As she put it, going from thinking about them to doing something takes a lot of time [T9 Interview]. This was different than Don, who felt very confident in his understanding of the expectations in the new curriculum, assessment and evaluation. His confidence was marked by comments to Cheryl such as an offer to look over her rubric once she thought it was ready [T9 Interview], and his implementation of his action plan. Don did not feel he needed the same reflection time, and went ahead with negotiating a rubric and introducing technology in his Grade nine class. A paradox that surfaced from this comparison was that Don’s beliefs did not change, although some of his practices did. This kind of change undermined the purpose of the changes as was evidenced in the previous section on implementation. Yet, although Cheryl did not have overt changes in her practice with respect to the dimensions she selected, there was evidence substantiating Cheryl’s changed approach integrating the new expectations into her thinking. For example, her desire to create a rubric and introduce it when she found a link between its purpose and a student task, homework. Notwithstanding the differences, there was evidence near the end of the study that Don felt the addition of the Triangle activity may have fostered a better understanding of the content. Don made a point of reporting that of the unit test results from the three Grade nine sections, the one that participated in the “experiment” appeared to have had a higher average. He then conjectured, although there was a lot of content, it was compressed into a richer problem. Don’s reflection on the risk taken was that a richer student task does not mean that less content will be covered [T9 Interview].

**Observations**

Both Cheryl and Don stated benefiting from the observations by the researcher. Cheryl reported seeing what she does and say in class in written form brought to consciousness what it is that she is doing in class [T9 Interview]. Additionally, she appreciated conducting the peer observation because it offered her the opportunity to observe an activity or approach that she perceived to be successful in Don’s class, which encouraged her to take the risk and adopt it for her own classes [T9 Interview]. Although Don stated he appreciated the observation notes, he felt that the exercise of learning to conduct an observation was the real benefit to him [T9 Interview].
Interview] because it was not something that he had done before. Although Don focused on conducting the observation and did not emphasize the researcher’s observations, Don commented on the significance of reading about what kids were saying. For example, when Don read the observation notes from the negotiated rubric, he noted the importance of the students internalizing his approach as low expectations of the students [T7 Post-observation talk].

In-Service

Cheryl felt that the second in-service updated her on how to satisfy the assessment requirements in the new curriculum [T9 Interview]. The fact that she had been out of teaching in schools for the last four years intensified her concerns about meeting the new requirements. The in-service provided her with an update on the new expectations and some ideas and guidance on how to meet those demands [T9 Interview]. Notwithstanding the good ideas she reported receiving, she felt very strongly about having the ideas work within the curricular topic being taught at that time. Hence, she did not feel it would be appropriate to return to her classroom and implement any of the ideas at the in-service directly, but keep them in her mind and strategize on how to include them as she was planning future lessons [T9 Interview]. Alternatively, Don originally reported the in-service was analogous to the one-shot P.A. days where you learn very little [T9 Interview]. He did clarify that he thought that it would benefit someone who was not already aware of the new assessment requirements, but that he did not fit into that category. Consequently, he reported that it was not a useful part of the study. It was only after I had asked him about the source of his motivation for the negotiated rubric plan [T4 Interview], that Don withdrew his statement. Having been reminded that his enthusiasm of trying a negotiated rubric was generated in the in-service, Don stated it was indeed useful [T9 Interview].

Relationships and Circumstances

Finally, an important enabler was the positive working relationship they had already established [T9 Interview]. The fact that this was both their first year at UTS, that they both had personalities that fostered a team approach to teaching, and that between the two of them they taught all of the Grade nine courses meant that they could implement comprehensive grade-wide changes. Although they felt encouraged by the director of the school, the traditional school culture increased caution of making too many changes to the Grade nine programs [T9 Interview]. The structure of the mathematics department insisted on pre-determined dates for summative assessments, which would restrict some of the flexibility required for a completely exploration focused assessment [T4 Observation]. Hence, the combination of traditional teaching resources, school structures, and departmental culture did not foster experimentation with the students or non-traditional approaches to teaching [T9 Interview], which retarded changes.

Case Reports for Paul & Christine

By Alkistis Verevi

Paul’s Report

Introduction

At the beginning of the project, Paul introduced the focus topic of the lesson, providing definitions of key terms. A quiz was handed out at the second lesson and afterwards a new topic was presented on the board. The teacher set the problem; he provided examples and assigned class work. At the beginning of each period,

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2 The data on which this pair of case reports is based was collected by Anne Hogaboam-Gray and John Ross.
Paul wrote key information writing on the board such as topics, activities or factors affecting the lesson (e.g. visitors, adding and subtracting polynomials -Oct 2 & 3, Obs Field notes). In the third lesson, students took a unit test. If they finished it before the end of the period, an extra activity was scheduled (reading an article and answering questions).

Topics were presented in a linear way: Paul provided definitions, (which were copied by the students) and examples:

“Okay question #1 from the sheet”. Teacher writes the question on the board and several students put their hands up to offer to solve the problem. “Let me do this one. Put together all things that are similar. I'm putting all the a's together, now watch what I'm doing. Then b's, next line put brackets around to separate it. They are all like terms so now subtract and add” (Oct 2, Obs Field notes).

While he was illustrating the steps he would sometimes write down answers offered by the students, unless the topic was presented for the first time. Student practice followed.

While students were working on exercises Paul gave directions or prompts. He reminded them of the steps in the procedure and he discussed problems individually with students if they were encountering difficulties. He also circulated around the class providing help to whoever asked for it.

Paul generally encouraged and spoke to the class as whole (e.g. “just do as many questions as you can. Just be careful when you do these, but once you get going they’re pretty easy” -Oct 2, Obs Field notes). Sometimes he would underline the difficulty of the subject using words such as “fail” and “difficult” (e.g. “I’ve told you before that math is difficult and if you failed then you need to come for extra help” -Oct 2, Obs Field notes).

Positive feedback to individuals or to the whole class was infrequently observed, with the exception of those (anonymously) who had asked for extra help. (“No one has yet taken advantage of extra help. This class is a little more successful than the class I had last year, but you will fail if you don't attempt to get help” -Oct 2, Obs Field notes). Occasionally he would assign difficult tasks so that the students would be urged to seek help.

I gave you a sheet that was a little more difficult. I wanted to see who would show up for extra help. I did that to jar you and to push your buttons so that you would have to come for help and some of you did today. You have to get help from some teacher or a peer tutor (Oct 3, Obs Field notes).

When the students posed questions, Paul simplified them so that they could fit in with the content taught, or he gave extra examples. For instance, when a student asked whether the correct answer was the one that the teacher had written on the board, Paul replied “You can’t simplify this any further. I want you to group like terms and add and subtract them” (Oct 2, Obs Field notes). In a few cases no answers were given. However, he tried to show that “math is a lot more than you think” (Oct 17, Obs Field notes) by connecting the subject to word problems and English.

Paul seemed reluctant to accept students’ alternative solutions and his reluctance appeared to disappoint some students. When a student offered an alternative solution to the one he had presented on the board, he said, “I know what you're trying to do and that’s tomorrow. You need to add and subtract polynomials this way today. There are different ways to add and subtract polynomials and tomorrow we'll do multiplication, so just do it this way” (Oct 3, Obs Field notes). Also when a student asked whether a solution would be different if a question written on the board did not include brackets, he replied “I know what you’re saying, but this is the best I can tell you now.” “Other students join in and question why they are solving problems in this manner, but teacher does not respond” (Oct 3, Obs Field notes).
Students were working on exercises from textbooks or question sheets. Different strategies were mentioned as applicable, although Paul suggested to the students they follow a particular sequence and handle each task at a time. He modeled the steps to be followed for the completion of the task, but discussion was not generated, even if some students seemed eager to explore their hypotheses.

The teacher’s role was predominant. At the beginning of the project, Paul set guidelines for the process of the lesson. He explained to students the focus of the lesson and gave directions (e.g. “we are starting a new one today, so in your notebooks [students get out notebooks] start a new page” or “Teacher writes the word definitions on the board and begins writing out the definitions” -Oct 2, Obs Field notes). He also determined the activities in which the students would be engaged in, although students could work at their own pace:

You can use your calculators. Okay books away let's go. You have to the end of the period, but I don't think you'll need it and once you're done there's an activity for you to pick up and come to me and I'll tell you how to do it (Oct 17, Obs Field notes).

He consistently followed predetermined steps with the result that students’ ideas could not always be exploited. For example, when Paul wrote the word monomial on the board and a student called out his/her guesses, he replied “Once you start working with them then you’ll understand the terms, but I want you to have the definitions” (Oct 2, Obs Field notes).

Paul was the main person to use the board. We frequently observed such actions as:

Teacher writes the word definitions on the board and begins writing out the definitions.

The teacher puts up question 8 on the board (Oct 2, Obs Field notes).

Teacher has written the following on the board (Oct 3, Obs Field notes).

Sometimes he reprimanded the students for improper behaviour and threatened them with assignments or tests. “You have an assignment coming today and how much of an assignment depends on how you behave” (Oct 2, Obs Field notes).

Paul gave instructions: “I told you I want to get these definitions out to you; that’s the way I prefer it” (Oct 2, Obs Field notes); he presented each unit through a short lecture; and he answered questions. However, he did not seem to foster students’ participation, especially when he was presenting a new topic. “Teacher writes the question on the board and several students put their hands up to offer to solve the problem. T: ‘Let me do this one’ (Oct 2, Obs Field notes)”.

During the test, he rarely gave the answers. Sometimes he gave clues, (e.g. “use brackets” -Oct 17, Obs Field notes), while in other cases he provided encouragement and modeled the task:

S: I don't know how to do it.
T: Yes you do. Well do it on your calculator. [The teacher takes her calculator and starts pushing buttons and says,]
T: There.
S: But how do I represent that? [teacher does not answer her] (Oct 17, Obs Field notes).

Nevertheless, in his interaction with students he was easy-going. He was willing to inform the students about the research project; and he made comments based on his experience and knowledge. For example, he referred to the connection between math and language and tried to explain to them the purpose of their language activity:
One of your next units is word problems and how you look at them and interpret them. It has interesting points and I would bring them up in careers [class], so read the article and do the activity. I think it has worthwhile points (Oct 17, Obs Field notes).

He also excused students’ misbehaviour (“Yesterday was a special day.” “You had fun yesterday” -Oct 3, Obs Field notes) and he permitted some students to make off-task comments, including those that might be interpreted as challenging his authority (e.g. A student said to Paul “I must say your writing has improved” -Oct 2, Obs Field notes).

Students worked in pairs, groups (“Two girls move desks together and then 3 other girls move their desks together” -Oct 2, Obs Field notes) or individually (“students begin working individually” -Oct 3, Obs Field notes). When they were on task, they were mainly repeating to each other the steps illustrated by the teacher (“I overhear 3 students talking about 'Group them then add them' ” -Oct 3, Obs Field notes) or they were comparing their marks (“Students are comparing test marks back and forth” -Oct 2, Obs Field notes). Although our field notes on students’ interaction and the probes given to them are limited, we found no evidence that Paul exploited students’ interaction for instructional purposes.

Assessment seemed to be central in Paul’s classes. He regularly assigned a numeracy test (“until everyone gets at least 80%” -Oct 3, Obs Field notes) and he talked to students individually about their marks when their tests were handed out. He explained some points in his marking scheme and justified the selection of the questions included in it. Paul also reassured the students, allowed them to take a last look over their notes before the test (Oct 17, Obs Field notes), and they felt free to ask him questions during the test.

The teacher attributed some classroom management problems to the observer’s presence. Student drawing of stick figures of the teacher with captions was observed. (One caption saying he “is confusing” was verified by Paul at the interview).

**Teacher’s Action Plan**

Paul focused on *Teacher's Role*, for which “he placed himself at Modified Procedures” and on *Students’ Interaction (Communication)*, for which “he placed himself at Modified Exploration. He is going to move toward Modified Exploration for Role and Exploration for Interaction” (Oct 30, In-Service Session).

In terms of Teacher’s Role, Paul described himself as the sole knowledge expert in his class but he wanted “to have some student experts” (Oct 30, In-Service Session). He was probably referring to students who provide assistance and knowledge to their peers, and this might imply creating quasi-duplicates of himself; however no further explanation was provided. He said he would be reluctant to move to the Exploration focus, as he was feeling “superior to the students” and he rejected the idea of the teacher as a co-learner: “How can I be a co-learner with my students? How could they possibly know more than I do? Am I supposed to pretend like I'm a complete buffoon?” (Oct 30, In-Service Session).

No clear justification was recorded for selecting these dimensions, but we could assume that his alleged proficiency in math and his current role as disseminator of knowledge influenced his choice. (The word “experts” connotes that he could share his role as the knowledge transmitter.) No reference was made to students’ socio-cognitive development or to co-operative exploration of mathematical approaches. However evidence to support this claim is inadequate.

In terms of Student-Student Interaction, Paul remarked that students “hung up on one way to do things”, and he wants them “to compare different strategies to solutions” (Oct 30, In-Service Session). This could mean that he believed that fostering students’ interaction and group work would stimulate discussion about their
strategies and allow them to pose questions to each other. This could lead students to take initiative in their learning process.

In any case his wording may imply a modest change compared to what he had said during the first follow-up discussion. When the observer asked “why he didn't let some of the kids solve the problems the way they wanted to, he said he wanted them doing it his way and they would do it the other way another day” (Oct 22, Follow-up Discussion).

**Implementation of the Teacher’s Action Plan**

The case report data for Paul (and Christine) is not as rich as it is for the other cases in the study because we were not able to implement our observation schedule as we had intended. However, we were able to obtain sufficient information to address the research questions for the study. The discussion of the participant’s progress is based on just two observations (Nov 7 and 27) due to the previously described data collection problems.

Topics were still written on the board (“the teacher has written on the board: 1. Review 2. Notebook check” -Nov 7, Obs Field Notes) or, alternatively, the purpose of the lesson was stated (“Paul stated that tomorrow they would use the calculator to simplify the investigation listed on the assignment sheet handed out earlier” -Nov 27, Obs Field Notes). Students worked on exercises from a worksheet (Nov 7, Obs Field Notes) or listened to Paul’s presentation. He still modeled correct math language, put some questions on the board and illustrated the appropriate steps:

No one has reached #25 yet, so the teacher writes the question on the board and starts talking as he goes through it:

T: Common denominator on left side and right side.
Like before, just cross-multiply.

Now it's just distributed law, so is that the problem? Just do the left side and then the right side (Nov 7, Obs Field Notes).

After students had worked for a time Paul told them step by step the commands to enter (Nov 27, Obs Field Notes).

However, now Paul welcomed students’ answers as well as his own and invited students to put their solutions on the board:

A student tells the teacher she needs help with #17, so the teacher asks another girl to put her solution for that question on the board (Nov 7, Obs Field Notes).

The student at the board says he doesn't know how to go any further with this question.
T: So what does he do?
S: Divide both sides by 2 (Nov 7, Obs Field Notes).

He also introduced the topic by taking into account their answers. “The lesson was introduced with ‘we are doing a note’. Paul wrote ‘recall’ and said ‘remember the slope y-intercept form of the line’. After much prompting, students called out various answers. Paul wrote down \( y = mx + b \). He then asked students to identify
what each of the terms stood for” (Nov 27, Obs Field Notes). “Afterwards he circulated around the class and provided support by prompting students with the steps while they practiced. (However, sometimes ‘the help was entirely procedural’) (Nov 27, Obs Field Notes).

The teacher circulated to help students who ask him for help.

I overheard a student asking the teacher how to do one of the word problems and the teacher replied:
T: What is it we do to check our understanding of word problems? (Nov 7, Obs Field Notes).

Paul also kept reprimanding the students who did not respond to his suggestions for extra help: "Where were you in math help yesterday? You said you were coming and you didn't " (Nov 7, Obs Field Notes).

The tasks usually called for a single algorithm and the questions for “short answers describing parts of procedures or facts about math” (Nov 27, Obs Field Notes). Justification was not always asked for or provided and opportunities for exploring “unknown” fields “in public” were scarce and therefore met with hesitation. However Paul was reassuring.

He asks a boy to try working it out at the board, but the boy doesn't want to saying,
S: I don't want to make a fool of myself.
T: It's easier than you think (Nov 7, Obs Field Notes).

Paul said there was another way to express Ax +By +C=0. Students called out “do we have to know? …You are always confusing us.” Then he said he would give an example. Students called out “just one…you give us more than one and we get confused” (Nov 27, Obs Field Notes).

Worksheets containing investigations that involved a richer type of task were not observed in use. Even when tasks could be viewed as providing multiple representations/ strategies (graphic and algebraic), emphasis was not put on this distinction. (While using the graphing calculators “it was not clear why students would do this” [i.e. simplify solving linear equation systems, plotting lines, etc] “and the connections to concepts were not explicit” -Nov 27, Obs Field Notes). The teacher usually illustrated a single strategy but students sometimes explored alternatives on their own:

One student is describing to another student how he solved #21 and it seems he used a different strategy from the teacher's.
S: I know it's not the right way to do it, but at least I got the right answer (Nov 7, Obs Field Notes).

Students were usually assigned individual tasks and they worked individually, in pairs or in groups. (However, at the last lesson observed “students worked independently on the task, even if they were in a group” -Nov 27, Obs Field Notes). They were trying to clear up what the teacher had presented or they were discussing their answers, steps or alternative strategies in order to satisfy the teacher’s aim that they “compare different strategies to solutions” (Oct 30, In-Service Session).

I observe 2 boys working together and overhear one saying to the other,
S: I'm right, so don't ask any questions.
The other student doesn't respond.

S1: Did you get negative 2 for that question?
S2: I got the right answer which is 2.
Same 2 boys:
S1: Did you get [gives other student his answer but I couldn't hear it] for #7?
S2: No, you did it wrong.

I observed 3 or 4 students copying down the answers to some of the questions from other student's notebooks (Nov 7, Obs Field Notes).

Paul referred to forthcoming assessments (tests and assignments) and he reassured students that unexpected items would not be included in the tests (S: “So if we understand all this sheet we should be okay for the test tomorrow?” T: “Yes, you should be” -Nov 7, Obs Field Notes).

Using a rubric (“a class set of ‘Notebook Assessment Rubrics’ to fill in” -Nov 7, Obs Field Notes), Paul checked students’ notebooks spending some time with each student. He also solicited an informal peer-assessment, although discussion of the criteria of assessment or its purpose was not observed and students did not have the notebook assessment rubric.

The student stops writing at this point.
To whole class:
T: What mark should he get for this?
Class: Two.
T: Two, maybe three.

T: So far, for marks, we would have 5 out of 7. So for full marks I need to see a formal check of left side, right side and a concluding statement (Nov 7, Obs Field Notes).

In one case Paul made a mistake while presenting a topic and afterwards he wrote on the board with coaching from the peer teacher, followed by a lengthy conference between them. The discussion between the teachers had the form of a debate that was open to students:

Paul wrote A,B, C Σ R [it was very difficult to read his writing]. The C was added later with the words “I left something out”.

Paul erased the C saying it was incorrect, leaving “A [symbol for not equal to] B [symbol for not equal to] 0”. He told the class that sometimes he makes a mistake to keep them on their toes but this was not such an occasion (Nov 27, Obs Field Notes).

Such errors coupled with Paul’s illegible writing seem to have confused the students adding a misleading perplexity and incoherence to the lesson.

The teacher maintained his “knowledge expert” role. There was little evidence of assessment being used to provide constructive feedback to students; tests and assignments were still used as a threat: “Sit down and be quiet. It seems to me you are looking for an assignment, so you'll get one” (Nov 7, Obs Field Notes). Other motivational strategies were not observed.

However, in other cases he seemed to be more encouraging. For example, when a student was writing on the board:

The teacher asks another girl to put her solution to #4 up on the board.

The student puts her solution up. To the whole class while referring to the answer on the board:
T: What she did is what I expect all of you to do.
The student goes up to the board.
T: C. is our resident expert on word problems (Nov 7, Obs Field Notes).

The teacher seemed to convey contradictory emotional meanings. In one case Paul lost his temper: “The teacher goes over to a boy's desk and begins a very heated argument with him about not coming for math help yesterday when the student had said he would come” (Nov 7, Obs Field Notes). Sometimes he would reverse his announcements (e.g. he “reversed his previous announcement that he was going to check homework. Yesterday’s homework would be today’s homework” -Nov 27, Obs Field Notes) and other times he had to struggle for order (“He tried various strategies to get order, none of which worked for more than a moment” -Nov 27, Obs Field Notes).

On the other hand he would behave in “a joking and at times flippant manner” (Nov 27, Obs Field Notes), he accepted extraneous comments and much off-task activity. This inconsistent behaviour affected students’ reactions. At times they were openly mocking him and questioning his teaching techniques (“do we need to know this?”, “why do we want to do this?” “do we have to know?”, “you are always confusing us” -Nov 27, Obs Field Notes).

Eventually students turned to their peers for help, serving Paul’s purpose to “use group work because students found him confusing” (Interview Dec 3), and to “have some student experts” (Oct 30, In-Service Session). A conversation broke out at the back of the class as to whether the R was an R or something else (because of the multiple lines). The students concluded it was an R.

One girl turns around to help the girl behind her. She gives procedural advice and tells the girl what to write down for 2 steps of the question and then says,
S: Cross multiply (Nov 27, Obs Field Notes).

Teacher Perceptions of Professional Change

Paul believed that he had made progress on the teacher’s role, since “students who came up with the right answers wrote them on the board” and he was recognising students, who “emerge from the groups”, “as experts in his class” (Interview Dec 3).

He claimed that his assessment practice had changed, because he was now “doing more problems in class”. He “did not lecture as much as before” (Interview Dec 3), but he was still avoiding leading questions, since he wanted “students to figure things out for themselves” (Nov 27, Obs Field Notes). He “was combining students who knew with those who didn’t” (Nov 27, Obs Field Notes) and he believed that he was using group work more systematically “because students found him confusing”. (This was attributed to the use of “upper level math, especially correct mathematical language” -Interview Dec 3).

Paul did not express a wish to alter substantially his teaching approach. “He wanted to continue what he was unconsciously doing ‘but with a purpose’”. And since confusion was a conscious teaching strategy, “his plan was 'more of the same with control…directed confusion'”; this “should strengthen them up” (Interview Dec 3).

Christine’s Report

Introduction

At the beginning of the project, Christine focused on reviews before getting into the actual Grade 9 curriculum. A test was often scheduled after the review.
During her first classes, she worked with students on exercises from worksheets. Christine or the students put on the board responses (after the teacher checked them). Students wrote their answers while indicating their steps. Christine insisted on writing the steps, which were sometimes revealed by the questions she was posing or by the “tips” she offered.

What do we do? [directed to the whole class]

What’s the sign? (Oct 2, Obs Field Notes)

She emphasized the process for the completion of the task, without further discussion on different approaches to the problems. Students were expected to follow certain rules and do the exercises step by step. Correctness was emphasized.

Another student wanted to know the answer to a question, but the teacher asked him a series of questions to take him through the question and the student arrived at the right answer (Oct 17, Obs Field Notes).

She asked a student to recall the rules (Oct 3, Obs Field Notes).

Christine indicated that the exercises had a single correct answer/solution but there were different representations of the answer possible (“It doesn't matter if you work with fractions or work with decimals” - Oct 17, Obs Field Notes). However, Christine seemed reserved in exploring ideas that did not fit in with the rules that students had learnt (“they are only using power rules and are not changing the bases to answer these questions” -Oct 17, Obs Field Notes).

While working on the exercises, Christine provided help so that the students would complete the task. She used analogies (“Ice cubes, warmer, degrees, bingo chips; use whatever helps you get it” -Oct 2, Obs Field Notes), and asked students to state what should be done. (She posed “what” rather than “why” questions: “what do I do to change it to improper”, “what do I do to the second fraction?” -Oct 2, Obs Field Notes). She circulated around the class helping individual students (asking students to recall rules, giving examples, or indicating problems). A peer-tutor provided assistance and the resource room was also available. Christine guided students through the completion of each task. Skill practice was the theme of the lesson (“practice is the only way that you’re going to get this”, “Math is a skill and you won’t get it unless you practice it” -Oct 2, Obs Field Notes).

She gave advice (“you have to practice”, “we don’t have that much time” -Oct 2, Obs Field Notes) and very often she offered positive feedback both to individuals and to the whole class (“some of you have this all done and know it all and that’s great”, “most got that okay” -Oct 2, Obs Field Notes). Negative remarks were also addressed to the whole class and individuals (“this room is open everyday at lunch for you to come in and I haven’t seen any of you yet”, “that’s not a good answer” -Oct 2, Obs Field Notes). She was also reassuring (“I know you’re a bright student” -Oct 3, Obs Field Notes) and she encouraged participation (“We need a few more people participating here and I’m waiting for some other hands to come up” -Oct 2, Obs Field Notes). She avoided negative comments when she was given incorrect answers and did not reprimand students severely. Although she was very encouraging while teaching, she described “kids” as being lazy and “not interested in doing extra” (Oct 22, Follow-up Discussion). This might imply that although she offered ample support, she was rather skeptical about students’ will to do anything more than the minimum.

The teacher’s role was dominant in Christine’s teaching and she saw herself as the expert who provided help with the task or answers. Christine identified the exercises that students should deal with; she directed students’ activities; wrote questions on the board and checked answers. Students could work in self-selected
pairs or individually (“Nine students are working on their own, while 13 are working in pairs” -Oct 17, Obs Field Notes).

Christine mentioned that there would be a review section where she would involve students in guided investigations but no examples were provided. Students mainly answered questions using rules and following their own pace. In some cases she gave the exact answers, while in other cases she “contextualized” the lesson (“we are only worrying about multiplication because we haven’t done anything about addition” -Oct 17, Obs Field Notes). We obtained little evidence of strategies to deepen students’ thinking. There was also no evidence on attempts to employ students’ errors to “reconstruct” knowledge (“The teacher finds the error and tells the student what it should be”, “I’m not giving you the answers”, “It’s is just 2” -Oct 17, Obs Field Notes). The aforesaid practices seemed to converge on the teacher’s assertion that “it’s hard to do investigations with the students [who are] in Applied” (Oct 22, Follow-up Discussion). Christine guided the class to the review by indicating the sequence of the exercises. She explained the steps for each exercise and she modeled math language (“try to use negative because minus implies subtraction” -Oct 2, Field Notes).

Students felt free to choose any help (peer-tutor, resource room or teacher) to complete the task. In some cases students assisted each other by focusing more on the correctness of their answers, rather than the process (e.g. “another pair of students is observed comparing their final answers”, “the helping student tells her exactly what to write down for each step” and “shows her how to use the exponent on her calculator” -Oct 17, Field Notes).

During the first lessons observed, no formal assessment procedure seems to have been employed, although we observed explicit questioning that could be seen as an assessment procedure. (A test was scheduled for the next day. The test was to be “be marked in the traditional way; she is not using levels because she finds it too difficult to mark tests using levels. She uses levels for assignments” -Oct 3, Obs Field Notes).

Christine used informal assessment methods. She went “up and down the rows asking for answers from the students” (Oct 2, Field Notes), while in other cases students were calling out the answers when she was writing on the board. She checked students’ answers and the class could monitor the performance of those students who were putting their solutions on the board.

Although there was no formal peer-assessment, students were informally evaluated by their peers (“one student asks another student; I’m on #7 and I want to know if I got it right” -Oct 17, Obs Field Notes). They also conducted informal self-assessments by comparing their answers to other students’ answers, to the ones on the board or to the teacher’s answer sheet at the end of the lesson.

Rubrics were not visible in the classroom, but Christine revealed elements of her marking scheme (e.g. “for 2 [marks] out of 3 I need to see your thought process” (Oct 17, Obs Field Notes) and “you’ll get full marks for reducing” -Oct 2, Obs Field Notes).

**Teacher's Action Plan**

Christine focused on two dimensions: Student Tasks and Assessment. For the Student Tasks dimension, “she placed herself at Modified Exploration and for Assessment she placed herself at Exploration for Purpose and Transparency and Modified Exploration for Variety” (Oct 30, In-Service Session). She worked toward Exploration for both Tasks and Assessment Variety.

Christine was planning to modify her practices by using “more open-ended questions around thinking and logic” (Nov 7, Follow up Discussion), adjusting her lesson to a more open environment, and by raising the number of the formative assignments (“assignments are more summative and she wants to make them more
formative” -Oct 30, In-Service Session). We could presume that Christine considered that more assignments would provide more practice to the students and would designate how far students had achieved each task; however, the procedure that would be followed was not described in detail. (“She then said she would try to do 2 assignments over the 4 weeks, but she didn't offer up any details” -Oct 30, In-Service Session).

Christine said that the only formative assessment she was using was “a work habits checklist” (Oct 30, In-Service Session). Although the means of assessment that she used were not clearly stated, we thought she was relating the number of assignments to the improvement of her assessment strategies. In our interpretation, she meant that if she used more assignments she could switch between different forms of assessment. Christine also said that she was willing “to do more assignments focused on communication” (Nov 7, Follow up Discussion).

Based on the data from the In-Service Session, we could not identify an explicit justification for choosing to focus on these dimensions. Nevertheless, it seems that her commitment to student practice, content mastery and application of rules motivated her to choose dimensions that would enable her to do “more” within her established conceptual context. The phrases “I want to use more open questions” and “Do more assignments” (Oct 30, In-Service Session) suggest that Christine perceived her change in terms of a quantitative, rather than qualitative modification of her practices.

Her position on teaching could be further elucidated through her concept of the teacher’s role (i.e., rejection of co-learner -Oct 30, In-Service Session) and her concept of students’ attitude towards math (“Kids look for the rules and don’t question math” -Oct 22, Follow-up Discussion). Christine was providing explanations to the students and she was supporting them in accessing the tasks, possibly in more than one way, which might help those who were looking “ahead to university”. During one of the interviews (Interview Dec 3), Christine underlined the necessity to prepare students for university and expressed concern about students who go to universities without having mastered basic skills (“She felt that kids who are good in math, the ones who will do Ph.D.’s are turned off by calculators. Christine believed that students who use calculators cannot do simple calculations, such as figuring out their final mark, without them” -Interview Dec 3). Moreover while referring to the calculators she said, “The old way is what they will see in universities”. This could explain why technology was not used during the lessons observed, and why the use of calculators was not highly recommended (“Yes you can use calculators, but remember to write the steps. Don't rely on your calculator for the right answer” -Oct 3, Obs Field Notes).

Implementation of The Teacher's Action Plan

The discussion of Christine’s progress is based on only two observations (Nov 7 and 27) due to the previously described (see Paul’s Case Report) data collection problems. During these classes Christine went through the questions in the worksheet. Some students participated. She frequently offered tips (“if it doesn’t make sense then there is no correlation” -Nov 7, Obs Field Notes), analogies and mnemonics (“think of this as the amount of energy you would use to climb a hill” -Nov 7, Obs Field Notes). She modeled tasks and asked questions that would clarify misunderstandings. (“Christine modeled the task: draw the line on the graph. Christine drew a Cartesian plane” -Nov 27, Obs Field Notes). She also “provided procedural support by prompting students, although often before they needed help” (Nov 27, Obs Field Notes), while the peer-tutor and the resource room were also available to help students:

talking with friends on this will give you much better answers, so discuss it with each other. S [the peer helper] is here to help you (Nov 7, Obs Field Notes).

There was a peer tutor who provided additional help to students in the form of modeling the procedure (Nov 27, Obs Field Notes).
Further discussion was not generated once she got a correct answer and there seemed to be no involvement “in higher level math” (Nov 27, Obs Field Notes).

She asked what each of m and b meant, accepting short answers. Christine stated the items in #1 “could also be done algebraically but it is not like algebra where you have x’s and y’s.”

Christine reads the next question, telling them the question looks hard. Without waiting for a response she reduces the cognitive difficulty of the task. She told them all points in the problem are on the y intercept (Nov 27, Obs Field Notes).

However, a graph that she constructed based on students’ knowledge enhanced participation and students could associate the concept presented to their own experiences. (“The teacher asks the students to give her the names of the communities where they live. Then she asks them to order the places in terms of closest and furthest from the school” -Nov 7, Obs Field Notes).

Some tasks still called for short single answers (“you’re going to put positive, negative…” -Nov 7, Obs Field Notes) and others for a variety of representations (numerical, verbal, graph):

T: How about b?
S: Positive.
T: Strong or weak?
S: Strong because they are tight.

T: c
S: None.
T: d
S: Negative and kind of in the middle.
T: let’s put these on a chart so we graph them (Nov 7, Obs Field Notes).

Now Christine occasionally mentioned or implied alternative/multiple possible solutions while presenting the procedure and students were encouraged to reach their own conclusions (“Using distance usually means measurement using kilometres, but we didn't do that. We kind of rated it”, “what conclusions can you draw from this?” -Nov 7, Obs Field Notes).

Occasionally open-ended questions were recorded:

Is it possible to have a few points go down and still have a positive correlation?
When you look at the two things would you think there would be related?
Positive, negative or no correlation and why? (Nov 7, Obs Field Notes)

On the other hand when Christine was drawing a graph on the blackboard she solicited no input from students (Nov 7, Obs Field Notes), although students’ contribution to the construction of a graph could have been a starting point. Christine asked students to discover the relations of times and distances based on their experiences (time it takes to reach school). However when a student answered that it takes him “five to 10 minutes” to come to school, she said, “let’s go with 7, this is not perfect stats” (Nov 7, Obs Field Notes), without discussing it. She also passed up the opportunity to exploit a student’s error and pose questions that would clarify why 12 is not a suitable scale for time (“when do we ever use 12 as a scale? [in a sarcastic tone]” - Nov 7, Obs Field Notes). The transmission of algorithms was still prevailing, with little evidence of a constructivist approach.
Her role as a teacher was still central; she was seen as a knowledge expert calling for participation and providing guidance:

let's hear from some people we haven't yet
I'm going to collect the booklet and I'm going to give you a review assignment.
Instead of doing notes on the board I just want you to listen (Nov 7, Obs Field Notes).

Students could work in pairs, groups or individually and “these could be considered assigned roles” in the sense that her rules “permitted them to work together” (Nov 27, Obs Field Notes).

Christine kept providing positive feedback to the students (“I think you guys can do this” or “you’re really getting correlation” -Nov 7, Obs Field Notes). There is some evidence that she was now providing encouragement mostly to the class as a whole. Also at the last lesson observed she stated that she did not expect most students to finish the assignment and she seemed to depress the confidence levels of the students.

Christine announced that students who finished early “and this only means John” would get a bonus assignment. Students reacted very negatively “what about the rest of us” (Nov 27, Obs Field Notes).

However, this attitude differed greatly from her former routine and viewpoint and it would, therefore, be precarious to record it as a modification of her typical behaviour.

Christine continued to control the discourse and she guided students’ activities; “students were assigned individual tasks”, which she sometimes explained, and she selected students “to repeat the procedure at the board” (Nov 27, Obs Field Notes). There were no instances of students’ questions to the teacher or of teacher questions probing that all students were following the procedures:

While students worked at the board, Christine worked closely with them. Students talked among themselves about non-math matters. They could not really see or hear what was happening at the board. Christine announced that the items written on the board were correct. She asked for questions. None were offered so she moved on (Nov 27, Obs Field Notes).

We were able to obtain little evidence about students’ discourse. However, we noted that there were no rules “to guide student interactions in learning groups” (Nov 27, Obs Field Notes).

Christine’s questioning of students could be considered an informal evaluation. Students volunteered to answer. Christine’s main concern appeared to be the correctness of responses. Although other forms of assessment were not clearly observed, Christine was aware of different assessment strategies that she could employ.

Christine identified a range of methods including a rubric listing levels of performance on five criteria for assessing investigations. Christine said this rubric was shared with students. In addition Christine told students what proportion of their test mark was attributed to four levels of objectives. However, none of these interview statements was observed.

In the interview Christine identified a variety of assessments: tests, investigations, bonus assignments (Nov 27, Obs Field Notes).

She explained to students what they would be assessed on and the assessment procedure (“it will be marked on a rubric and you’re familiar with the investigation rubric” -Nov 7, Obs Field Notes) and she reviewed the expectations of the assignment (“You’re going to be marked on communication, knowledge and
inquiry. I want to see what you're thinking and give me a clear and concise explanation” -Nov 7, Obs Field Notes). Therefore the guidelines given to the students for her marking scheme seem consistent with her goal “to do more assignments focused on communication” (Nov 7, Follow up Discussion). However, students were not involved in the assessment design process.

Christine gave marks individually when a test was returned to the students and she wanted to discuss their marks (“I’ll come around and give you your marks individually and have a discussion with you” -Nov 7, Obs Field Notes). However at the class observed she did not have enough time to do so.

The assessment seemed to be an important procedure for her classes; while describing the schedule for the week she referred to a quiz and a test. Moreover she now claimed that process was also important and that her goal was “to start to include process in her marking (rather than just product)” (Nov 27, Obs Field Notes).

**Teacher Perceptions of Professional Change**

Christine believed that she had made a progress on the student task dimension. She was now using “a variety of tasks in her teaching”, she “included more investigations in her teaching” and “some tasks which provided for different solutions” (e.g. graphically or algebraically) (Interview Dec 3).

She also claimed that her practices in assessment had changed and when interviewed she identified a variety of assessments, i.e., summative assessments based on tests, investigations, bonus assignments and review assignments (Nov 27, Obs Field Notes). She said that she was using rubrics, which were shown to the students, and checklists (Interview Dec 3) (students would be informed about the proportion of their test mark, which was attributed to four levels of objectives -Nov 27, Obs Field Notes). She also mentioned that she was marking “communication, inquiry, knowledge and understanding, and thinking” (Nov 27, Obs Field Notes) and that she now included “assessment items that call for more than a single answer” (Interview Dec 3). However she did not think that her tests had changed. “She was not assessing concepts in more than one way —she relied mostly on tests.” Therefore while commenting on the dimension “Variety in Assessment” she said “she had made progress but she was still not consistent” (Interview Dec 3).

**Enablers and Sources of Tension/Obstacles**

Paul and Christine shared a common viewpoint for various aspects of teaching. When they met at the beginning of the year, they were each delighted to find a colleague with similar professional views. They interacted every day. During these interactions, they reinforced each other and consolidated their views about teaching and learning. The project provided further opportunities for them to interact, increasing the consensus between them. The project supported a convergence that was already occurring. The similarities included:

(a) Students’ abilities to discover the rules: Christine “would not expect students to invent the rule that Gauss discovered” or “come up with the general from the specific” and this is why she “almost always” presented “the rule first”; Paul similarly stated that “students cannot discover rules on their own” (Interview Dec 3).

(b) The role of the teacher as co-learner: “Christine said, ‘The kids don't respect you anymore when you do that because they know that you're just playing dumb and they know that you know it’. Paul remarked, ‘How can I be a co-learner with my students? ’ (Oct 30, In-Service Session)”. They also expressed some doubts about the validity of the presentations initially made by the researchers (“Paul agreed with enthusiasm that he did not like this activity. She [Christine] felt that as a student she would have failed the circle poem assignment. Paul said the poems were 'good poetry but they were not about math' ”-Interview Dec 3).

(c) Conception of the Discipline. They concurred in their beliefs about math as a subject (“math is philosophy—there are no numbers” -Interview Dec 3), the merit of the traditional math approach and the
separation of technology and mathematics. Christine “said that everyone felt that technology was taking over
the math curriculum” and that “kids who are good in math are turned off by calculators. Paul agreed. Teachers
should not use calculators until the universities bring in calculators too. Christine: ‘The old way is what they
will see in universities.’ Paul agreed stating that by having them use calculators 'we are not doing them any
favours'” (Interview Dec 3).

(d) Beliefs about Changes in Curriculum Policy. They also expressed similar ideas about course
revisions included in provincial curriculum guidelines. They were ambivalent about the changes, judging each
in terms of its likelihood of preparing students for university. They were “looking ahead to university” and what
they want “to be doing goes against the new curriculum” (Interview Dec 3). There were elements they liked.
“Christine said that the Data Management of the new guideline was good. ‘Data Management is good for
anyone going to university.’ Paul thought the emphasis on communication was good because it had not been
done well in the past” (Interview Dec 3). However, they were very opposed to the emphasis on technology in
the math curriculum, as noted above. This is probably why Christine “can’t wait until the new administration
brings back the old curriculum” (Interview Dec 3).

(e) Objections to School Policies. Both viewed themselves as opposed to key student management
policies of the school. (“They have stopped sending students to the office because the office just sends the kids
right back to class” -Nov 7, Follow up Discussion).

(f) Attitudes Toward the Research Project. Although some of their reactions suggest that they were
rather sceptical of the effectiveness of the project (they had “not met at all to discuss the project” -Nov 7,
Follow-up discussion), gradually they seem to acknowledge that certain factors could facilitate teachers’
awareness. They claimed that a change in their teaching practices had occurred. Nevertheless, Christine
“attributed the change in her teaching to the change in her math knowledge, not her participation in the project”,
and to Paul, “someone knowledgeable about math that she could talk to” (Interview Dec 3).

In our view, Paul and Christine changed very little over the course of the project. There were changes at
the margins of their practice. Some of the factors that enabled this shift are common for both teachers:

Peer Conferencing: Christine and Paul “believed that the changes that occurred this year were the
result of the many conversations they had. They start and end the day by talking about their teaching, as well as
about politics in their school”. Christine also said that Paul’s presence “enabled her to become more
comfortable about her disciplinary knowledge” (Interview Dec 3). During their interaction, they compared their
practice and thereby became more aware of their questioning techniques (“He said that, unlike Christine, he did
not ask leading questions” -Interview Dec 3) and their role as teachers (“she was never a co-learner. Paul
indicated that the same was true for him as well” -Interview Dec 3).

Moreover, during Paul’s classes, Christine helped him with the presentation of the topic, with some
procedural aspects in delivering the lesson (e.g. distribution of calculators -Paul-Nov 27, Obs Field Notes), and
with classroom management (“Christine told the students who were uncertain to pair up with someone who did
know” -Paul-Nov 27, Obs Field Notes). Paul also circulated to help students during Christine’s classes
(Christine-Nov 27 Obs Field Notes).

Self-assessment tools: In retrospect Paul placed himself at a different level, when commenting on
his self-assessment (Interview Dec 3). This might imply that he was becoming more aware of the meaning of
the rubric, which could be a starting point for a purposeful shift in teaching practices. Christine, who also placed
herself at a different level when commenting on her self-assessment (Interview Dec 3), claimed that “the self-
assessment made her think more about how she taught math”.
Apart from the aforesaid enablers, which were stated by both of the teachers, Paul also mentioned that having the researcher and the teacher observer “made him more conscious of his teaching”, he “paid more attention to what kids were saying” and started to “second guess” himself (Interview Dec 3).

Finally, Paul’s position that he should “keep things as simple as possible” and encourage “students to ask their friends for help” enabled him to focus on students’ interaction (Interview Dec 3). It appears that Paul’s existing teaching style may have facilitated growth.

Christine and Paul used different teaching practices. Nevertheless they shared similar ideas about math as a discipline, and they shared similar doubts about the project’s call for a new role for the teacher and the project’s recommendation that students explore concepts. Therefore, any changes in their practices entailing a modification in their firm beliefs about their role, about their students’ cognitive abilities and math as a subject were unlikely to be pursued. Moreover, Christine seemed comfortable with her role and her current teaching practices, while her orientation towards any modification was perceived within her established conceptual framework as a teacher. Any attempted changes seemed to amplify/ elaborate her practices in the direction she was already working. From the Interview Notes we deduce that Christine gradually became more capable of stating clearly her practices and the means of teaching she was employing, which were coherent within her framework, and she could justify her choices. For example:

in the last observation, students could do the problem graphically or algebraically. When [Christine was] asked if any students had done it algebraically she said that one student had but his solution was incorrect. Christine needed to provide him with a lot of help before he got it right. She said that many of her students can do the problems when she is prompting them but not when they are on their own (Interview Dec 3).

Factors contributing to the maintenance of their established teaching practices might be the following:

Attitude towards the project: Paul’s neglectfulness in providing some information to the researcher (“I asked him to send me an email with the information, but he never did” -Oct 22, Follow-up Discussion) or to give some observation sheets to the peer-teacher, and his brief comments on the peer-teacher’s teaching might imply that at the beginning he was not convinced about the project. (“Paul provided little feedback” -Interview Dec 3, “when I asked Paul if he had anything to add he said that he had noted everything that I had and had nothing more to add” -Oct 30, In-Service Session).

Moreover, the fact that Christine wanted “to be convinced” (Oct 30, In-Service Session), implies that she had certain hesitations about the project, which were accentuated by her dislike for “the presentations made by the researchers about how to teach math” (Interview Dec 3). This may have affected the number of the peer-discussions about the project, although she mentioned that they discussed a lot about teaching math.

Math as a discipline: Paul’s devotion to the subject and the philosophical dimensions that he was attributing to it probably made him believe that the depth of math, “a balance between science and art” (Oct 22, Follow-up Discussion), was too difficult for the students to appreciate. He responded by presenting each unit in a linear way, at times oversimplifying it. On the other hand, he seemed eager to reveal to his students the grandeur of mathematics by describing indicative cases (e.g. a cult “for philosophers and mathematicians” -Oct 17, Obs Field Notes). However, such attempts did not appear to influence students’ routines.

At the follow-up discussion (Oct 22), Christine also mentioned that in math “there are basic patterns that don’t change”, even if things “can be disproved”. However her routine might indicate that she would consider easier for the students to be presented with less “disputable” patterns.
Teacher’s Role: Paul, rejecting the co-learner’s role, stated that he feels “superior to the students” (Oct 30, In-Service Session), since he was “good in math”, and he wanted “the kids to see that” (Oct 22, Follow-up Discussion). This belief impelled him to retain his central role (a medium between students and math). He was presenting himself as an expert who would serve the integrity of the subject. In reviewing an earlier version of this case report Paul emphasized that his objection to the teacher’s role espoused in the project was based on his criticism of Rousseau’s philosophy of education. He associated the project with cycles of progressivism that move through education from time to time.

Christine firmly believed that the teacher couldn’t be a “co-learner”. She provided help to students, because “many of her students can do the problems when she is prompting them but not when they are on their own”. Sometimes “she overprompts students, almost giving them the answer”, which “may give them a misleading impression of their true ability” (Interview Dec 3).

Moreover, Paul’s assertions that “kids see him as being eccentric” and this “may help students to like math” (Oct 22, Follow-up Discussion) could explain why he was feeling content with the image that he put forward as well as with his distance from students’ cognitive process. The latter urged students to turn to their peers for help and eventually compare their strategies, as the teacher had initially planned. However, this interaction looked rather “suspended”; students were trying to elucidate teacher’s presentation, rather than building up purposefully selected concepts (cf. “He liked to use group work because students found him confusing” -Interview Dec 3).

Some additional factors that might be considered as obstacles to a shift in Paul’s practice are the following:

“Confusion dissonance”: Paul’s firm belief that confusing the students would compel them to figure things out for themselves was preventing a change in his practice. Instead of creating dissonance by providing challenging activities, Paul intentionally confused students by giving unconnected (for them) information. “He said he ‘wanted to confuse the kids, the academic ones, anyway.’ He added, ‘you want to make them thinkers, questioners.’ Paul said that he wanted to continue what he was unconsciously doing ‘but with a purpose.’ [the researcher] offered the term cognitive dissonance and he agreed” (Interview Dec 3). Based on this viewpoint for cognitive development, any shift in teaching practices would probably focus on the improvement of techniques, rather than be based on a substantial change in his orientation to teaching.

Student Confidence: Contradictory emotional meanings affect his role. Lax discipline and his off-task friendly approach seemed inconsistent with his infrequent positive feedback and his hesitation to support students’ cognitive struggles. This led the students to express their disappointment with the teacher’s attitude.

Observer’s presence: The fact that Paul attributed students’ disorder and ineffective teaching to the observer’s presence (once stated as “intimidating presence” -Nov 27, Obs Field Notes) suggests that the teacher felt uncomfortable when being observed.

Personological factors: In Christine’s case, some personological factors may have contributed to the maintenance of her established teaching practices. She described herself as too “leading”, “too grounded in reality to be truly pure” and “pretty cemented”, while she did not seem to feel comfortable in an “unstructured environment” (Interview Dec 3).

Summary of The Cases

Paul and Christine believed that they made some progress on the dimensions they had been working on. The changes that they mentioned were in accordance with their goals set during the In-Service Session. These changes mainly concerned certain features in their teaching practices, but did not contribute to a substantial
Case Reports for Victoria & James

By Alkistis Verevi & Caroline Rosenbloom

Victoria’s Report

Introduction

Victoria was the mathematics chair at a junior high school and had been teaching for 7 years. She was an elementary teacher who was teaching grade 9 for the first time. She taught grade 7, 8 and both academic and applied grade 9 mathematics classes. Her teaching style reflected an active learning environment mainly through her questioning techniques. These techniques often demonstrated some type of scaffolding to guide the students, while “what if… questions” and questions like, “how do you know this is right?” were frequently recorded (Oct 8th, Obs). Victoria scaffolded the questions and asked students for responses. She asked questions such as “How are you going to find the height for the prism?” and when students responded, she reiterated what had to be done (Oct 8th and 10th, Obs).

The teacher continued to solve the problems with the class’ participation by asking probing questions. Scaffolding the questions allowed many students to participate in the discussion (Oct 8th, Obs).

She would ask questions like, “What does the cylinder look like?” or “Why would I ask for the circumference?” (Oct 8th, Obs).

Her skilful questioning techniques also provided students Opportunities to Learn (Dimension 2) as they guided students “to generate the answers themselves” (Oct 8th & 10th, Obs) and encouraged students to investigate a concept.

Students who required assistance mainly asked the teacher. Responses were mainly questions that were asked back to the student in order to probe more information for the students so they can generate the solutions themselves (Oct 8th, Obs).

The questions were guided to scaffold the questions for the students. The teacher went through some algorithmic questions and identified information students needed to know. Acronyms (or memory cues) were used to remember some facts (Oct 8th & 10th, Obs).

The teacher continued to ask students questions to identify information that is already known. In one example, the teacher wanted to reinforce that $s^2 \times s = s^3$. The teacher asked, “What is $4^3$? Is it 12? Explain” (Oct 8th & 10th, Obs).

Investigation of concepts was also pursued through the tasks she assigned. For example, for one of their tasks, students had to “make a hypothesis about the dimensions of the cylinder”, “complete the chart and calculate the surface areas”, “draw a scatter plot and draw conclusions” (Oct 8th, Obs).

In this open concept classroom, students’ desks were grouped in either pairs or trios with a circular table in the back. There was no overhead screen but an overhead was used at the front of the class. The walls were
covered with math information such as Math Olympic and contest dates. Curriculum expectations were posted on the wall as well as a math poster on tessellations and one on What Do I Need Math For? (Oct 8th Obs). However, although Victoria had an interactive classroom, “she felt a little uncomfortable with the subject area, particularly at the grade 9 level” (Oct 8th, Obs). Therefore she liked to ensure she knew the material well and was well-planned prior to when she taught her classes. “She has expressed her discomfort with the grade 9 content and describes her routine where she spends quite some time ensuring that she understands the material before she teaches it” (Nov 21st, Obs).

Victoria often used verbal checks to indicate how much progress students were making in their thinking. She would do verbal checks “to see where the students were in understanding” and she “would ask students questions throughout the lesson to ensure they understand” (Oct 18th, Obs).

She regularly identified common errors while she was demonstrating solving a problem. “The teacher says, ‘This is where people usually go wrong…” (Oct 8th & 10th, Obs). Also,

In one instance, the teacher identified an error that a particular student made on a quiz. She was very positive in saying that this student made this particular type of error because of the displacement investigation they did last class. The student transferred incorrect information from last class and tried to apply this to solve the problem. The teacher through encouraging words said that it was easy to see how one can make this type of error (Oct 8th, Obs).

Victoria often had students recall prior knowledge. “Throughout the directed lesson, the teacher constantly refers to prior knowledge and applies it to what they need to know now. The teacher reinforces the formula and definitions. The teacher will ask, ‘How do you know what the base is? How does it relate to the height?’ (Oct 8th & 10th, Obs). In one example, a student had a question about solving the area of a rectangular prism. She referred to a previous lesson and said, “Remember when we did 2D. Same thing for 3D but height is added” (Oct 18th, Obs).

Wait time was used to encourage students to participate. Victoria would say, “I’ll give you a minute to think…”; then she would ask for a volunteer to share their solution. She also encouraged her students to take a risk and she underlined that trying was what was important (Oct 18th, Obs). In one instance, a student said, “I don’t want to answer. My answer is stupid.” Victoria replied, “I don’t care” (meaning that she accepted of all answers and that no answer was stupid because effort was given) (Oct 15th, Obs).

She regularly pursued and achieved students’ participation. “Lots of participation and math discussion occurred during the actual directed lesson” (Oct 8th & 10th, Obs), while those discussions “involved both students and teachers” (Oct 8th, Obs):

Many students regularly had their hand up to volunteer answers (Oct 8th, Obs).

Students offered their solutions in class and the teacher reiterated their choice on how to solve the problem by saying, “Yes you work backwards” (Oct 8th & 10th, Obs).

Since the task was scaffolded, it provided an entry point for all students (Oct 8th & 10th, Obs).

Victoria frequently offered help to the students who needed it and positive feedback “to let the students know their answers were leading in the right direction” (Oct 8th, Obs); it was evident that she had created a safe learning environment in her class.
Students felt comfortable asking questions to both the teacher and other students. During the task, she walks around the class and sits with students who require help (Oct 8\textsuperscript{th}, Obs).

Lots of positive reinforcement is given. The teacher also reviews with some students some of the errors they did but in a guided way using the same questioning technique she used with the whole class (Oct 8\textsuperscript{th} & 10\textsuperscript{th}, Obs).

Some comments that were made by the teacher…
“ It’s ok. Don’t worry, we’re not there yet.”
“Good” (Oct 18\textsuperscript{th}, Obs).

As far as her role as a teacher, Victoria was seen as “an expert rather than the learner.”

She said what needed to be done (i.e. “You have to convert the units first”).

Most of the questions to the students were to direct them as to what information would be substituted in the formula (Oct 8\textsuperscript{th}, Obs).

As far as the assessment procedures are concerned, Victoria had always determined how student work would be assessed. Pencil and paper quizzes were given regularly to assess concepts that were just recently taught.

The students began with a mental math exercise. A worksheet was handed out for students to complete independently given a fixed amount of time. Marked quizzes were handed out and debriefed (Oct 8\textsuperscript{th}, Obs).

Peer assessment was also used, “The mental math exercise was to be marked by peers in class (on another day due to the time constraints)” (Oct 8\textsuperscript{th}, Obs).

Although Victoria used a variety of ways to assess learning (quizzes, worksheets, explicit questioning) some of the questions did not reflect the same type of questioning that was asked in class. The assessments occasionally were more procedural and did not have the openness that the tasks in class did. Moreover, in some cases, there was “no evidence of a rubric or students involvement in designing the assessment” and self or peer assessment was not recorded (Oct 8\textsuperscript{th} & 10\textsuperscript{th}, Obs).

The content consisted of solving low level decimal/fraction and number fact questions. There was no opportunity for a variety of solutions as the final answer was all that was counted, not the process (Oct 8\textsuperscript{th}, Obs). The instructions were guided for students to follow so that they can continue to do the rest of the questions. Several students solved it and called out the answers. The instructions showed one way of solving it. Alternative ways may have been represented by students but there was no clear evidence of this at this point (Oct 8\textsuperscript{th} & 10\textsuperscript{th}, Obs).

Therefore solutions tended to elicit one answer, often with a single approach to solving it. For example, a worksheet was provided for students to complete.

Many of the questions were in the form of “Find the volume…given…”.
A cylinder has a volume of 96 cm\textsuperscript{3}. What is the volume of a cone that just fits inside the cylinder? (Oct 18\textsuperscript{th}, Obs).
However there was evidence that “the conclusions would elicit multiple solutions.” But “solutions are left open and can vary from being very specific (identifying the pattern as the radius increases and its relationship to the height, or stating the optimum dimensions for the cylinder) to very vague (the radius increases)” (Oct 8th, Obs).

At school, Victoria had also taken the role as mentor to James who was a first year math teacher and was her peer in this project. James and Victoria had a positive working relationship. “Both teachers were working together on a regular basis. Victoria is also James’s mentor. They shared resources and gave feedback on work for each other in the grade 9 unit” (Dec 3rd, Interview). They understood each other’s strengths and often had several conferences with one another to plan together both at school and during their own personal time (“Finally, we haven’t really had a chance to talk to each other yet. Maybe this week between meetings, open house and report cards” (Nov 18th, email).

Teacher’s Action Plan

After participating in the self-assessment, Victoria chose to focus on Student Confidence (Dimension 3) and Student Assessment (Dimension 9).

The self-assessment indicated she was a level 3 in the Student Confidence dimension and “her goal was to create some type of tracking sheet for students to monitor their own progress and to generate a rubric with students” (Oct 30th, Interview).

Victoria was interested in this dimension because she taught grade 9 applied students who felt they were not aware of their own progress (“she still gets students who are not aware that they are doing well or not doing well” -Nov 21st, Obs). She was also self-conscious about her own mathematical abilities and was at times unsure of her role as a math teacher.

Victoria described herself as being math phobic. She always felt that math was a weak area in particular grade nine. Although she leads the program and James follows her plans, she is unsure whether or not she is doing the right thing. She spends a lot of time planning and ensures that she has the answers and understands the concepts completely before teaching it. She said that a lot of the time, she doesn’t understand the concepts and has to spend a lot of time learning it herself. Although this teacher has excellent questioning skills, she does not feel exactly comfortable with how she is teaching the math (Nov 12th, Interview).

Therefore, in our interpretation, focusing on Student Confidence dimension would help Victoria ease her own anxiety about the subject area at the grade 9 level and how she taught it.

Victoria modeled learning and encouraged her students to do the same. Also, she often saw herself as a learner rather than an expert and as a result her classroom was interactive with students regularly participating in discussions (Survey Results). Moreover, “Scaffolding the questions allowed many students to participate in the discussion” and these discussions “involved both students and teachers” (Oct 8th, Obs).

Although Victoria’s self-assessment indicated a level 3 and 4 in the Student Assessment dimension, she had always felt that she has been in control of the types of assessments that were used to assess student learning. She wanted to explore a variety of assessments, which would be more transparent to the students (Survey Results).

Implementation of The Teacher’s Action Plan

Victoria implemented a tracking sheet to assist students in becoming aware of their own progress. She recognized that she gave her students “praise in the form of lollipops, stickers”, encouraging words, etc.
However her students were “not aware that they are doing well or not doing well” and they often still asked her about their progress, seemingly unaware of their own mathematical abilities (Nov 21\textsuperscript{st}, Obs). She felt that, by understanding where their strengths and weaknesses were, they would be able to build their confidence in mathematics.

Victoria “began the class by saying that they will be working on their student confidence”. “The teacher continues to explain that they will be using a tracking sheet to keep track of their performance on the mental math and estimation activities. The tracking sheet was handed out to the students and they all reviewed the components of this tracking sheet” (Nov 21\textsuperscript{st}, Obs).

Victoria asked her students “to write something positive [they learned] from their estimation activity on their tracking sheet” so they could identify their areas of strengths (Nov 21\textsuperscript{st}, Obs). By focusing on a positive aspect, she felt that it would increase confidence and encourage them to want to do better.

In a percent to fraction question, one student was excited because it was one of the few questions he understood. He used percents and fractions as benchmarks (Case) to be able to do the conversion between percents and fractions. The teacher said that this was what he knew and that he should write about this as his “Positive” on the tracking sheet (Nov 21\textsuperscript{st}, Obs).

Victoria also kept using several other strategies to build students’ confidence. She identified students who made “unique” or “out of the box” solutions; she reviewed the questions and asked students along the way for verbal answers. Praise was given for correct responses, while for incorrect responses she would “scaffold questions to ensure an entry point for students to provide an answer” (Nov 4\textsuperscript{th}, Obs). Another strategy that was also used to build students’ confidence was reviewing and explaining questions:

The teacher then went over the instructions for the quiz. [It seemed that she reviewed all the questions and explained what each question was asking for.] Students were asked if they required a calculator (Nov 26\textsuperscript{th}, Obs).

She continued to provide positive feedback but also identified areas of weakness to students. Also, when marks for a test were handed out, praise was given to those who did well. The teacher expressed concern to those who didn’t do well and encouraged them to look over to see where they had made their mistakes. Students seemed to understand why they received the mark they did and did not dispute it nor were surprised by it. “Students saw their marks with some peers surrounding them. Students obviously felt ‘safe’ in this situation and felt no need to keep their mark ‘secret’ (Nov 12\textsuperscript{th}, Obs).” Therefore it can be further verified that Victoria had created a safe learning environment in her class.

James made some interesting observations and speculation as to possible reasons why Victoria chose to focus on Student Confidence:

The only positive critique I could provide for Victoria is allowing herself to believe that she is a GREAT Math teacher. She seems to lack confidence, especially in the domain of Grade 9. Ironically, maybe this is why she chose to develop her ability to assist her students with this particular area. She fails to realize that acknowledging her mathematical difficulties, although rare, in front of her classes provides them with the confidence she strives for. Not to mention that her sincere love of her students creates a warming, closed environment that all teachers dream of (Nov 20\textsuperscript{th}, email).

Quizzes were still given regularly to assess concepts that were recently taught. Students completed a quiz in the computer lab using the Geometer’s Sketchpad software (Nov 12\textsuperscript{th}, Obs), while mental math or estimation challenges were given at the beginning of class and were either self assessed or marked by their teacher. (E.g. “The teacher takes up the estimation activity which was marked by the teacher” -Nov 21\textsuperscript{st}, Obs).
Victoria decided to create a problem-solving rubric with her class to help make the assessment more transparent to students. She had always decided how student work would be evaluated and didn’t know how the results would turn out by involving the students.

Victoria introduced the idea of a rubric by asking students “what would make an awesome party. Students were engaged and provided many responses such as good food, girls, good music and not having a brother there”. Victoria described this as a Level 4 party. She then encouraged students to think about what a Level 1 party or R party would look like. After this discussion, the problem solving assignments were handed out and the teacher discussed how these would be evaluated. “These were assessed by levels (2+, etc.)” (Nov 4th, Obs).

Her students were extremely interested and they really understood how a rubric would be used to describe a party (Nov 4th, Obs). Using this example, students worked on creating a problem-solving rubric. However, Victoria had not had a chance to try the rubric with her class at this point but would use it during the next session. One grade 9 class did the initial draft. They came up with the statements for each level, but they didn’t finish the task so another class continued. In an another lesson students were divided into 5 groups and they reviewed the statements and made modifications and additions to each level. However, during that lesson, most of the time was spent on a quiz and not many students had the opportunity to work on the rubric task.

Apart from generating a rubric with the students, Victoria also kept using her regular assessment tools, such as quizzes, to assess students’ thorough understanding of the taught concepts. For example:

Students then wrote a quiz on geometry to review angles, parallel lines, sides and diagonals of quadrilaterals. Some interesting questions included:
State when the following statements are always true, sometimes true, never true.
- a square is a rectangle
- a parallelogram is a square
- a rhombus is a square
- the diagonals of a kite bisect each other (Nov 4th, Obs).

Students were to construct a triangle and label each of the following:
- altitude
- medians
- angle bisectors
- orthocenter, incenter, and centroid (Nov 12th, Obs).

You can also add a communication part such as having them give an example of when a median and altitude would be the same in a triangle or when the median and altitude would be different in a triangle. It gets them to identify specific properties or really understand these terms (Nov 12th, Obs).

Besides, thinking, reasoning and understanding were also evaluated through the assignments. For example, one of the assignments she gave had 3 questions which had an asterisk beside them. This indicated that students were to show their thinking and understanding.

When taking up the questions the teacher breaks down the question, into steps (scaffolds) to identify each step and the reasoning behind why it is chosen (Nov 21st, Obs).

Self-assessment was also used since students marked their own integer homework sheet in class. Also while reviewing the estimation activity, Victoria categorized each question as rounding questions, percent
questions, percent from fraction questions so that they could see what general areas they were good at or where they needed improvement.

It is worth noting that a few months after the project had been completed, Victoria combined the two dimensions she was working on. She discussed with her students the sections that would be included in an exam:

I continued to work on the student confidence objective for my grade 9 applied. What I did was outline the 4 possible areas to cover on the exam, we discussed them then we (they) selected by a majority vote which 3 sections would be on the exam. We also compromised on an assist sheet (formulas) for the measurement unit. Hopefully they are feeling a little better about it but they are still anxious” (April 22nd, email).

Technology was also infused in the assessment process and was well integrated into the geometry unit. The use of the computer lab often alternated with their regular classroom math class to provide another means for exploring concepts (Mathematical Tools – Dimension 7).

Moreover when students were to complete the geometry quiz in the computer lab using GSP, “the teacher reviewed the expectations of the quiz prior to entering the lab. A brief review of the technical aspects such as printing was discussed as well as the format of what they needed to hand in” (Nov 12th, Obs). Students were aware of how they were being assessed, while unique solutions were highly valued.

This quiz should have students do the constructions to allow them to have unique solutions from others. This can also distinguish the level 4 from the level 3 (Nov 12th, Obs).

Teacher Perception of Professional Change

Victoria felt that she had “moved up a level for Student Confidence and Student Assessment” (Dec 3rd, Interview). She said that she had progressed from a level 3 to a level 4 in Student Confidence. Victoria reflected on her implementation of the tracking sheet for the grade 9 applied students. She noticed that the tracking sheet helped her students “focus on what they are responsible for” (Dec 3rd, Interview). This increased student awareness motivated students to try harder. A de Bono thinking skill strategy which examined a situation from different perspectives: Plus, Minus, Interesting had a big impact because students were then noticing their areas of weakness and strength and the tracking sheet gave further input into their own ability. On the 2nd quiz, Victoria noticed that the students started to try harder and did not give up right away; “it gave students input into their own ability” (Dec 3rd, Interview). She thought it would be neat to see on the tracking sheet the differences between mental math vs. estimation activities. She wondered if “there was change in one task would there be change in the other task?” (Dec 3rd, Interview). This was something that could be examined over a longer period of time.

By the end of the project her applied students were “still keeping track of their marks”. “Many just received a unit test back where they were rather pleased with their results. However a few have asked for information to take the transfer course so they can take academic next year.” Victoria felt that she had been “pretty successful in encouraging only the students who actually can handle it try it, the others” she just told them “they should continue with the program they feel comfortable with and successful in” (Feb. 28th, email).

Victoria felt she had progressed to the next level in the rubric for the dimension Student Assessment. She had implemented various assessments and began creating a problem solving rubric with her class (the process of the rubric took longer than she had expected).
Since this was new, she didn’t know what the outcome would be and will have to see. She could throw it out if it doesn’t work (Dec 3rd, Interview).

As far as how do I feel I'm doing, I guess ok. The rubric creation exercise I did with both of my [grade] 9 academic classes was not as successful as I had hoped. I'm in the process of typing up all 5 groups work and having them do a final draft. Hopefully by the last week of November we will be set and we will begin using it on their second problem solving exercise. My applied group has not really begun their dimension work on improving confidence. I plan to start that this week as we will be beginning their second term (Nov 18th, email).

By the end of the project her academic students had completed “two problem solving assignments using their rubric as an evaluation tool” (Feb. 28th, email). Victoria could now see an improvement as it became easier for her to explain to students why a response got a level 3 response and not a level 4 when it was mathematically perfect (ie. didn't include assumptions made, did solve using various methods, vocabulary). She also “began with them a review oral presentation where not only the person presenting is evaluating but also the people who can contribute to the presentation by providing insight” (Feb. 28th, email).

**James’ Report**

*Introduction*

James was an enthusiastic first year math teacher in a junior high school and taught grades 7-9 mathematics. His background was in mathematics and science at the secondary level. James was getting used to the challenges of being a first year teacher and “felt comfortable with the subject area. He said that he enjoyed teaching mathematics over science and feels that he can make a difference through his teaching” (Oct 8th, Obs).

He had a great rapport with the students and was very friendly but maintained “authority” (Oct 8th, Obs). He provided positive and negative feedback “using humour as a vehicle to ease the anxiety” students might have (Nov 21st, Obs). James also verbally praised his students and provided external rewards to recognize achievement and to motivate students to complete their tasks. “I think an external reward was given to the first group to finish (chocolate I think)” (Oct 18th, Obs).

In this open concept classroom, students’ desks were grouped in either pairs or trios with an overhead and screen at the front of the class. The daily assessment was on the overhead for students to do in the first few minutes of class. The walls were covered with functional math posters that dealt with units of measure, order or operations and study skills. Curriculum expectations were posted on the bulletin boards as well as a list of classroom expectations for his math classes. By his desk was a box of chocolates for those prizes awarded for a variety of challenges.

James had also developed his own organizational strategies. At the beginning of class during Staff Advisor, for example, James “did his daily routine, which included an attendance probability chart” (Oct 8th, Obs).

A typical lesson structure was 1) individual daily assessment; 2) overhead notes about the concept being taught; and 3) [a hands on] task/ investigation. Giving overhead notes was a common feature in James’s lessons. His notes were projected using the overhead for students to copy in their notebooks. In one lesson, the notes gave a definition of medians of a triangle and explained what they will be doing and that they are responsible for completing 3 investigations in the computer lab. Therefore these notes gave an overview of how the class would be structured. He described concepts and constructions they would be required to do.
The various tasks that James implemented incorporated manipulatives (“their task was to demonstrate the difference between medians and altitudes using straws and tape” - Oct 18th, Obs) and technology. He tried “to alternate an in-class lesson and then an investigation on the computers” (Oct 8th, Obs). However, in some cases the availability of the computer lab dictated the structure of the unit and booking time in the computer lab was difficult, as there were “conflicts with the science department” (Oct 8th, Obs). In one case there was a scheduling conflict with another grade 9, when they got to the lab.

James also incorporated individual and group work in the tasks he assigned as well as peer teaching. Students “worked independently on the task” or “in pairs to explore the other investigations”. They worked independently for the daily assessment and then worked in pairs in the computer lab (although many worked at their own computer, except for a trio of female students). One member from the first group was to present their solution to the class. The teacher chose a student from the first group who finished. The student’s explanation was excellent. She demonstrated one triangle showing the altitude and another showing the medians. She explained what both looked like and the differences between the two, reinforcing the definitions of altitude and median (Oct 18th, Obs).

Most of the tasks were interactive. Therefore students were motivated and very involved. Students who were on track got excited when they did see something work and made comments like “Look how cool that is” and “That’s so cool”. His students also felt free to ask either their peers or the teacher when they required assistance. Sometimes students would ask the person beside them for assistance such as “How do you label this?” “Where do you find the XXXX tool?” (Oct 8th, Obs).

The tasks usually served as a review of concepts rather than a construction or exploration of a new concept. Some tasks were a review of the GSP tools and through this review, students were constructing various polygons and exploring the tools through investigations. These investigations gave students an opportunity to review and apply the definition of a median through a problem solving, exploration task.

Another grade 9 task required students to work in groups of 3 (their desks were already arranged in this way). Their task was to demonstrate the difference between medians and altitudes using straws and tape. The task was timed and it was a race to be the first group to complete it. A student presented their group’s solution. However, after this presentation, there was no class discussion to consolidate the concepts taught (“No closure was done for the task just complete”). Students put everything away and did an estimation challenge. This was unrelated to the task itself. The estimation challenge was a worksheet that consisted of 20 multiple choice questions. Content was basically number facts, %, decimal, fractions” (Oct 18th, Obs).

Several tasks or assessment tasks elicited multiple solutions, although students generally approached the problem as they had been instructed. For example, for one investigation task, there were different ways of creating what had been asked but many students followed the instructions in the book (as instructed). Small variations consisted of colour and size of the shapes. Another task allowed students to create any type of triangle and therefore solutions would vary. Perhaps requesting a different solution from another group would demonstrate an alternate solution.

James gave sufficient time for the completion of each task (“Sufficient time was given for students to complete the tasks” - Oct 8th, Obs). He walked around to observe the students in their groups and he offered assistance, which was for the most part directed instruction. The interaction between the teacher and student mainly consisted of students asking for some assistance and the teacher guiding them through the answer.

On one occasion, the teacher offered assistance by saying “Try this”, “Do this...”, while on another occasion, in the computer lab, the teacher walked around to offer assistance and make sure students were on task. Students asked the teacher for assistance. One student asked for help.
Teacher asked, “Is that a median… how do you know?”
Student replied, “Isn’t a median a line that goes down the middle?”
The teacher explains what it is and demonstrates how to construct the median (guided instruction) (Oct 8th, Obs).

James was seen “as expert rather than a learner”. [This could be perceived as the teaching was portrayed as more instructive than modeling of learning], (Oct 8th, Obs). In the first lesson, he gave directional instructions on what was to happen in class and directions so that the students could complete the task; also students were given instructions on what they were going to do in the lab. For example, for the first Investigation, the teacher read the instructions and students followed. To see if students were on task and following he asked, “Does everyone see it?” The tasks were a list of instructions for the students to follow and therefore did not require any higher order thinking, while teacher responses were mainly directed instructions to show students how to proceed to the next step.

He also took the opportunity to exploit students’ errors and broaden their knowledge in different directions. A student meant to ask “What is a median?” and instead asked, “What is a meridian?” The teacher explains that the term is used in geography and clarifies the difference between the two terms. He then proceeded to talk about longitude and latitude (Oct 8th, Obs).

James gave daily assessment tasks that were usually submitted to the teacher; students were aware of the regular daily assessment. He often mentioned that they needed to study a particular concept because they needed to know it for EQAO. Therefore assessment seemed to be a pivot in his classes. In one class, a daily assessment is given which they copied from the overhead. This was submitted to the teacher. The assessment question was “Write down 2 properties of medians of triangles.” They were given about 5-10 minutes to complete the task independently (Oct 8th, Obs).

In between classes, the observer noticed that RAT booklets were used in James’s class with the grade 7 & 8 to give rich assessment tasks. These were not used in grade 9 because of time. They had resources at grade 7 & 8 (Gage Assessment booklets) but didn’t have any grade 9 resources available and would require them to seek out questions elsewhere.

James regularly gave an estimation challenge to his students. This was a timed task which students worked on independently. At the end of the estimation challenge, he took up the answers in a unique way. Everyone had to stand up. As he read out the answers, students would continue standing until they got an incorrect answer. If their answer were wrong then they would sit down. James also identified questions he felt might be difficult for students and gave a description of a solution for answering these questions (Oct 18th, Obs).

However, at the first lesson observed, there was no evidence of a rubric or students involvement in designing the assessment, while self/peer assessment did not take place at this time. It was also observed that “the investigative tasks were used as a review and exploration exercise, but were not assessed” (Oct 8th, Obs). The investigative tasks were used to explore the concept being taught. Although students were asked to take notes and record any answers to questions, there was no evidence that this was being assessed. [Assessment may be in the form of a daily assessment for next class] (Oct 8th, Obs).

Moreover, during another lesson no assessment was given to debrief or close the lesson, while students’ progress was informally assessed. The teacher could get a sense of who was doing well or not informally, but no mark was recorded during that time. Students in that case were evaluating their own worksheet.

James’s peer in this project, Victoria, was also his mentor. James and Victoria, as already mentioned, had a positive working relationship and they co-operated to plan their lessons both at school and during their
own personal time. (“We discussed how their peer relationship was ideal because each of them is strong in an area where the other one is weak” – Nov 12th, Interview).

James was feeling his way through the curriculum and had followed Victoria’s long range plans. He said that he was experiencing the curriculum to see what it is. Next year, he would be able to implement and modify his program. James felt unsure of what to expect because this was his first year of teaching. He felt that there was lots of useful information that he would like to implement but needed to do the year once so he had an idea of what the curriculum looked like (Oct 30th, Interview). Because he was following the other teacher’s long range plans, he felt that he could not really contribute yet because he needed to see the year through first. He did say that next year, he would know more and be able to contribute more (Nov 12th, Interview).

Teache’rs Action Plan

After completing the self-assessment rubric, James decided to work on Student Tasks (Dimension 4) and Student Assessment (Dimension 9). As a new teacher he felt that he was at a learning stage and would be at an implementation stage this year.

James’s self-assessment rubric results indicated he rated himself as having a level 4 in Solution Strategies and a level 3 in Multiple Representations (Survey Results). James decided that by choosing Student Tasks, he would be able to find out more about a variety of different instructional strategies. His goal was to create short, manageable tasks each week and to provide several types of assessments for these tasks (Oct 30th, Interview).

Student Assessment was the other dimension that James was interested in. He rated himself at a level 3 stage in this dimension (Survey Results). James said that he just loved to assess everything. He liked to give a variety of assessments, planned and unplanned, because he felt that students needed to be prepared at all times and by giving regular assessments, they would try to keep up with their work. He liked to give various assessments to the students, without them necessarily expecting it, so as to ensure they were on task and following instructions. At this point, collecting marks for reporting seemed to be a focus of the assessments. A daily assessment, mental and estimation challenges, and peer assessments were a few of the things he had already implemented.

Implementation of Teacher’ S Action Plan

At the implementation phase, the tasks still served as a review of concepts, but at the same time, pursued the development of intellectual skills such as creative thinking within a collaborative context. One example of a task used as a review (a summary activity) incorporated the use of toothpicks as manipulatives. The task was to construct a model using toothpicks and glue that would encompass all the topics that had been covered until then (e.g. medians, altitudes, angle bisectors, etc). The most inventive model would win an “amazing” prize. Students rushed to complete this task as it was timed. Therefore, the task enabled students to create a design that clearly demonstrated the properties mentioned on the overhead and it allowed students to become creative by creating examples that distinctly distinguished each property (Nov 4th, Obs).

Another task that James assigned was a presentation of an individual lesson by the students. James decided to have his grade 8 students do “partner presentations”. He divided the unit Number Sense & Numeration into individual lessons.

Each set of partners was assigned a lesson. The partners were responsible for:
- writing up overhead notes for their classmates to write in their notebooks
- teach a ½ hour lesson and do either an activity or give out a worksheet
- optional –they can assign homework and/or give a quiz (Nov 26th, Obs).
James provided the topics to teach, page numbers in the text, and a sample of a worksheet to use as a reference. Throughout the presentation, the teacher gave feedback during their lesson.

In a discussion with James, he said that “he would stop the presentation if their information was incorrect or wasn’t sufficient because of their lack of preparation. He mentioned that he didn’t want to take control of the presentation but would if needed to” (Nov 26th, Obs). He also said, “he felt comfortable assigning this unit for students to present because most of the content would be a review”. When asked if he felt if the partners were learning he said, “Definitely yes because you end up knowing more when you have to teach it” (Nov 26th, Obs).

While students were on task and during their presentations, James provided positive feedback. He also walked around to check that students were on task, to answer questions students had and to remind students of the amount of time they had left. Moreover, James intervened during the presentation to give positive feedback to the presenters and to clarify some points.

James also tried to encourage Student-Student interaction by providing tasks that required students to work together. For example in one lesson, students worked in partners, some groups of three and one group of four. They were engaged in the tasks and often huddled around the work; therefore student-student interaction took place. Students often made suggestions and gave positive comments to each other although in some cases, there was one dominant student (Nov 4th, Obs).

Students were motivated to work in partners to present their lesson to the class; they asked their partners for assistance (“students were asking each other questions” - Nov 26th, Obs) and they were encouraged to take responsibility for some part of their own learning. For example, during the Independent Study Unit, students asked other students or the teacher questions, or they turned to their partners for assistance. However, the teacher intervened if he thought it was necessary. For instance the teacher intervened to select some of the students during one of the activities, which was a game (Nov 21st, Obs).

Therefore teacher’s role -especially in the case of the Independent Study Unit- was that of a resource person rather than an instructor. Students were to learn on their own but he was there to clarify any difficulties they may have had.

James had used a variety of instructional strategies and various hands-on tasks and assessment tasks that did elicit multiple solutions. In one class, he assigned a task that provided opportunity to varied solutions, although in the Independent Study the depth seemed limited to what the textbook offered, which demonstrated another teaching strategy.

Moreover in some cases the use of technology was also incorporated in the assessment procedure. In one case, students were to complete a geometry quiz in the computer lab using GSP (Nov 12th, Obs). Three slightly different quizzes were handed out. Students were to construct a triangle and label each of the following: altitude, medians, angle bisectors, orthocenter, incenter, and centroid. This quiz provided for some difference in solutions, depending on the type of triangle that the students had initially created.

As mentioned above, James regularly gave an estimation challenge, a 5-minute task, which students worked on independently. Occasionally it was peer assessed, while the teacher also elaborated on the most difficult questions. For example, in one lesson, after the 5-minute task, students were to turn their sheet over, while students who had finished early could put their hand up and the teacher could tell them their time. Afterwards James collected the estimation sheets and redistributed them to the class for students to mark. This estimation activity was a peer assessment out of 20. James read out the questions aloud –elaborating on
questions that might be difficult– and the students marked it. Once they were marked, the teacher collected them (Nov 21st, Obs).

Through these kinds of estimation activities, students were highly motivated and there was a sense of self-efficacy where students wanted to continue to improve, since they gave the strong students a goal to reach. They would try to get the most correct in the least amount of time.

James had also incorporated peer assessment for the task using toothpicks (“construct a model using toothpicks and glue that encompasses all the topics covered to date”). Students were told prior to the task that the final product will be evaluated by their peers”. So, students were to vote for the most inventive design. With about 10 minutes left of class, students had to bring their designs to the back table. Each person was given a slip of paper to write down the number of the design they thought was most inventive. The teacher was also included in this vote”. The achievement of the expectation was not necessarily considered in the votes. Students rushed to give their vote. The winner was not mentioned during this time. Students quickly gazed over the designs but most students did not check for accuracy (Nov 4th, Obs).

In that case, group work was being assessed (“Partner up…the most inventive model wins an ‘amazing’ prize!!” -Nov 4th, Obs), while in other cases students were assessed individually. There is also evidence of a lesson where no formal assessment took place.

The criteria on which students were assessed also varied. In some cases creativity was assessed for the most inventive design while in other cases students would be assessed on the correctness. Generally speaking, students seemed to be aware of those criteria. However in a few cases, the instructions given for the assessment task or the peer assessment were not very clear. There was also one case where a rubric or scoring guide was not provided to students and another where the instructions as to what the product should look like were a bit vague and caused some confusion. For example, in the latter case, students were not clear whether or not they could label their diagram, while some students were unclear on whether or not they had to create separate triangles when they were working on the quiz on Geometer’s Sketchpad. The teacher was asked:

what happens if the student draws the incorrect triangle (i.e. constructs an acute triangle instead of an obtuse) but constructs all the required components. What kind of mark will they get? The teacher felt that the initial mistake would have an impact on the rest of the quiz and therefore students would lose a lot of marks (Nov 12th, Obs).

James implemented an Independent Study Unit for the Number Sense and Numeration strand. Students were given an outline of the tasks required for this unit. They were given one week to complete the following:

<table>
<thead>
<tr>
<th>Class #1</th>
<th>Integers</th>
<th>Class #2</th>
<th>Decimals &amp; Fractions</th>
<th>Class #3</th>
<th>Percent</th>
<th>Class #4</th>
<th>Rational Numbers</th>
<th>Class #5</th>
<th>Operations with Rational Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class #6</td>
<td>Review</td>
<td>Class #7</td>
<td>Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Nov 21st, Obs)

As students were working on their Independent Study Unit, James walked around with the class list and assessed their math binders. The teacher looked for organization, dividers for each section and looked for loose papers. Afterwards, James walked around and recorded how the students were progressing on their Independent Study Unit. He wanted to see if they were on task or needed assistance.
In a discussion with James, he described himself as a teacher who liked to give various assessments to the students. He wanted students to know that he would be checking to ensure that they were “on task and following instructions” (Nov 21st, Obs).

**Teachers’ Perceptions Of Professional Change**

James was a first year teacher; therefore we could not talk of substantial changes in already established teaching practices, as the observations took place at the first few months of his teaching career. The teacher himself mentioned this on several occasions.

James indicated that “as a first year teacher it was hard to tell if there was change” as far as the *Students Task* Dimension was concerned. However he felt that “there was change but that he was at the same level” in the rubric (Dec 3rd, Interview). As a first year teacher, he was using this time to implement and explore a variety ways of teaching and delivery concepts. He hoped that even as soon as next term he would be able to incorporate some of what he had learned towards next term. He said that he knew and was aware of the dimensions and knew how to apply them. Moreover, the self-assessment tool gave a better perspective and would help in future planning.

As far as the *Student Assessment* Dimension is concerned, James felt that there was change but that he was at the same level. He stated that he did like to use a variety of assessments and collect a lot of marks. He liked to give various assessments to the students, without them necessarily expecting it. However, he was at an implementation stage and was trying different ways. After this year, he believed he would be better able to determine what worked for him and what didn’t.

He felt that he needed to do the year once so that he could have “an idea of what the curriculum looks like” (Oct 30th, Interview); next year, he would “know more and be able to contribute more” (Nov 12th, Interview).

**Enablers, Sources of Tension/Obstacles**

Victoria and James felt that by participating in this project, it gave them an opportunity to reflect on their teaching. There were several factors that enabled a shift in their teaching practices and very few –mainly concerning the project timelines– that did not facilitate this change.

(a) Self-Assessment Tool: Both Victoria and James felt that the self-assessment tool was a good starting point to see at what level they were rating themselves at in the various dimensions (“the self-assessment tool was a starting point for reflecting on their teaching. The tool was unclear though. Information about SBT gave input on what levels looked like. It was too focused. The goal was to get level 4” –Dec 3rd, Interview).

(b) Rubric: The rubric made them aware of their teaching and helped them focus and set goals to improve teacher practice. They also felt that if they knew about this earlier, this information could have been better incorporated into their curriculum plans.

(c) Observation: They both liked having an outsider observe and they enjoyed having an “expert” observe. But they felt the scheduling of the visits for the observations “was difficult due to the short timelines of the project” (Dec 3rd, Interview). Moreover James said that he did not feel uncomfortable at all being observed. Being observed was nothing new; it seemed to be more the norm rather than anything different, as he had just graduated from University.
For myself, however, I am a project in the works as a first year teacher, although I have appreciated this program as it encouraged me to analyze aspects of my teaching style I would not have at this point in my early, YOUNG career (Nov 20th, email).

(d) Peer Observation-Peer Conferencing: Both teachers were working together on a regular basis, while Victoria was also James’s mentor. They shared resources and gave feedback on work for each other in the grade 9 unit. A peer coaching relationship already existed due to their mentoring relationship. They regularly met, discussed and planned together during school and on their own personal time. “Peer Coaching was already happening prior to the project. They will meet to plan out the next unit” (Dec 3rd, Interview).

Both James and Victoria felt comfortable as peer coaches. For example, during our observation, James did make some observations and speculations about Victoria’s progress. Victoria also provided a positive critique in return and asked some questions to James when he developed his next unit. She questioned the order of content and the questioning strategies outlined in the unit. He explained his reasoning for choosing the order and the type of questions and they came to a comfortable agreement (Nov 26th, Obs). Therefore peer observation did not have an impact on their teaching and they had not gained much from this kind of observation. They preferred a team teaching situation rather than a peer observation because since they were in an open area, they had been used to being in each other’s classes all the time.

(e) Project Timelines: Both teachers felt that the project timelines were too short which lead to short term goals. The time for the project was too short and therefore difficult to really schedule this into their program. They also mentioned that a template would be helpful to keep them focused on what they have to do and that more time was needed to debrief.

Both teachers were both able to share information about their experience in this project with other staff members and they showed a definite interest in participating in this project for next term. Besides they both felt that if they were given time to plan, they would be able to incorporate the dimensions they were focusing on and implement some of the new ideas into their curriculum plans for the next term.

Therefore, when discussing continuing the project in 2003, Victoria and James had an opportunity to establish a wish list that would help them implement their dimensions to their program. They requested two days of planning and some type of template to help them focus on their goals.

Summary of the Cases

It seems that both teachers enjoyed and profited from their participation in the project. They had already established a safe and interactive learning environment; students worked individually or in groups, they helped each other or turned to their teacher for help and they actively participated in the learning procedure.

Teachers also provided help to the students and gave them positive feedback. Some of the main features of their teaching were their questioning techniques that demonstrated scaffolding, tasks incorporating manipulatives, recalling of prior knowledge and reviewing concepts previously taught. Moreover, assessment played an important role in their lessons. Students were regularly assessed, while peer assessment was also used.

Their participation in the project helped them to reflect on their teaching practices, reinforced their successful teaching practices and pursued them to create or implement more elaborated dimensions to their teaching.

It seems that the project was an incentive for them to apply their concepts of teaching in a more concrete form. For example James’ students moved from demonstrating the difference between medians and altitudes to
constructing a model that would encompass all the topics that had been covered. Therefore variety in tasks and their multiple solutions were implemented in a more elaborated context. Victoria moved from providing positive feedback, scaffolding questions to direct students to the correct answer and making references to prior knowledge, to the use of a tracking sheet so that students themselves would keep track of their performance and progress. As reflective teachers they felt safe to implement new ideas in their teaching, evaluate its effectiveness and reflect on their future plans.

Even if the two teachers differed in experience, they were both enthusiastic and open to new ideas. They were able to implement their dimensions to their program according to their set goals in an open concept and interactive classroom.

Summary and Conclusions

The case reports of the ten teachers provided a wealth of data about their experiences in the project and evidence about the effects of particular features of the in-service on their professional growth. The case analysis revealed a series of themes that we summarize here as obstacles and enablers to change in teaching practice.

Sources of Tension/Obstacles

There were four themes that were problematic in successful change during the course of the project. The obstacle/tension that was predominant in all of the cases was Reflection and Time. The other three factors were present in all of the cases, although in different degrees: Personological factors, Relationships, and the structure of the Structure of the Self-assessment tool.

Reflection & Time

The project timeline was identified as too short, and discussed at length in all five pairs of cases. Although the talk was not solely focused on time issues, most of the obstacles being discussed translated into a problem stemming from lack of time. The participants reported they did not have adequate time to reflect on the rubric and incorporate it into their planning. In addition, they did not have enough time to plan their lessons using new methods or teaching strategies, nor did they have the time to have sufficient conversations with their peers about the changes they wanted to make. Accordingly, the participants reported that because of the short timeline, the only kinds of goals that were conceivable were short-term goals, and consequently, growth in their teaching was difficult to measure. One participant summarized the feelings of those teachers that were demonstrating changes in their practices when he indicated that they were just getting started as the project was ending. The timeline of the project allowed the teachers to reflect on their teaching and to start thinking about what kinds of changes they need to make in their practices, and how they were going to accomplish those changes.

The effects of the short timeline were exacerbated by the fact that the teachers were trying to work on changing two dimensions at the same time. This meant that the teachers’ time and effort were divided between trying to reflect, plan, and implement changes in two dimensions of their teaching practice. Hence making the pressure to improve within a restricted time feel even greater. This dual effort contributed to the feeling of being overwhelmed, or as one teacher put it, “too much too fast!”

Personological Factors

There were two themes within this category that affected the success of change for the participants, attitude towards the project and self-confidence in teaching abilities. Project “buy-in” was a key factor that proved important in changing practices. Although all of the participants did voluntarily join the research project, there were three participants whose motivation was not focused on learning from the process. These three
teachers participated as a result of encouragement from their school administration. Two of the participants were strongly encouraged to participate directly by their principal, while the third had a strong desire to be recognized for his innovative practices, and his director strongly supported the project’s professional development approach. The indirect pressure from school administration did not translate into teacher “buy-in,” as the teachers were skeptical of the benefits of the project for them professionally apart from a political association with a university research program. Their reservations were coupled with the second factor, self-confidence, producing a condition where change was unlikely.

Teacher self-confidence in the case of the three teachers mentioned above contributed to their lack of change. They believed that they were good teachers and they knew best. Their misconceptions about the superiority of their practice were evidenced in their self-assessments, which were markedly higher than what the researcher recorded from observations. Additionally, they were under the strong belief that their teaching strategies and beliefs were better than that of the other teachers participating in the project, which was best illustrated in interview responses regarding the in-service. Two of the teachers disregarded the suggestions offered by the researchers as being unrelated to mathematics education as they knew it. The third teacher felt that he was just as much an expert as the presenters and that the in-service would only benefit those teachers who were unfamiliar with reform teaching and assessment, which was not his case. The overconfidence in their abilities and mathematics beliefs undermined an open communication so that these teachers could not internalize the knowledge and skills the project was fostering because they systematically rejected the ideas presented if the ideas did not feed into their established beliefs and practices.

This tension/obstacle must be considered cautiously as it also served as a facilitator to progress and growth in the other teachers. The positive attitude of the other teachers regarding learning in the project was essential. Additionally, the teachers that did make changes needed to have the confidence in their teaching abilities and those changes they were implementing. This was illustrated in the case when the mathematics department head undermined the efforts of two of the teachers who were making changes. If it were not for the confidence of the teachers in their practices, they would not have been able to continue with their growth. Hence, this particular variable needs to be carefully balanced where teacher confidence is fostered, but so is their ability to self-evaluate in a realistic and appropriate manner.

Relationships

Although the right combination of teachers in the appropriate environment can prove to be an enabler to growth, these can also act to circumvent teacher change. In the case of Christine and Paul, their relationship supported the teachers’ individual resistance to changing their beliefs and practices about mathematics education. Each one felt that the reform teaching strategies were inappropriate, and the traditional methods were better. Communicating with one another allowed them to find further support in their belief regarding the transient nature of reform mathematics.

Self-Assessment Tool Structure

Although the self-assessment tool proved to be a starting point for discussion and consequently acted as an enabler, the teachers reported feeling that its structure was too rigid. The categorical nature of the four levels created a stringent instrument where teachers had difficulties placing themselves in one of the four levels for each sub-dimension. One teacher suggested that a sliding scale would facilitate its use, which addressed the critiques of the other teachers regarding the structure of the tool. Although the researchers thought of each set of response options as a continuum anchored by four sets of descriptors, the feedback the teachers received from the website represented the underlying metric as an ordinal scale.
All five case study teacher pairs experienced change in their teaching practices as a result of the following six intervention elements: the project as a whole; personological reasons; the self-assessment; the in-service workshops; the observations and peer-conferencing opportunities; and school-related issues. The extent to which change occurred in the teachers varied, but relied heavily on the personological element, particularly the relationship formed within each teacher pair.

The Project as a Whole

All five teacher pairs reported a change in their teaching practices as a result of the project. Although one teacher pair claimed that their teaching practices did not change directly because of the project's influences, all teacher participants acknowledged that the project made them aware that teaching practices could be influenced by external interventions. The four teacher pairs that reported teacher change due to the project were generally pleased with their participation in the project and their individual outcomes. These teachers felt that the project offered a safe environment to work in. A teacher expressed that the project presented him "a good opportunity to try new and completely different instructional strategies". When they realized that they were not being judged or evaluated on their performances, these teachers were able to take risks in their teaching approaches in order to allow change to occur.

Personological Reasons

The individual personalities and the relationship formed within each teacher pair were significant determinants of how the project developed for each teacher pair. The personalities of both teachers in each pair were complementary and they generally shared the same outlook towards teaching and their teaching practices. The relationships established within each teacher pair provided the prevalent attitude with which the teachers approached the project.

The four teacher pairs that found that the project had a positive impact on their teaching practices formed a relationship that fostered the changes to their teaching practices. Within one pair, one teacher had a history of engaging in personal professional development and his conception of mathematics was that of "an ever changing dynamic construct that allowed him to explore mathematics teaching in new ways continuously". His teaching partner is a "very reflective teacher" who is committed to continuously improving his practices to better meet the needs of his students because of his own love for the subject area. These two teachers shared the same attitudes towards learning and mathematics, which enabled their relationship to flourish and enhanced their ability to engage in teacher change. Another teacher pair that just began collaborating together during the current school year had different background experiences, but both teachers were enthusiastic about working towards changing their teaching practices to reflect the demands of the curriculum. In these teacher pairs, regardless of whether the relationship between the teachers was a "community of practice" developed over the past three years, or had just been developed over the current school year, the complementary personalities enhanced the teachers' ability to make changes to their teaching practices.

Self-Assessment

All teachers, whether or not they attributed change in their teaching practices as a result of the project, gauged change in their teaching practices based on the self-assessment they participated in using the interactive website. The self-assessment aided the teachers in two aspects. First, the teacher was able to decide on the dimensions that s/he wanted to work on during the project. Second, the teacher was able to determine what focus s/he was using to establish or validate his or her teaching methods. Each teacher chose two dimensions to work on and identified for him or herself specific focuses within those two dimensions. The teachers appreciated the self-assessment tool because it offered them a measuring stick for both their current teaching practices and their desired teaching practices. The extent to which each teacher wanted to change his or her teaching practices varied. Some teachers believed they needed to change considerably whereas other teachers
felt they had to change very little. How much a teacher changed in his or her teaching practices ranged from very little to a considerable amount. However, all the teachers were satisfied generally by the amount of change that occurred in their own teaching practices during the project.

The In-Service Workshops

All teacher pairs reported that the in-service workshops provided by the OISE/UT research team stimulated conversation between and amongst themselves about teaching math. Excluding one teacher pair, the remaining four had a general consensus that their time spent at the in-service workshops was worthwhile because they were offered teaching strategies and resources that they could take back into their classrooms. As one teacher commented, looking for appropriate technology-based activities on the net is often a "fruitless endeavor", whereas she really appreciated the resources that her researcher was able to offer her.

Teachers reported that the in-service workshops provided them with a forum where they were able to discuss their teaching strategies with other teachers. When teachers were able to share their experiences, they were able to reflect and to gain insight into their teaching practices, which supported their ability to change. One teaching pair commented that although they were continuously collaborating before and after classes, in-service workshops distanced them from their regular school duties and hence they were able to focus and to reflect more on what they were doing in terms of trying to change their teaching practices.

Observations and Peer-Conferencing Opportunities

All teacher pairs claimed that having the opportunity to observe their teaching partner helped instigate rich conversations during the times they spent peer-conferencing with each other on their teaching practices. Although one teacher commented that he felt uncomfortable at the beginning being watched by people other than the students in his classroom, he grew more reflective in his teaching practices. He also became more comfortable with having an observer in his classroom as the project continued. He stated that after this experience he would be more empathetic to teachers being observed because his career goals involve having administrative duties where he will be the one doing the observations.

Teachers appreciated the opportunity to observe other teachers in action because they were able to formulate ideas and new approaches to the topics that they would also have to teach to their students. Observing their teaching partners in the classroom stimulated discussions for their peer-conferencing sessions. After these sessions, the teachers were able to design activities that they could both use, discuss how their students performed and determine if any changes were needed to make the activity even better.

School-Related Issues

Teacher pairs that had the support of their administration felt that their efforts to change their teaching practices were validated. These teachers appreciated their administration staff allowing them release time and flexibility in terms of scheduling for the project.

As well as finding support from their own administration, one teacher pair was working towards establishing connections with the secondary school their students would be attending following graduation. These two teachers wanted to link up with the math department at the secondary school so that their students would have an easier time with the transition. One of the teachers in this teaching pair was also required to take on administrative duties as principal when his own principal was away. Hence this teaching pair had established good rapport with the administration and they felt totally supported during the project.

When there was no indication of administrative support, or worse, negative sentiments from a department head, teachers still followed through to complete the project objectives. Although the teacher pair
that was ridiculed for participating in the project felt frustrated with their individual incidents, both teachers believed in what they were doing and they appreciated hearing positive reinforcement from their school's administrative staff. They suggested that if their department head heard positive comments coming from the administration, then their head's disposition towards these types of projects might change.

Conclusion

All five case study teacher pairs experienced change in their teaching practices by participating in the project. The extent to which the six intervention elements influenced the change varied, although the extent of the change depended heavily on the personological factors of the individual teacher and the relationship formed within the teacher pair.

The interactive, self-assessment website gave teachers a starting point from which they were able to measure their progress. The in-service workshops provided the teachers with resources and an opportunity to focus on their teaching practices away from their regular school duties. The observation and peer-conferencing opportunities provided the teachers with a chance to discuss their teaching practices in-depth with another teacher and to develop new ideas and approaches. Finally, the teachers who received flexibility and accommodation from their school administration felt most supported. Those teacher pairs that involved themselves in the project with a positive attitude towards reaching change in their teaching practices and took advantage of the other elements were satisfied with their achievements.
References


# Appendix 1: Standards-Based Mathematics Teaching Rubric

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Program Scope</td>
<td>The teacher addresses one strand.</td>
<td>The teacher addresses most of the strands.</td>
<td>The teacher addresses all strands, each taught separately.</td>
<td>The teacher addresses all strands, taught so the interconnections among them are explored.</td>
</tr>
<tr>
<td>2. Opportunity to Learn</td>
<td>The teacher provides all students with activities to consolidate mathematical algorithms.</td>
<td>The teacher provides all students with activities to consolidate mathematical algorithms and procedural support.</td>
<td>The teacher provides all students with the opportunity to learn higher level mathematics and procedural support.</td>
<td>The teacher provides all students with the opportunity to learn higher level mathematics with appropriate support, such as cues.</td>
</tr>
<tr>
<td>3. Student Confidence</td>
<td>The teacher builds student confidence by providing external awards for achievement.</td>
<td>The teacher builds student confidence by providing external awards for achievement and praising student effort.</td>
<td>The teacher builds student confidence by providing external awards for achievement, praising student effort, and modeling positive attitudes.</td>
<td>The teacher builds student confidence by providing external awards for achievement, praising student effort, modeling positive attitudes, developing strategies for student success to occur, and helping students recognize their mathematical ability.</td>
</tr>
<tr>
<td>4. Student Tasks:</td>
<td>The teacher assigns tasks that can be solved by using a specific algorithm that the teacher identifies.</td>
<td>The teacher assigns tasks that can be solved by using a specific algorithm that students must identify.</td>
<td>The teacher assigns tasks that have several possible solution strategies OR that have several possible answers using one strategy.</td>
<td>The teacher assigns tasks that have several possible solution strategies AND that have several possible answers.</td>
</tr>
<tr>
<td>Solution Strategies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Student Tasks: Multiple</td>
<td>The students are expected to use one form of representation as defined by the teacher.</td>
<td>The students are required to use multiple representations for their ideas when the teacher prompts them to do so.</td>
<td>The students are encouraged to represent their ideas in various ways (i.e., numeric, algebraic, or graphic).</td>
<td>The students generate different representations and select the most appropriate one(s) to best represent their ideas or solutions.</td>
</tr>
<tr>
<td>Representations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Construction of</td>
<td>The teacher believes that students learn through transmission of facts and algorithms.</td>
<td>The teacher believes that students learn through transmission of concepts and algorithms.</td>
<td>The teacher believes that students learn through development of concepts and algorithms through application.</td>
<td>The teacher believes that students learn through construction and elaboration of concepts and algorithms through inquiry.</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Teacher's Role</td>
<td>Teacher is the sole knowledge expert. Student roles focus on tasks which require minimal cognitive effort.</td>
<td>Although the teacher is the sole knowledge expert, some student expertise is acknowledged. Students are assigned roles with the teacher being central to the activities.</td>
<td>The teacher shares the knowledge expertise role with the students. More teacher-directed tasks are provided for students with lower abilities, and more student centred activities are provided for higher ability students.</td>
<td>The teacher is a co-learner with the students. The teacher and the entire student body are responsible for building a math community. The teacher ensures that each student is an integral part of the learning process.</td>
</tr>
<tr>
<td>Dimension</td>
<td>Level 1</td>
<td>Level 2</td>
<td>Level 3</td>
<td>Level 4</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7. Mathematical Tools: <strong>Manipulative Use</strong></td>
<td>The teacher uses manipulatives to demonstrate concepts/ideas to the class. The students use the manipulatives only occasionally.</td>
<td>The teacher uses manipulatives to model concepts/ideas which the students imitate when directed.</td>
<td>The teacher uses manipulatives to model concept/ideas. The students use the manipulatives in both teacher-directed explorations and through free choice.</td>
<td>The teacher uses manipulatives to model concept/ideas. The students use the manipulatives in teacher-directed explorations and through free choice. The students are also encouraged to create their own inventive uses for the manipulatives and test their own mathematical ideas.</td>
</tr>
<tr>
<td>7. Mathematical Tools: <strong>Technology Use</strong></td>
<td>The teacher uses technology for class demonstrations. There is little student use of technology.</td>
<td>The teacher uses technology for class demonstrations which the students imitate when directed.</td>
<td>The teacher uses technology to involve the students in teacher-directed explorations. The technology is available should the students choose to use it.</td>
<td>The teacher uses technology to involve the students in teacher-directed explorations. The technology is available should the students choose to use it. Students are encouraged to create inventive uses for the technology and test their own mathematical ideas.</td>
</tr>
<tr>
<td>7. Mathematical Tools: <strong>Purpose of Manipulatives and Technology Use</strong></td>
<td>The teacher uses manipulatives and technology to illustrate concepts.</td>
<td>The teacher uses manipulatives and technology to demonstrate for students connections between concrete and abstract mathematical ideas,</td>
<td>The teacher uses manipulatives and technology to encourage students to make their own connections between concrete and abstract mathematical ideas,</td>
<td>The teacher uses manipulatives and technology to encourage students to move, on their own, from concrete ideas to building generalizable abstractions which they can defend.</td>
</tr>
<tr>
<td>8. Student—Student Interaction: <strong>Explicit Instruction</strong></td>
<td>The teacher provides instruction on expected classroom behaviours focusing on whole class management without reference to student interaction.</td>
<td>The teacher provides instruction on expected classroom behaviours focusing on small group management.</td>
<td>The teacher provides instruction and models expected small group behaviours focusing on general cooperative learning skills and shared group leadership.</td>
<td>The teacher provides instruction and models expected small group behaviours focusing on cooperative learning skills, shared leadership and effective math communication.</td>
</tr>
<tr>
<td>8. Student—Student Interaction: <strong>Task</strong></td>
<td>The teacher assigns tasks that require students to work independently at their desks.</td>
<td>The teacher assigns tasks that require students to work independently within small groups.</td>
<td>The teacher assigns tasks that require students to work independently and share their solutions with their peers to check for accuracy.</td>
<td>The teacher assigns tasks that require students to work together within groups to develop joint solutions and strategies.</td>
</tr>
<tr>
<td>Dimension</td>
<td>Level 1</td>
<td>Level 2</td>
<td>Level 3</td>
<td>Level 4</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>8. Student Interaction: Communication</td>
<td>The teacher controls question and answer discussions by providing opportunities for students to recite their answers to the whole class.</td>
<td>The teacher allows students to describe their answers to peers, either as a whole class or within small groups.</td>
<td>The teacher allows students to explain and defend their answers to peers, either as a whole class or within small groups. Students are encouraged to challenge the validity of their classmates' solutions.</td>
<td>The teacher allows students to explain and compare their solutions and solution strategies with their peers. They are encouraged to discuss the mathematical concepts within the problems and to be both supportive and challenging to their peers.</td>
</tr>
<tr>
<td>9. Student Assessment: Purpose</td>
<td>The purpose of assessment is for the teacher to report to parents.</td>
<td>The purposes of assessment are for the teacher to report to parents and to sort students into achievement or ability groups.</td>
<td>The purposes of assessment are for the teacher to report to parents and students in order to improve student learning.</td>
<td>The purposes of assessment are for the teacher to report to parents and students to improve student learning, teaching methods, and curriculum modification.</td>
</tr>
<tr>
<td>9. Student Assessment: Transparency</td>
<td>The teacher's criteria for assessing student work are defined during marking.</td>
<td>The teacher defines the criteria for assessing student work before administering the assessment but does not disclose the criteria to the students beforehand.</td>
<td>The teacher defines the criteria for assessing student work and discloses the criteria and assessment procedures to students before administering the assessment.</td>
<td>The teacher negotiates with students the criteria for assessing student work and the assessment procedures before administering the assessment.</td>
</tr>
<tr>
<td>9. Student Assessment: Variety</td>
<td>The teacher consistently uses one type of assessment that enables students to demonstrate their learning in one way.</td>
<td>The teacher consistently uses a dominant type of assessment that enables students to demonstrate their learning in one way, and supplement it with the occasional use of other types of assessments.</td>
<td>The teacher consistently uses an assortment of assessments that enable students to demonstrate their learning in several ways.</td>
<td>The teacher consistently uses an assortment of assessments that enable students to demonstrate their learning in several ways, and consults with the students to decide on which assessment to use.</td>
</tr>
<tr>
<td>10. Teacher's Conception Of Mathematics As A Discipline: Dynamic Nature of Mathematics (stability/flexibility)</td>
<td>The teacher views math as a fixed body of knowledge.</td>
<td>The teacher views math as a fixed body of knowledge with some new concepts being added over time.</td>
<td>The teacher views math as a stable body of knowledge that is occasionally modified as new concepts are added to the mathematics field.</td>
<td>The teacher views math as a flexible and dynamic body of knowledge that is based on human activity including new research.</td>
</tr>
<tr>
<td>10. Teacher's Conception Of Mathematics: Connections</td>
<td>The teacher describes math as a single set of defined mathematical rules and algorithms.</td>
<td>The teacher describes math as a set of topics that are distinct from one another and from other disciplines.</td>
<td>The teacher describes math as a linked set of math topics that are connected to each other.</td>
<td>The teacher describes math as an integration of interdependent topics.</td>
</tr>
</tbody>
</table>

Appendix 2: Observation Template

**Dimension 1: Program Scope**
*Concerns how the teacher implements the mathematics curriculum*

**Guiding Questions**
- What will you and the students be working on today?
- Is this a typical lesson for you and your students? Explain.
- How does this topic fit in with the rest of your mathematics program?

**Possible Evidence**
- Multi-strands or multi-topics represented in the student tasks
- Level of topic coverage (depth and breadth) discussed by the teacher
- Teacher identifies how the program includes all strands of the math curriculum

**Discussion and Observations**
Dimension 2: Opportunity to Learn
Concerns the extent to which the teacher provides students with the opportunity to learn higher mathematics.

Guiding Questions
- What opportunities are provided for students to work at higher order math concepts?
- Are connections from prior learning to new learning made by students/ facilitated by the teacher?
- Are students provided with rich learning tasks that provide access to all students?
- How does the teacher support the students (scaffolding) in accessing the tasks?

Possible Evidence
- Tasks have a conceptual focus
- Tasks allow students to explore concepts deeply
- Tasks allow students to apply concepts in a problem solving context
- Teacher uses a range of teaching strategies and tools to allow all students access to the tasks

Observations
Dimension 3: Student Confidence
Concerns the range of strategies the teacher uses to build confidence in their ability to do mathematics.

Guiding Questions
• What does the teacher do / say to build student confidence?
• What do the students do / say that demonstrates self-confidence?

Possible Evidence
- Positive verbal feedback
- Positive written feedback
- Tasks are achievable
- Expectations are high
- Teacher describes students as mathematicians
- Criticism is construction to lead students toward improvement

Observations
Dimension 4: Student Tasks
All work assigned to students to complete. This would include items such as projects, handouts, homework questions, experiments, and investigations.

Guiding Questions
• Do the tasks solicit different possible strategies?
• Do the tasks solicit different possible solutions?
• Do the tasks require / encourage a variety of representations?

Possible Evidence
- Problem solving tasks with more than one possible solution strategy presented to students
- Tasks with more than one possible solution presented to students
- Tasks require a range of representations: graphic, numerical, written, verbal, physical

Observations
Dimension 5: Construction of Knowledge
*Refers to how the teacher helps students develop their mathematical understanding*

Guiding Questions
- How are students encouraged to discover mathematics?
- Do students extend their ideas through exploration and shared (discussed / demonstrated) experiences?

Possible Evidence
- Student questions drive the lessons and tasks
- Teacher asks probing questions to deepen thinking and understanding
- Teacher provides significant blocks of time for student exploration of concepts using a variety of materials and strategies

Observations
Dimension 6: Teacher’s Role
*Refers to how the teacher presents his/her mathematical knowledge/expertise to students.*

Key Questions
• How does the Teacher position himself/herself in the classroom?
• Does the teacher empower student learning through facilitation?

Possible Evidence
- Students build on one another’s ideas without teacher intervention (small group, whole group)
- Teacher depends on students to generate mathematical solutions
- Teacher celebrates student discoveries with students
- Teacher looks to students to defend their ideas

Observations
Dimension 7: Mathematical Tools
Concerns how the teacher uses manipulatives and technology to teach math.

Manipulative use
• What manipulatives are made available?
• How are they made available to students? What are students doing?
• Does the teacher model use of manipulatives?

Technology
• Does the teacher model use the computer or the calculator? Are these directions addressed to the whole class, to groups, or individuals?
• What are students doing (e.g., following an interactive program, using algorithms, reading from the screen, data processing)?

Possible Evidence
- Range of manipulatives readily available
- Students select manipulatives to assist with problem solving contexts
- Teacher demonstrates use of manipulatives
- Students are provided with access to computers and calculators
- Students access technology in problem solving contexts
- Teacher demonstrates use of technology

Observations
Dimension 8: Student - Student Interaction

Refers to how the teacher guides the student conversations about mathematical ideas

Guiding Questions
- What directions does the teacher give to students? Are these directions addressed to the whole class, to groups, or individuals?
- Do students work on math alone, in pairs or in groups? For how long?
- What are students saying? What is the teacher saying?
- Are the interactions following any guidelines or ‘rules’?
- How do students communicate with one another about mathematics?
- What is the teacher doing when students are working on math? Does he or she provide coaching? Monitor learning?

Possible Evidence:
- Teacher models using rich mathematical language
- Students state opinions and ideas
- Students build on one another’s ideas and interact without continuous teacher intervention
- Students defend their position
- Students use rich mathematical language
- Teacher encourages students to explain another student’s point of view and to agree or disagree with an opinion, providing reasons (robust discourse)

Observations
Dimension 9: Student Assessment

Refers to how the teacher collects and interprets data on the quality of student performance.
(may require discussion with teacher and / or students)

Guiding Questions

• What assessment strategies are observable in the classroom / in teacher-student interaction?
• Are students involved in the assessment design process?
• Are students involved in self and / or peer assessment?
• Are students aware of how they are being assessed?
• Are a variety of assessment strategies implemented?

Possible Evidence

- Evidence of rubrics in use (several levels of performance described)
- Teacher records observations during and / or after class
- Students use assessment tools such as portfolios, learning logs, journals
- Students provided with frameworks (verbal or written) to engage in self-assessment or peer assessment
- Students participate in negotiating evaluation schemes with the teacher

Observations
Dimension 10: Teacher’s Conception of Mathematics as a Discipline
Refers to how the teacher views mathematics as a body of knowledge and as a way of thinking.
(requires conversation, may include observation)

Guiding Questions
• How do you see mathematics as a discipline? Is it fixed in time, or is it always changing?
• Do you think there is a hierarchy of learning that students must follow in order to understand, or does the learning sequence fluctuate?
• What does mathematics represent to you?

Possible Evidence
- Teacher describes their view of mathematics as dynamic, ever changing
- Teacher does not necessarily teach skills in a sequence, but allows skills to be learned as needed within context and a loose framework
- Teacher indicates comfort with math as ‘a subset’ of the truth

Discussion and Observation
Appendix 3: Prompts from the Self-Assessment Website

**DIMENSION 1: PROGRAM SCOPE**
*Concerns how the teacher implements the mathematics curriculum.*

<table>
<thead>
<tr>
<th>I address one strand and include some of the others.</th>
<th>I address most of the strands, teaching each one separately from the others.</th>
<th>I address all of the strands, teaching each one distinctly from the others.</th>
<th>I address and integrate all of the strands.</th>
</tr>
</thead>
</table>

**DIMENSION 2: OPPORTUNITY TO LEARN**
*Concerns the extent to which the teacher provides all students with the opportunity to learn higher mathematics.*

<table>
<thead>
<tr>
<th>I provide all my students with activities that allow them to consolidate algorithms.</th>
<th>I provide all my students with activities that allow them to learn higher-level mathematics. I offer all my students procedural support for learning algorithms such as breaking down the problem into steps or simplifying it.</th>
<th>I provide all my students with activities that allow them to learn higher-level mathematics. I offer all my students procedural support for learning higher-level mathematics such as breaking down the problem into steps or simplifying it.</th>
<th>I provide all my students with activities that allow them to learn higher-level mathematics. I offer all my students support such as cues, to elicit prior mathematical knowledge that connects with their current understanding of a problem.</th>
</tr>
</thead>
</table>

**DIMENSION 3: STUDENT CONFIDENCE**
*Concerns the range of strategies the teacher uses to build student confidence in their ability to do mathematics.*

<table>
<thead>
<tr>
<th>I build student confidence by providing external rewards, such as grades, for achievement.</th>
<th>I build student confidence by providing external rewards for achievement in addition to giving verbal and written praise for student effort.</th>
<th>I build student confidence by providing external rewards for achievement in addition to giving verbal and written praise for student effort. I demonstrate a positive attitude towards mathematics, through promoting a desire to learn mathematics and an appreciation for its nature.</th>
<th>I build student confidence by providing external rewards for achievement, in addition to giving verbal and written praise for student effort. I demonstrate a positive attitude towards mathematics, and helps students identify themselves as capable mathematical thinkers. I organize my program and provide appropriate strategies so that students experience success and recognize their mathematical abilities.</th>
</tr>
</thead>
</table>

**DIMENSION 4: STUDENT TASKS**  
*All work assigned to students to complete. This would include items such as projects, handouts, homework questions, experiments, and investigations.*

**SOLUTION STRATEGIES**

<table>
<thead>
<tr>
<th>I assign tasks that can be solved by using a specific algorithm. I tell students which algorithm to use.</th>
<th>I assign tasks that can be solved by using a specific algorithm. I expect students to figure out which algorithm to use.</th>
<th>I often assign tasks that have several possible solution strategies, or tasks that can produce different acceptable answers by students using the same strategy.</th>
<th>I often assign tasks that have several possible solution strategies and which can produce different acceptable answers.</th>
</tr>
</thead>
</table>

**MULTIPLE REPRESENTATIONS**

<table>
<thead>
<tr>
<th>I expect my students to represent their ideas and answers in the form that I indicate.</th>
<th>I tell my students if the task requires that a variety of representations be used to demonstrate ideas.</th>
<th>I encourage my students to always represent their ideas in a variety of forms to demonstrate their thinking.</th>
<th>I expect my students to generate a variety of representations when solving a problem and be able to choose the most appropriate one given the specific task.</th>
</tr>
</thead>
</table>

**DIMENSION 5: CONSTRUCTION OF KNOWLEDGE**  
*Refers to how teachers help students develop their mathematical understanding.*

<table>
<thead>
<tr>
<th>I teach my students mathematical facts and algorithms. Students use these facts and algorithms to answer questions and solve problems.</th>
<th>I teach my students mathematical concepts and algorithms. Students use their conceptual understanding and algorithms to answer questions and solve problems.</th>
<th>I help my students explore mathematics and build understanding through the use of applications. Students explore mathematics problems using a variety of algorithms and conceptual understanding.</th>
<th>I help my students develop their mathematical ideas by constructing understanding with them. Students extend mathematical ideas shared by the class and they inquire into new situations to apply and test their knowledge.</th>
</tr>
</thead>
</table>

**DIMENSION 6: TEACHER'S ROLE**  
*Refers to how the teacher presents his/her mathematical knowledge/expertise to students.*

<table>
<thead>
<tr>
<th>I am the knowledge expert in my class. My responsibility is to pass on everything I know about mathematics to my students. I provide students with the correct answers.</th>
<th>While I am the knowledge expert in my class, I acknowledge that my students also possess some expertise. I allow students to share what they know about mathematics when I can control how my students share the information.</th>
<th>I take part in the learning with my students. I understand my role as a teacher changes depending on the nature of my students. I challenge my stronger students to help one another share and develop answers.</th>
<th>I collaborate with my students to build a math community within the classroom. I believe that I learn with my students as each one contributes to our understanding. I encourage and facilitate my students to share and develop mathematical ideas.</th>
</tr>
</thead>
</table>
### DIMENSION 7: MATHEMATICAL TOOLS
*Concerns how the teacher uses manipulatives and technology to teach mathematics.*

#### MANIPULATIVE USE

<table>
<thead>
<tr>
<th>Description</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use manipulatives to give class demonstrations. Students rarely use the manipulatives on their own.</td>
<td>I model the use of manipulatives for my students and they follow my instructions step-by-step when they are using them.</td>
<td>I model the use of manipulatives for my students. Students use the manipulatives in teacher-directed explorations and at any other times they choose.</td>
<td>I model the use of manipulatives for my students. Students use the manipulatives in teacher-directed explorations and at any other times they choose. I encourage my students to find new uses for manipulatives, including using them to test their own mathematical ideas.</td>
</tr>
</tbody>
</table>

#### TECHNOLOGY USE

<table>
<thead>
<tr>
<th>Description</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use technology to give class demonstrations. Students rarely use the technology on their own.</td>
<td>I model the use of technology for my students and they follow my instructions step-by-step when they are using it.</td>
<td>I model the use of technology for my students. Students use the technology in teacher-directed explorations and at any other times they choose.</td>
<td>I model the use of technology for my students. Students use the technology in teacher-directed explorations and at any other times they choose. I encourage my students to find new uses for technology, including testing their own mathematical ideas.</td>
</tr>
</tbody>
</table>

#### PURPOSE OF MANIPULATIVES AND TECHNOLOGY USE

<table>
<thead>
<tr>
<th>Description</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use tools in my class to illustrate concepts for my students.</td>
<td>I use tools in my class to help me explain the connections between concrete and abstract mathematical ideas to my students.</td>
<td>I encourage my students to use tools to help them make their own connections between concrete and abstract mathematical ideas.</td>
<td>I encourage my students to use tools to explore mathematical concepts in a concrete manner, then build generalizable abstractions on their own. Students use the tools to defend their conjectures.</td>
</tr>
</tbody>
</table>
### DIMENSION 8: STUDENT--STUDENT INTERACTION
*Refers to how the teacher guides student conversations about mathematical ideas.*

#### EXPLICIT INSTRUCTION

<table>
<thead>
<tr>
<th>I expect my students to know how to interact with each other.</th>
<th>I outline the guidelines for student interactions and expect my students to follow them.</th>
<th>I describe and model the co-operative learning skills I expect from each group. I create opportunities for the students to share leadership roles within each group.</th>
<th>I describe and model how students should interact and communicate mathematical ideas, including using correct mathematical terminology. I provide opportunities for students to practice these skills with each other.</th>
</tr>
</thead>
</table>

#### TASK

<table>
<thead>
<tr>
<th>I assign tasks that require students to work independently at their desks.</th>
<th>I assign tasks that require students to work independently while placed in small groups.</th>
<th>I assign tasks that require students to work independently then share their solutions with peers in their small groups.</th>
<th>I assign tasks that require students to work together within their small groups to develop joint strategies and solutions to the problems. I also have students work independently or in whole groups as needed.</th>
</tr>
</thead>
</table>

#### COMMUNICATION

<table>
<thead>
<tr>
<th>I control all question and answer discussions. I provide opportunities for students to recite their answers to the whole class.</th>
<th>I allow students to describe their answers to their peers, either as a whole class or within small groups.</th>
<th>I allow students to explain and defend their answers to their peers, either as a whole class or within small groups. I encourage students to challenge the validity of their classmates' solutions.</th>
<th>I allow students to explain and compare their solutions and solution strategies with their peers. I encourage them to discuss the mathematical concepts within the problems and to be both supportive and challenging to their peers.</th>
</tr>
</thead>
</table>

### DIMENSION 9: STUDENT ASSESSMENT
*Refers to how the teacher collects and interprets data on the quality of student performance.*

#### PURPOSE

<table>
<thead>
<tr>
<th>I assess students so that I will be able to report grades to parents.</th>
<th>I assess students so that I will be able to report grades to parents and to distinguish the high and low ability math students.</th>
<th>I assess students so that I will be able to report grades to parents and students so as to improve student learning.</th>
<th>I assess students so that I will be able to report grades to parents and students so as to improve student learning. I also use assessment as a way to improve my own teaching methods and develop a better mathematics program.</th>
</tr>
</thead>
</table>
**TRANSPARENCY**

| I decide how I will assess students as I mark their assignments. | I decide how I will assess students before giving out the assignments but I do not disclose my marking scheme to students beforehand. | I decide how I will assess students and describe the criteria and the assessment procedures before giving out the assignments. | I negotiate with students the assessment criteria and procedures before giving out the assignments. |

**VARIETY**

| I consistently use one type of assessment that allows students to demonstrate their knowledge and skills similarly for all the topics. | I rely on one type of assessment that allows students to demonstrate their knowledge and skills similarly for most of the topics. Two to three times throughout the year, I use a different assessment strategy that requires the students to demonstrate their knowledge and skills in a different way. | I consistently use a variety of assessments that allow students to demonstrate their knowledge and skills in diverse ways for different topics. | I consistently use a variety of assessments that allow students to demonstrate their knowledge and skills in diverse ways for different topics. I also consult with the students to help me decide what assessment I will use at different times. |

**DIMENSION 10: TEACHER'S CONCEPTION OF MATHEMATICS AS A DISCIPLINE**

*Refers to how the teacher views mathematics as a body of knowledge and as a way of thinking.*

**DYNAMIC NATURE OF MATHEMATICS (stability/flexibility)**

| I view math as a fixed body of knowledge that will not change much in the future. I believe that the timeless math truths must be accepted. | I view math as a fixed body of knowledge that is modified from time to time by adding new concepts. I believe that the standard rules in mathematics must be followed. | I view math as a stable body of knowledge that is modified when new concepts are introduced to the field. I believe that there are some key ideas in mathematics that must be revised as new ideas are added. | I view math as a dynamic body of knowledge that changes regularly based on human activity. I believe that current research and thinking in mathematics is changing our conceptions of the world. |

**CONNECTIONS**

| I believe that math is a set of defined mathematical rules and procedures. The goal is to learn those rules and their sequences and then students can do the math. | I believe that math is a set of distinct topics. The goal is to focus on each topic and then make a few connections between one topic and another. | I believe that math is a series of topics that are related to one another. The goal is to cover all of the topics and make links between the topics that enhance student understanding overall. | I believe that math is a series of interdependent topics that are linked to other disciplines. The goal is to explore topics and discover how they are interconnected. |
Appendix 4: Researcher Roles
A Joint Decision

There will be planned variation in researcher roles. Each researcher will develop a role that is comfortable for the researcher and the two teachers she is working with. We anticipate there will be a continuum anchored by non-participant observation on one end and participant observation on the other.

Non-Participant Observation

The researcher will

1) facilitate the dialogue between the two teachers,

2) clarify what each of the dimensions mean,

3) collect data at each of the project events and make sure that the tasks of the project are completed, and

4) offer general teaching advice about how to implement the dimensions and facilitate access to specific teaching advice when asked.

Participant Observation

The researcher will

1) facilitate the dialogue between the two teachers,

2) clarify what each of the dimensions mean,

3) collect data at each of the project events and make sure that the tasks of the project are completed, and

4) offer specific teaching advice about how to implement the dimensions.

Note: The decisions about what and how to teach rest with the teachers in the project. The researchers will facilitate teachers’ decisions and give advice when asked but will not try to run someone else’s classroom.

Each researcher, in collaboration with her two teachers, will attempt to place herself on this continuum.