# Evidence-Based Design from the Mathematical ACTS MSP Project at the University of California-Riverside

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## Abstract

The research and evaluation theme of this proposal from the Mathematical ACTS MSP project at the University of California-Riverside is evidence-based design for facilitating teacher change. Using the project's logic model this paper will begin with an overview of its activities, intended outcomes, and evaluation design. The remainder of the paper will focus on the development, training and administration, and results from an observation instrument used to assess the classroom practices of teachers who participated in Mathematical ACTS professional development and follow-up support over the previous school year, as well as the practices of comparison group teachers. The role of this assessment in the project's evidence-based design will also be explained.

Specifically, the paper will describe: the project's decision to create an observation instrument rather than use one of several existing instruments, the collaborative development process involving core team members, training of observers, procedures for establishing inter-rater reliability, the use of the instrument, analyses conducted and lessons learned for this pilot year.

Preliminary findings from the observations will compare Mathematical ACTS participants and non-participants. Interpretation of these findings will be discussed, along with anticipated further analyses. The paper will conclude with a discussion of issues and challenges, plans for observations to be conducted in the 2005-06 school year, and commentary on this assessment's role in providing evidence for the effectiveness of Mathematical-ACTS.

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## Illustrative Classroom Scenarios

Mr. Hanson's fifth grade class quietly but excitedly moved from station to station in the room. At each station were collections of objects that students had brought from home: marbles, pencils, stickers, etc. Each student had created two 'probability questions' that were posted next to the collection. Students worked in pairs to answer the questions, and then evaluate whether the question was clear. Mr. Hanson modeled the procedure once with the group and then circulated about the room, checking for difficulties and asking students to explain their thinking. When the group came together, Mr. Hanson led the discussion. Students recalled from the previous day the characteristics of a good question, and talked about their efforts to solve the probability problems. Mr. Hanson carefully selected questions and collections that posed challenges, either because of the nature of the groupings or a muddled probability question. Students discussed these and went back and forth: rewriting questions, solving them, creating more challenging questions about probability. Student engagement was high throughout and students shared their explanations and used the student-owned collections of objects to demonstrate their understanding.

Ms. Beeler's sixth grade classroom was working with probability combinations using both algorithmic and graphic methods. For the first problem, Ms. Beeler read the definition for fundamental counting principle: total possible outcomes using formula $m \times n$ (m = ways to choose, n = ways to choose) and then wrote the example on the board (6 shirts, 3 shorts, 4 hats: $6 \times 3 \times 4 = 72$). The teacher then modeled the same problem using a tree diagram and asked students the advantages of each approach. Bags of different colored polygons were then distributed to students and they were asked to come up with all possible combinations. Because of duplicates in the bags of polygon colors and shapes, students were sidetracked. Ms. Beeler had students re-label some of the pieces and told them to look for different pairs, not duplicate pairs. Ms. Beeler reiterated the questions again: How many combinations and what are the combinations? Within three minutes, half of the groups were off task, and Ms. Beeler brought them together again to check on progress. Her guidance went back to the formula method, and questions were brief and answered by students in 2 -3 word answers. Incorrect responses were corrected but not explored: "How did you arrive at these combinations?" Students responded with guessing: "Add", "subtract", "multiply", "divide." Students appeared frustrated and disengaged " I don't get it." Ms. Beeler replied, "I don't get it is a copout."

The contrast between these two scenarios illustrates how difficult it is for teachers to implement a conceptually based approach to teaching; lessons that provides a clear and accurate representation of a concept; and activities and questions which draw from and extend student prior experiences, reasoning, logic, and persistence in mathematics. Providing the instruction and the supports to enable teachers to do so is the main work of the MSP Mathematical ACTS. Evaluating the implementation of the same in the actual classroom required the development and use of an observation instrument, protocol, and coding system that mirrored these instructional objectives. Preliminary analyses of findings reveal predictable gaps between instruction, teacher perceptions and self report, and teacher practice in the classroom.

# Overview of Project

Mathematical ACTS, Achieving through Collaboration with Teachers and Students, is a targeted mathematics education project between the University of California, Riverside and a unified school district in Southern California. ACTS was funded in the first round of the National Science Foundation Mathematics and Science Partnerships in 2002-03. The focus of the project is mathematics professional development for teachers in grades 4 through 9 and the effect of this professional development on growth in teacher content knowledge and pedagogy, classroom practice, and student achievement.

In order to evaluate the influence of this professional development, the ACTS team worked with the partner district to form matched pairs from the existing elementary schools. Elementary schools were matched using principal components analysis on the dimensions of student achievement, family poverty, parent education level, English language proficiency, and mobility of the families in the school service area. Through a coin toss, ACTS randomly assigned pairs of matched elementary schools to different cohorts, thereby creating a wait-listed control group within the district. Teachers were invited to participate in the professional development during their assigned cohort, although new teachers to the designated schools could enroll after their cohort's time period in order to be folded in to the design. This strategy allowed ACTS to compare teacher and student achievement growth by control and treatment classrooms.

The linkage between teacher professional development and student achievement inherent in this research design reflects numerous studies connecting professional development to change in instructional practice, and change in instructional practice to change in student achievement. The links between these areas are neither simple nor obvious. Identifying and providing evidence for these connections has often proved elusive (Loucks-Horsley & Matsumoto, 1999; Wilson & Berne, 1999). Initially, this line of research identified generic teacher behaviors that were correlated with higher achievement; for example, isolating the main idea, using advance organizers, identifying and clarifying important linkages among concepts (for reviews see Brophy & Good, 1986; Gage, 1978; Doyle, 1977).

Ebmeier & Good (1979) specifically trained teachers in active teaching of mathematics (presentation of concept, modeling, guided practice, independent practice) and found the students of trained teachers posted greater gains in basic mathematics skills (although not problem solving) than students of non-trained teachers. Without observing or quantifying behavior, other researchers determined that teacher knowledge, as measured by credentials, certifications, or subject matter tests, positively impacts student knowledge (Greenwald, Hedges & Laine, 1996; Hanushek, 1996; Wayne & Youngs, 2003). However, these studies do not isolate how this knowledge affects teacher-student interaction in the classroom.

Carpenter, Fennema, Peterson, Chiang & Loef (1989) posited that teacher knowledge of *how* students learn mathematics, not just knowledge *of* mathematics would positively impact student achievement. Primary grade teachers were randomly assigned to professional development that emphasized research in young children's conceptual understanding of number operations or to professional development that emphasized teaching strategies in problem solving. Teachers in the research-oriented workshop posed complex problems, listened to student problem solving strategies, and encouraged alternative methods, while teachers from the other workshop focused on fact recall, and fluency (speed) in operations. In addition to observed differences in practice, student achievement was consistently higher and growth in both basic knowledge and problem solving skills were greatest for the students with teachers engaged in the professional development focusing on how students learn.

Hill, Rowen, & Lowenberg-Ball, (2005) worked to clarify how teacher knowledge of students' learning affects student achievement. They created precise measurements of teacher pedagogical content knowledge which focused on the work of teaching mathematics. This more task-sensitive assessment reliably captured teacher's mathematical knowledge and positively predicted student gains in mathematics in first and third grade. Although the measures were designed to reflect knowledge that would be used in the classroom, the study did not actually assess classroom teaching.

Each of these studies addresses a piece of the linkage, but as yet there are few efforts to "connect all the dots." The current need is for an experimental design that incorporates precise and reliable measurement of teacher pedagogical content knowledge, addresses pedagogical content knowledge through professional development, measures changes in both teacher knowledge and classroom practice, and link these measures of teacher change with growth in student achievement.

Specifically, ACTS was designed to impact student achievement and certain teacher outcomes as delineated in the project's logic model (see Figure 1.) It shows the major areas of activities (creation of professional development curriculum, school-year and summer professional development, classroom implementation) and long- and short-term outcomes (student experiences, learning, achievement; and teacher experiences, learning, career growth, and retention) that comprise the project.

The evaluation and research designs for ACTS complement each other. The use of randomly assigned delayed intervention control group schools and intervention schools provides one important comparison. The second comparison is the use of measures that can assess change or growth. The following sub-sections describe the main components of the logic model, including further detail on how each are being evaluated. This detail shows how the evaluation encompasses formative evaluation (How can the intervention be improved?); implementation evaluation (To what extent are intervention activities being implemented as specified?); and outcome evaluation (To what extent have the target populations changed as anticipated – due to participation in ACTS?) This first major section of the paper overviewing the project concludes with descriptive information and research findings on the context of the school district where ACTS is being implemented.

**Creation of Curriculum for Professional Development**

During the initial planning phase of the ACTS professional development, the instructional team reviewed teacher surveys and summaries of student test results to determine persistent areas of weakness in strands of California Mathematics Standards. Predictably, fractions, the relations among fractions, decimals, percentages and ratios, and the connections between formulas and graphing, surfaced as particularly troublesome at all grade levels. Our conceptual approach to these problems was based on our reviews of research efforts from Stigler & Hiebert's *Teaching Gap* (1999), Liping Ma's *Knowing and Teaching Elementary Mathematics*, (1999) and the National Research Council's *Adding It Up* (2001). We also reviewed the mathematics Research Based Instruction (RBI) model provided to teachers by the district, which drew heavily from the work of Good and Grouws (1979) and the Missouri Mathematics Project. Finally we considered the effect of the home environments of the majority of students in the district. The combination of poverty and English as a second language did not provide opportunities for students' exposure to numbers, number operations, thinking about and discussing numbers, patterns, and shapes in a variety contexts.

While striving to offer modeled activities that were grade-level specific, we also determined that general number sense and the connections between and within mathematical concepts should be the focus of our professional development. Without these underpinnings, the students were forced to memorize increasingly greater amounts of disconnected algorithms; and the long-term recall and application of the same to problems was very poor. In addition, our pre-tests of teachers indicated that there was great variance in mathematics preparation and knowledge. We could not expect teachers to teach what they themselves did not know.

**Professional Development**

The guiding principles of the professional development offered to teachers were the five strands of mathematical proficiency recommended in *Adding It Up* (National Research Council, 2001). These intertwined strands are:

1. Conceptual Understanding: Comprehending mathematical concepts, operations, and relations—knowing what mathematical symbols, diagrams, and procedures mean.
2. Procedural Fluency: Computing—Carrying out mathematical procedures, such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately.
3. Applying: Being able to formulate problems mathematically and to devise strategies for solving them using concepts and procedures appropriately.
4. Reasoning: Using logic to explain and justify a solution to a problem or to extend from something known to something not yet known.
5. Motivation and Perseverance: Believing that mathematics is useful and doable, and being willing to expend the effort and time necessary to succeed.

Within a workshop on mathematics demonstrations for example, teachers might work with various dilutions of Kool-Aid and water to demonstrate the concept of powers of 10, fractions, ratios, and proportions. This activity provides practice in computation within and between these number formats. Building tables of data from the solutions allows teachers to apply new knowledge of the relationship among these concepts to a specific problem, and then use logic and reasoning to explain how these data contribute to the answer. Finally, the concrete representation of these concepts through the dilutions experiments, and the work involved in organizing data on tables and comparing patterns provides a setting that motivates teachers and requires persistence.

Teachers in grades 4-6 in elementary schools, science and mathematics teachers in middle school (grades 7-8) and teachers in high schools that teach Algebra I or lower courses are invited to participate in and are expected to commit to a year-long, summer to summer series of institutes. Teachers are compensated for their time or receive a classroom substitute to enable them to attend. The scheduling of the institutes is planned to avoid conflicts with summer school teaching.

The institutes follow a deliberate pattern of teacher as a learner, teacher as a teacher, and teacher as a reflector. How these roles were created in each of the institutes is explained in the individual descriptions below. These roles for teachers were designed to expose preconceptions teachers had about how mathematics is learned and understood.

> Students (and teachers) come to the classroom with preconceptions about how the world works. If their initial understandings are not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.
>
> *How People Learn*, 14-15, National Research Council, 1999.

***MATE: Mathematical Academy for Teaching Excellence***

MATE is a two-week, all-day summer institute held immediately after the close of the academic school year for approximately 70 teachers. Teachers across grade levels 4 – 6, middle school mathematics and science teachers, and high school science and mathematics teachers work together during the institute. MATE is taught by the mathematics education instructional team of ACTS, and the content emphasizes algebra readiness, algebra, and the connections between algebra and geometry. The morning sessions focus on mathematics content within a demonstration lesson; the teachers themselves participate as learners as they work with either new material or material they have not seen used with students. The afternoon sessions address the teacher as a teacher, focusing on the various ways that the model content and approach can be used with students of different grade levels, English Language Learners, and struggling students. At the close of each day, teachers are asked to reflect individually and with their colleagues on the application of these ideas to their classrooms.

***CHAMP: Climbing Higher with the Academy of Mathematics Performance.***

CHAMP is a grade-level specific four-day lab school for teachers in grades 4, 5 and 6. The ACTS Director leads these lab schools, which are geared towards belying an oft heard teacher pre-conception: "This strategy might look good in a workshop, but I can't do that with my students." Teachers arrive for the day before the students, listen to a description of the mathematics concepts covered in the lesson to be demonstrated, and what role they should play in the instruction and assisting students. All teachers work to set up for the lesson. Students then arrive and the model lesson, which builds off of the demonstrations taught in MATE, is taught.

Each day, teachers are asked to pay particular attention to the reasoning and thinking of the students. The ratio of teachers to students is usually 1:4, which allows for intense small group work. At this point, the teacher is the learner, as they observe both the demonstration and students working together on projects. As the week progresses, teachers become more proactive in their teaching role, and then lead the small group activities themselves. They also practice observing a teacher partner and providing specific feedback: what the teacher observed in the children's mathematical thinking, how questions encouraged or discouraged student attempts, what scaffolding of a task might be necessary to help the student. Teachers are given further opportunity to learn later in the day when they watch videos of classroom practice, read selected articles, discuss lesson extensions, and reflect on what they observed in their students during the morning.

### *ALIAS: Accelerating Literacy Integrating Algebra and Science*

ALIAS workshops are a five-part series of mathematics lessons grouped around science topics. In the field of physical science, the topics might include pendulums and motion, springs and Hook's Law, levers and weights, volume and surface area, etc. In life sciences, example topics are respiration, digestion, and growing conditions for grass. The workshops are three hours in length in the late afternoon and early evening, and spaced approximately four weeks apart. Participants are the annual cohort of teachers from the previous summer of MATE, who are now teaching in grades 4-8. The ACTS instructional team in mathematics-science provide an overview of the major concepts for each activity in both oral and written form. Participants are provided draft teacher and student manuals which isolate the particular mathematics standards each activity addresses. Teachers then work in small grade-level groups to complete the activities, learn how to work requisite equipment, and practice recording data, completing analyses and displaying results in graphs and tables. As a larger group, the teachers reflect on the applicability of the activities to the classroom.

### *ALIAS Summer Academy*

Similar to the CHAMP format, the ALIAS activities are duplicated in a lab school setting during one week in the summer. Students are invited by teachers to attend, and teachers replicate the science activities learned during the academic year in ALIAS. This allows teachers to work in their teacher role and to become comfortable with the materials and activities with a smaller group of children. After the students leave for the day, the teachers debrief on the success of the lesson, what should be changed, and reflections on the types of work they saw the students accomplish. Teachers are encouraged to note these changes in the teacher-student manuals, and to create a simple card index that links the ALIAS activity directly to a mathematics textbook entry around particular standards.

Table 1 describes the measures being used for research and evaluation of ACTS professional development. These include post-workshop evaluations, pedagogical and content knowledge assessments, self-reports on instructional practices.

**Table 1. Research and evaluation components for ACTS professional development.**

| Measure | Respondents | Description | Frequency | Comparison | Audience/Intent |
|---|---|---|---|---|---|
| ACTS CHAMP and ALIAS Evaluations | Participating teachers | ACTS developed feedback form of content covered in institutes | Immediate post institute participation | Analyze for strengths and weaknesses. | Address subsequent delivery of professional development. |
| MATE Content Assessment | Participating teachers | ACTS developed assessment of math content covered | Pre and post MATE participation | Compare pre and post | Address subsequent delivery of professional development. |
| Learning Mathematics for Teaching | Consenting Teachers in district | University of Michigan NSF RETA (Hill, Ball) measures pedagogical content knowledge in mathematics. | By cohorts, pre and post completion of professional development cycle | Compare pre-post test change, compare levels of participation. | Examine impact of ACTS on teacher knowledge, relate to changes in instructional practice and/or student achievement. |
| California Mathematics Diagnostic Placement Test: Geometry Readiness (assesses algebra I skills) | Consenting Teachers in district | Developed and used by California colleges to determine placement in college mathematics courses. | By cohorts, pre and post completion of professional development cycle | Compare pre-post test change, compare levels of participation. | Examine impact of ACTS on teacher knowledge, relate to changes in instructional practice and/or student achievement. |
| ACTS Survey | Consenting Teachers in district | Modeled after Horizon Inc. Survey of classroom practices | By cohorts, pre and post completion of professional development cycle | Compare pre-post test change, compare levels of participation. | Examine impact of ACTS on teacher knowledge, relate to changes in instructional practice and/or student achievement. |

## Classroom Implementation

As described above, the ACTS professional development is designed to provide teachers knowledge, skill, and strategies to promote deep understanding and learning in mathematics among their students. Table 2 describes the survey and observation measures being used for the evaluation of classroom implementation among ACTS and comparison teachers.

**Table 2. Research and evaluation components for ACTS teachers' and comparison teachers' classroom implementation.**

| Measure | Respondents | Description | Frequency | Comparison | Audience/Intent |
|---|---|---|---|---|---|
| Follow-up surveys | Participating teachers in district | Key questions form ACTS survey related to professional development sequence and classroom practice | By cohorts, at close of professional development cycle | Compare Cohorts, experiences | Assess implementation; address subsequent delivery of professional development |
| Classroom Observations of mathematics lessons | Consenting teachers in district | ACTS developed protocol | By cohorts, pre and post professional development | Compare control and treatment classrooms | Assess implementation; address subsequent delivery of professional development; link changes in classroom practice to teacher knowledge, attitudes, student achievement, student perceptions of classroom. |

## Student Outcomes

ACTS teachers' instructional strategies are intended to support growth in students' mathematics achievement. Table 3 describes the measures being used to compare the achievement among students of ACTS' teachers and students of comparison teachers. These measures include mandated state and district achievement tests, as well as a student assessment designed specifically for ACTS. A student motivational measure and analyses of student course taking patterns are also being undertaken.

**Table 3. Research and evaluation components for achievement among students of ACTS' teachers and students of comparison teachers.**

| Measure | Respondents | Description | Frequency | Comparison | Audience/Intent |
|---|---|---|---|---|---|
| State Mandated Achievement Tests in Mathematics | Students in Grades 4-9 | Nationally normed, group administered multiple choice | Annually for all grades beginning in 2nd grade. | Value Added Analysis of student growth in treatment vs. control classrooms | Evaluate effect of project on student achievement |
| District Criterion Referenced Tests for District Math Essential Standards | Students in Grades 4-9 | District developed criterion referenced tests: two forms per year | Quarterly for all grades | Value Added Analysis of student growth in treatment vs. control classrooms | Evaluate effect of project on student achievement |
| Extended Standards Assessments in Math | Students in Grades 4-8 | Developed by JUSD from NAEP and TIMMS items and reviewed by NSF ACTS math education consultants | Annually for JUSD in 4th-8th grades | Comparison of treatment vs. control classrooms | Determine if mathematics proficiency outside of computation affected by ACTS. |
| MAP: Student Perceptions of Class Activities related to motivation | Students in grades 4-6 | Developed with University of Michigan NSF RETA (Maehr, Karabenick) to measure motivation related beliefs | Annually for JUSD in 4th – 6th grades | Comparison of treatment vs. control classrooms | Compare student perceptions of classroom practice. |
| Course taking patterns | Students in grades 7-12 | District records of courses attempted and passed in mathematics | Reviewed annually | Compare to previous years | Examine impact of ACTS professional development and JUSD policy changes. |

## District Context

In addition to developing and implementing the ACTS professional development, the ACTS instructional team worked to understand the context of past professional development in the district, and how those preconceptions might impact the receptivity of teachers to different teaching strategies. Professional development in the past few years had been focused on standards and assessments. Curriculum in the district was driven by the district's "Essential Standards" which were a distilled version of the California State Standards. These standards were developed by teams of teachers. To assess student progress on the standards, schools administered district Criterion-Referenced Tests (CRT) on a quarterly basis. The results of these

CRTs were shared with teachers within one month of the test administration to enable teachers to adjust their instruction.

As part of the ACTS effort to understand the district context, we designed a survey that was administered to all teachers prior to their participation in the ACTS institutes. The survey was adapted from Horizon Research Inc. Instruments, which were developed under the National Science Foundation grants "2000 National Survey of Science and Mathematics Education" (REC 9814246) and "2002 Local Systemic Change through Teacher Enhancement" (REC 9912485.) Nine questions on the survey asked teachers about mathematics standards from three different sources: the National Council of Teachers of Mathematics, the State of California, and the school district. Teachers reported on their knowledge, agreement and implementation of the standards from each of these sources. For our initial two Cohorts of elementary teachers, the district standards were by far the most influential in terms of teacher knowledge and teacher classroom implementation. See Table 4 below.

**Table 4. Targeted District Elementary Teachers Level of Agreement with the Influence of Mathematics Standards on Teaching** (N= 107)

| | National Council of Teachers of Mathematics | | California Mathematics Standards | | District Mathematics Standards | |
|---|---|---|---|---|---|---|
| | Mean* | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| Familiar with Standards | 1.56 | .92 | 2.95 | .99 | 3.82 | .48 |
| Agree with Standards | 3.84** | .80 | 3.87 | .76 | 3.86 | .93 |
| Implement Standards | 1.44 | .97 | 2.14 | .92 | 2.64 | .61 |

*Response scale: 1 to 5 with 1 being "Not at all" and 5 being "Completely"
** Only 38 teachers were familiar enough with the NCTM standards to answer this question.

District staff recognized that the district standards, while focused, did not address the larger conceptual underpinnings of mathematics. In addition, professional development had been focused solely on the creation and assessment of standards, not instructional strategies. The goal of ACTS was to provide instructional strategies that address the larger concepts of mathematics. It would be the responsibility of the teachers to create the direct links to district grade-level standards.

Changes in district administration during the initial year of the grant (2002-03) began to direct teacher attention to the entirety of the California State Standards, reflecting the shift in testing from the norm-referenced Stanford Achievement Test 9 (SAT-9) and the California Achievement Test 6 (CAT-6) to the California Standards Test (CST). Much like the district criterion-referenced tests of essential standards, the CST consists of criterion-referenced assessments that established cut off scores for levels of Advanced, Proficient, Basic, Below Basic and Far Below Basic. These state mandated assessments were administered annually each spring, with results released to school districts in August of each year. How schools used these results for instructional purposes is partially determined by the school's performance on the CST. If the percentage of students who meet the proficiency level is sufficiently high, or if there is continuous growth in the percentage of students who meet proficiency levels, the progress of the school is deemed adequate. The percentage of proficient students must be met across all demographic categories of ethnicity, income level, English Proficiency, and special education eligibility. Schools which do not make adequate progress for a period of two consecutive years face a variety of state sanctions, including external evaluators, mandated professional development, and district and school site level data analysis of student test scores. It is within this accountability environment that the Mathematical ACTS professional development just described occurs.

## Classroom Observation Measure

The remainder of this paper focuses on one aspect of the ACTS research and evaluation design: the development, use and findings from a classroom observation instrument intended to assess the use of ACTS instructional strategies among ACTS teachers and comparison teachers (see Table 2).

The purpose of the classroom observations at this point in the project is directed at implementation: To what extent are teachers implementing the essential strategies of ACTS? Additionally, the use of a control group of classrooms allows us to address outcome evaluation: To what extent did teachers (and students) change as a result of the intervention? And, the analysis of the observation results will allow the ACTS team to undertake a formative evaluation: What can be done to improve the professional development intervention?

The ACTS Core Team undertook the development of a classroom observation instrument to assess teachers' use of ACTS instructional strategies, to be used in the Spring of 2005 with Cohort 1 teachers. This effort was headed up by the project's internal (Kathleen Bocian) and external (Rosalie Torres) evaluators. The decision to undertake creation of a new instrument rather than use an existing one was based on review of numerous instruments, and the determination that none were closely aligned enough with the content of ACTS staff development to accurately gauge intended implementation.

The specific purpose of the instrument was to capture the degree to which teacher and student behaviors and the classroom environment reflected the teachers' use of ACTS instructional strategies. The premise of the instrument was based on the following question: What would one expect to see in a classroom of a teacher who was effectively using ACTS instructional strategies? What would the teacher be doing? What would the students be doing and/or experiencing? The challenge of creating an objective instrument to assess these circumstances is exacerbated by the fact that implementation of the ACTS approach is largely dependent on teachers' creativity and judgment, and their capacity to integrate it with existing curricula and state standards. The instrument was designed to be applicable for use with both

ACTS participants and control teachers, with the expectation that ACTS participants would score higher on the rating scales of the instrument than non-participating teachers from comparable schools.

Finally, the instrument was not intended to be a complete measure of teaching quality in any one classroom. Rather, it was to specifically assess mathematics teaching in relationship to the use of ACTS instructional strategies. As will be explained below the instrument does provide for an overall rating which is a "capsule description of the lesson." This reflects the overall quality of the instruction observed in terms of its effectiveness for learning in mathematics among the students.

**Instrument Development**

The development of the ACTS instrument drew heavily on the instrument developed by the CETP Program Core Evaluation Project.[1] In all, the development process included the following steps, in general order of occurrence:

1. Observation of ACTS staff development sessions to identify crucial elements of the ACTS approach

2. Interviews with ACTS Core Team members to obtain their responses to the following questions: "Were ACTS being implemented in a teacher's classroom the way you intend, what would you see in that classroom? What would teachers be doing? What would students be doing?" These interviews were undertaken to capture the wide range of views and perceptions (although not necessarily inconsistent or conflicting) about what ACTS strategies look like in practice.

3. Review and consideration of:

    a. the five strands of the National Research Council's definition of mathematical proficiency upon which the project's expectations for student achievement and teacher professional development are based (see page 5)
    b. existing survey items and findings on teachers' classroom practices (baseline survey described in row 5 of Table 1, follow-up survey of Cohort 1 teachers described in row 1 of Table 2)
    c. the California Standards for the Teaching Profession consisting of six interrelated categories of teaching practice[2]
    d. the Elementary Mathematics Rubric (2004-05 pilot version) created by the project to assess student learning

[1] Collaboratives for Excellence in Teacher Preparation (CETP) Program Core Evaluation Project conducted at the University of Minnesota and funded by NSF.

[2] Engaging and Supporting All Students in Learning, Creating and Maintaining Effective Environments for Student Learning, Understanding and Organizing Subject Matter for Student Learning, Planning Instruction and Designing Learning Experiences for All Students, Assessing Student Learning, Developing as a Professional Educator

4. Interviews with developers and users of similar observation instruments about overall purposes, and analysis and training procedures

5. Meetings with the ACTS Core Team to:

    a. review plans for developing the instrument and conducting observations, and
    b. establish clarity about the primary purpose of the observations (i.e., for research and program evaluation rather than as a means for providing individual support/coaching to teachers)

6. Development of a first draft of main components, including broad categories of ACTS classroom practices based on all sources of data to date

7. Revisions based on input from the Core Team, and continued coding/categorizing of the instrument content by Bocian/Torres

8. Pilot use of the instrument by Bocian/Torres in four classrooms, and subsequent revisions, including development of recording and rating schemes

9. Input from the Core Team on latest version of the instrument

10. Second round of piloting with further revisions in the instrument content, and recording and rating schemes

**Current Version of Instrument**

The current version of the instrument consists of descriptions of 11 key indicators of the ACTS approach to mathematics instruction:

- Promote Understanding
    - Accuracy and Clarity (1)
    - Use Student Prior Knowledge (2)
    - Create Explicit Connections within Mathematics (3)
    - Create Explicit Connections across Disciplines (4)
    - Create Practical, Real World Applications (5)
- Promote Reasoning
    - Encourage Student Expression of Thinking (6)
    - Encourage Alternative Models of Problem Solving (7)
    - Encourage Predictions (8)
- Teacher Assessment of Student Understanding (9)
- Teacher Style that Encourages Motivation and Persistence (10)
- Classroom Environment (11)

For each of the first 10 indicators, the instrument included the following, as illustrated in Figure 2:

- A short description of the indicator (about 100-150 words)

- From four to 12 different *teacher behaviors* describing (a) what an observer would see the teacher doing were the indicator *absent* in the classroom, and (b) what an observer would see were the indicator *fully present* in the classroom

- From two to nine different *student experiences/behaviors* describing (a) what an observer would see students doing and/or experiencing were the indicator *absent* in the classroom, and (b) what the observer would see students doing and/or experiencing were the indicator *fully present* in the classroom

- Written examples of what different composite ratings (i.e., 1, 2, 3, 4, and 5) for each indicator might look like. These examples described possible scenarios that would constitute a particular rating. They were not necessarily meant for a direct comparison with any given observation in order to make a rating. Any one of the examples might address only one or two aspects of a key indicator.

The instrument requires that observers give an overall rating for each indicator using a 1 (low) to 5 (high) scale anchored by the descriptions of the indicator being absent or fully present.

The classroom environment indicator described what different aspects of the physical classroom itself would look like in a classroom where the ACTS approach was being practiced. As shown in Figure 3, observers give ratings of 1, 2, 3, 4, and 5 based on the extent to which various aspects were present.

Ratings of the 11 key indicators are based on all aspects of the key indicator, as seen (or not seen) in the lesson. This included accounting for both the number of "rows" (see Figure 2) that are seen in the lesson and the extent to which each is executed throughout the lesson. Thus, a teacher could cover only one "row" in his/her lesson, but do it so well and so consistently throughout the lesson that s/he received a higher rating than another teacher who addresses several "rows," but does so poorly and/or infrequently. Observers also use the following guidelines in making ratings of the key indicators:

| **Rating** | **Characteristics of Each Key Indicator** |
|---|---|
| 5 | 75% of characteristics listed under '5' are present |
| 4 | Student success is evident |
| 3 | Midpoint |
| 2 | Teacher effort is there, but it is not effective |
| 1 | Error or clear lack of the indicator; 75% of characteristics listed under '1' are present |

Finally, observers provide an overall rating of the lesson that considers the key indicators holistically in terms of the lesson's effectiveness (see Figure 4). In other words, the overall rating is not an average of the key indicator ratings, but rather focuses on the extent to which the lesson was effective in promoting student learning and understanding in mathematics. This section of the observation instrument is almost identical to that used in the CTEP observation protocol (see Lawrenz, Huffman, & Appeldoorn, 2002).

Observers do not make ratings when they are in the classrooms, but rather take a "running record" of both teacher and student behavior for the entire period of the observation (typically 45-60 minutes). Their "running records" or notes consist of the following:

- Start and end time of the observation
- Beginning and end times of each lesson segment. [Lesson segments are teacher directed and consist of each different major activity that teacher and students are engaged in (e.g., review of homework, introduction/explanation of math concept/lesson, student time on worksheet, student work in small groups, etc.).]
- For each lesson segment, the sequence of teacher activity and how students are responding, including their level of engagement.
- Examples of math problems being presented to or worked on by where possible.

The focus of these observation notes is what is seen in the classroom, not on the observer's interpretations of what they see. Observers are instructed to use their own style of note taking or short-hand – whatever would best enable them to recall classroom activity later for writing-up and rating. Immediately following each observation (or if not then, within the next eight hours), observers complete a protocol to capture the results of their observations (see Figure 5 for example of completed protocol). *First*, they complete the first page of the protocol, (a) filling in answers to brief questions they asked the teacher about the lesson to be observed, and (b) describing the classroom environment.

*Second*, observers review their hand-written notes: separating them into segments, giving a brief name to each segment, and showing start- and end-time for each segment. *Third*, they describe the lesson segments and level of student engagement for each one, entering this information onto the protocol. *Fourth*, they annotate their hand-written observation notes with additional notes (in different color pen) about the status of the different key indicators reflected in each lesson segment. *Fifth*, they flesh out a written description for each key indicator, based on what was observed throughout the entire lesson and annotations made, and enter this information on the protocol. *Sixth*, they make a preliminary rating of each key indicator. *Seventh*, they review their key indicator descriptions against their observation notes; and add to and/or revise descriptions as needed. *Finally*, they reconsider the initial ratings made, and changed or kept them the same, as appropriate. Thus, the protocol captures not only numeric ratings of the lesson observed, but (a) rich data about the details of each lesson and (b) written descriptions of its strengths and weaknesses which justify the ratings.

## Observer Training

The observer training took place in early March, 2004. In all, five observers were trained; and ultimately four conducted the majority of observations.[3] The training was conducted by Bocian and Torres, and took place over three days as follows:

| | |
|---|---|
| Day 1 | • Orientation to ACTS project<br>• Overview of qualitative methods and purpose of observations<br>• Examination of role of observer and potential biases/influences<br>• Overview of key indicators of mathematics instruction to support deep learning and understanding<br>• Introduction of instrument<br>• Demonstration lesson<br>• Instructions for observations on Day 2 |
| Day 2 | • Informal classroom observations at various schools in pairs or threesomes<br>• Debrief of observations focusing on evidence/lack of evidence for key indicators<br>• Overview and discussion of rating scale<br>• Application of rating scale to observations just conducted<br>• Further instruction on instrument, note-taking, write-up, and rating procedures<br>• Instructions for observations on Day 2 |
| Day 3 | • Formal classroom observations at various schools in pairs or threesomes<br>• Write-up and rating of observations<br>• Debriefing to reach consensus on ratings<br>• Next steps |

At the close of the third day of training, the group decided to conduct additional pilot observations during the following week before the formal observations began. Bocian continued to work with the observers during this period to reach consensus on ratings and use of the observation instrument. Observers returned from practice observations and immediately wrote up both the description of the lesson, the ratings for each of the dimensions, and the justification. They then compared scores and discussed their separate justifications. Following this the observers independently rewrote their justifications and compared them again. The purpose of these discussions was to clarify the differences in ratings within each of the 12 dimensions, particularly the strength of the justifications.

To establish inter-rater reliability, ACTS arranged for practice observation classrooms in a non-participating district and each of the five observers were paired with each other once. Practice observations across all raters during this time provided 10 different classroom comparisons for calculating inter-rater reliability across the five observers. Agreement was calculated for each of the dimensions of the observation protocol, with a 'total agreement score' being the average of these 11 dimensions. Agreement was calculated as 1 - (difference between the two ratings)/(sum of the two ratings). Between raters on any one dimension, agreement ranged from 67% to 100%. The average agreement 'total agreement score' between raters across

[3] Because of an unacceptable level of inter-rater reliability as well as scheduling difficulties, one observer was dropped.

the 11 dimensions ranged from 80% to 97%, with a mean across the 10 pairings of 90%. Inter-rater reliability for the overall quality of the lesson averaged 83%. Across all raters, the mean inter-rater agreement within each dimension is shown in Table 5.

**Table 5. Inter-rater agreement within dimensions (key indicators and overall quality).**

| Dimension of Rating | Average of Inter-rater agreement |
|---|---|
| Accuracy, Clarity | 0.88 |
| Student Prior Knowledge | 0.87 |
| Connections in Math | 0.87 |
| Connections w/other disciplines | 0.97 |
| Connections to practical | 0.97 |
| Student Expression of Thinking | 0.92 |
| Alternate Models of Problem Solving | 0.79 |
| Encourage Predictions | 0.90 |
| Assess Student Understanding | 0.91 |
| Motivation/Persistence | 0.91 |
| Class Environment | 0.89 |
| Overall quality of lesson | 0.83 |

**Data Collection**

The data collection design consisted of conducting a one-time class observation of both treatment classroom teachers: those teachers in Cohort 1 who had completed (or had the option of completing) the series of professional development offerings, and control classroom teachers: teachers who had not yet had the option of participating in the ACTS series. This translates into teachers who were part of Cohort 1 (treatment classrooms) and teachers who were part of Cohorts 3 and 4 (control classrooms). Teachers in Cohort 2 were in the midst of the professional development series and were not part of the 2004-05 research and evaluation design. Permission to observe in the classrooms was obtained from the district, with the caveat that the observations must be completed between March and the end of April to avoid the state testing cycle. The overall design scheme was introduced to the participating principals at regularly scheduled meetings, and to teacher representatives at a regularly scheduled instructional council meeting.

All teachers in the four schools in Cohort 1 who had participated in ACTS were asked to participate in a one-time observation visit, with voluntary teacher consent. Of the 33 teachers who were originally part of the four Cohort 1 elementary schools, 20 teachers were still teaching mathematics in grades 4, 5, and 6 in the district. This drop of 13 teachers enrolled in the initial professional development institute was due to changes in teaching assignments, not a drop from the ACTS program. Of the 20 eligible teachers, 16 agreed to participate in observations at the four schools: 60% of eligible teachers in School A; 33% in School B; 83% in School C; and 75% in School D.

Six schools remained in Cohorts 3 and 4, and we set as a target of four observations at each of the sites. Teachers in grades 4, 5, and 6 from the control classrooms were randomly numbered, and the first four teachers at each site were invited to give consent for the classroom observation. If this was not possible or a teacher refused, the next teacher on the randomly numbered list was chosen. Of the six participating schools which were controls, 19 teachers were observed: four teachers were observed from each of three schools, three teachers from one school, and two teachers each from the remaining two schools. The lower numbers in the final two schools were the result of inevitable delays or scheduling problems that pushed the observation out of the allowable calendar window set by the school district.

The voluntary consent form explained to teachers the following points:

1. The observations were part of the evaluation of ACTS, not an evaluation of teaching competence.
2. All information was confidential and would not be shared with the school site or district administration, and all confidentiality rules of the UCR Internal Review Board would be followed in terms of storage and reporting out of data.
3. The observation visit would occur within a specified three-day window noted in the letter.
4. The observer was 'blind' to the teacher's involvement in ACTS.
5. The teacher would receive a $50 gift certificate to a local school supply store.

Once permission was obtained from the teachers, the observers were assigned and the principals were notified that the schedule was in place. Observers completed the write-up of the lesson notes within 8 hours of viewing the lesson, and emailed the completed protocol to the ACTS Evaluation Coordinator (Bocian) within 24 hours of the observation visit.

Our initial plan for the observation design was to include repeated measures within randomly chosen teachers to determine the extent of variation across lessons. The limited window of access to teachers cut short this plan and we were able to collect repeated measures on only three teachers.

**Findings**

One-time classroom observations were completed for 19 control classroom teachers and 16 treatment classroom teachers during the spring of 2005 in grades 4, 5 and 6. Preliminary analyses examined the difference between the teachers in the control and treatment classrooms (see Table 6). While the means were higher for the treatment classrooms in eight of the eleven dimensions, they were not significantly different. The mean for *accuracy and clarity of concept presentation* and *assessment of student understanding* was actually higher for the control group. The mean rating of the overall quality of the observed lesson was almost identical. The treatment and control groups did not average above the mid-point of the scale (3) on any of the dimensions rated. Among the 11 key indicators, both treatment and control classrooms received the highest mean ratings for *teaching style that encourages motivation and persistence*, and the lowest mean ratings for *creating explicit connections across disciplines*.

**Table 6. Mean ratings of treatment and control group teacher classrooms for ACTS key indicators and overall quality of lesson.**

| **Variable*** | **Treatment Mean*** | **Treatment Standard Deviation** | **Control Mean** | **Control Standard Deviation** |
|---|---|---|---|---|
| Accuracy, clarity of concept | 2.40 | 1.12 | 2.58 | 1.12 |
| **Uses student prior knowledge** | **2.67** | 1.18 | 2.32 | 0.89 |
| **Connections in mathematics** | **2.27** | 0.88 | 2.05 | 1.08 |
| **Connections w/other disciplines** | **1.53** | 0.99 | 1.11 | 0.46 |
| **Connections to practical applications** | **2.13** | 1.36 | 1.74 | 1.05 |
| **Student expression of thinking** | **2.60** | 1.06 | 2.37 | 1.17 |
| **Alternate models of problem solving** | **2.20** | 1.01 | 1.83 | 1.04 |
| **Encourage predictions** | **1.80** | 1.01 | 1.58 | 1.07 |
| Assess student understanding | 2.53 | 1.25 | 2.68 | 1.20 |
| **Motivation/ persistence** | **2.93** | 1.44 | 2.68 | 1.34 |
| **Class environment** | **2.13** | 0.92 | 1.74 | 0.93 |
| Overall lesson rating | 2.75 | 1.38 | 2.74 | 1.21 |

*Bold-faced type indicates a higher mean for the treatment classrooms; however there are no statistically significant differences between treatment and control classrooms.

Further analyses are being pursued in several areas. *First*, use can be made of the considerable data within the observation. To gain a better understanding of which aspects of the different key indicators were being implemented well and which aspects were not being implemented well, more detailed coding and analyses of the observation ratings are being undertaken. As part of this follow-up analysis process, observers were asked to code the notes provided in the protocols which justified each key indicator's rating (see example in Figure 4). For this secondary coding, they used the subcomponents of each indicator specified in the observation instrument (see rows of Figure 1), indicating whether the justification provided a positive instance of the subcomponent, or a negative instance of it. Analyses of these "sub-ratings" will allow us to determine which aspects of the key indicators were most often being done well during the observations, which aspects teachers and/or students appear to be struggling with, and which aspects are not being addressed at all. This information will be used to refine supports provided to teachers through the professional development and coaching.

*Second*, we will look at the type and frequency of teacher activity (lecture, problem modeling, assessment), and the level of student engagement.

*Third*, the observational data can also be linked to other measures of teacher knowledge. Our analyses of pre and post test differences in content knowledge for teachers showed a clear influence of professional development on the post-test performance on the Mathematics Diagnostic Placement Test: Geometry Readiness. Teachers that participated in one or more of the institutes scored 7.5% higher in post test than they did in the pre-treatment test ($T=4.55$, $N=39$; $P<0.0001$). Differences between the pre and post test data were compared using paired, one tailed T-tests. There was not a significant influence of the professional development treatment on the performance of teachers in the Learning Mathematics for Teaching assessment.

*Fourth*, irrespective of participation in ACTS professional development, the influence of content knowledge on classroom practice can also be examined: do more knowledgeable teachers have higher ratings on accuracy of concept development for example? *Fifth*, the factors or latent traits within the ACTS pre-assessment questionnaire of current practices, can also be correlated with the dimensions in the observational protocol; and these teachers' classroom practices one year prior to the observations, but after a full year of professional development can also be correlated.

Although our classroom observations did not differentiate between classroom groups, our analysis of student achievement data *from the previous year* (2003-04 data has not yet been received for the 2004-05 academic year) did demonstrate significant differences between treatment and control classrooms, as shown in Tables 7 and 8. The overall trend was for slightly higher achievement in students whose teacher had participated in ACTS professional development.

To control for individual variation, each student's California Achievement Test-6 CAT/6 from the previous year (2002-03) was used as a covariate. In most cases there was not a significant interaction between the student's previous mathematics achievement and their teacher's participation in ACTS professional development. In those cases where the interactions were significant, they were only marginally so ($P > 0.03$). The strongest indicator for the effectiveness of the workshops to increase achievement is seen with the CAT/6 scores. Results from the district's own criterion referenced tests were in the predicted direction for grades 4 and 6 but in the opposite direction for grade 5. Scores on the new Mathematical ACTS/Extended Standards Test did not differ significantly between treatment and control classrooms. This last result is likely due, in part, to the novelty of this assessment, however we will be examining this assessment for reliability and ability to discriminate among students prior to its use in 2005-06.

**Table 7. Mean differences between control and treatment classrooms for California achievement tests and district criterion-referenced tests.**

| | CAT6/NCE | | District CRT Final Benchmark | |
|---|---|---|---|---|
| Grade Level | Treatment Teachers | Control Teachers | Treatment Teachers | Control Teachers |
| 4 | 49.2 | 45.3 | 72.0 | 68.3 |
| | P = 0.0031* | | P = 0.0095 | |
| 5 | 47.8 | 45.6 | 61.3 | 64.4 |
| | P = 0.0345** | | P = 0.0064 | |
| 6 | 49.5 | 46.5 | 62.3 | 59.8 |
| | P = 0.0032 | | P = 0.0174 | |

*A marginal interaction (P = 0.049) between teacher and the students third grade CAT/6 score was ignored for the purpose of reporting mean scores.
**A marginal interaction (P = 0.034) between teacher and the students fifth grade CAT/6 score was ignored for the purpose of reporting mean scores.

**Table 8. Mean differences between control and treatment classrooms for California achievement tests and district criterion-referenced tests.**

| | Mathematical ACTS Extended Standards Test (Multiple Choice) | | Mathematical ACTS Extended Standards Test (Written Response)* | |
|---|---|---|---|---|
| Grade Level | Treatment Teachers | Control Teachers | Treatment Teachers | Control Teachers |
| 4 | 55.2 | 52.9 | 8.9 | 8.2 |
| | P = 0.1762 | | P = 0.1598 | |
| 5 | 53.3 | 54.9 | 6.9 | 7.0 |
| | P = 0.6501 | | P = 0.5668 | |
| 6 | 44.6 | 44.2 | 7.9 | 7.2 |
| | P = 0.0571 | | P = 0.0772 | |

*Reported scores are out of 16 possible points; only one third of the tests were scored (stratified across all schools but random within each classroom)

**Discussion**

The results presented here are preliminary only, and are presented to the reader and conference attendees for purpose of discussion, not dissemination. Each of the measures in place for ACTS have been examined and compared only within their domains (eg. growth in student achievement measures; pre-post changes in teacher knowledge; control vs. treatment classroom observations) and the linkages among these measures inherent in our logic model have not been explored. We have made a conscious decision to solicit critiques and suggestions for strengthening the instruments and measures at this point in time because the potential of the data set is so rich and varied. It is our intent to explore the variations among teachers, students and schools, and minimize the variations due to measurement error.

It is worth considering the possible reasons for the lack of predicted findings in the classroom observations, particularly given that teachers participating in the professional development do show growth in the California Mathematics Diagnostic Placement Test and students from 'treatment' classrooms demonstrate significantly greater growth in several measures of student achievement. The *first* possibility is that the effects may have been under-represented due to sampling errors. Although heroic efforts were made to include all of the treatment teacher classrooms, and randomly sample from the control classrooms, the element of teacher consent to participate limited the number of treatment teachers. With an already small sample size, the limitation of power was considerable. We have not yet had the opportunity to compare other available teacher data from those that did and did not participate in the classroom observations, so we do not know if this self-selected sample is skewed in any way. With this pilot, we were working within an abbreviated time frame that pressured both observers and teachers in a time period when teachers are preparing students for mandated testing. While the observations at this time of year no doubt reflect classroom reality for students and teachers, observations across a full academic year will provide the ACTS team with better information about the consistency of teacher use of ACTS strategies.

The *second* possibility is the sensitivity of the rating scale (not necessarily the instrument) to detect the development of teacher change. The completed protocol in Figure 5 illustrates this dilemma well. It is clear from the lesson description that the teacher was using concrete representations, student manipulatives, and multiple representations to illustrate the concept of surface area. It is also clear that the work fell short, contained errors and produced confusion for some of the students, which earned the lesson a '2' in *accuracy and clarity of concept*. However, a '2' could also be earned by a teacher that presented a concept in a rote, mechanical and dry manner, but did not contain errors or generate confusion. A '3' within this category would need to explain the concept with a clear, concrete representation; a '4' would be a clear, concrete representation of the concept with evidence from students that they were questioning and absorbing the idea, and a '5' would be all of the above in an exemplary lesson. From a student perspective, both instances of a 2 may seem equal in terms of student learning. However these instances are not equal from the perspective of teacher learning. More detailed analysis of the 'row ratings' described above, analysis of the levels of student engagement, and a careful qualitative analyses of the protocols may suggest fine tunings of our rating system, which we can incorporate for this year's data collection.

A *third* possibility is the weakness of the link between the professional development and supports for implementation. It certainly was the intent of ACTS to clearly show the connection between the strategies modeled, the approaches to student learning, the demonstrated activities and resources with the standards teachers were expected to teach in mathematics. As Hill and Cohen (2005) point out, professional development is enhanced when it is directly connected to the curricular materials teachers use, the standards that guide the work, and the assessments to which teachers are accountable. One conclusion from the observational data is that not all teachers believed that the conceptually based teaching approaches in ACTS would help students with these standards in either a more efficient, more timely, or more effective manner than their past and current practice. This reaction of teachers may be even more pronounced in the context of teaching basic skill math standards to the district's struggling students.

Most likely, and most promising given that this a still a formative evaluation effort, the professional development of ACTS underestimated the supports necessary to create change in classroom practice. Unfortunately, this is not uncommon. Stein, Silver and Schwan-Smith (1999) captured this succinctly in their case study analysis of school reform professional development in two different settings. They realized that most teachers were under-prepared and too overwhelmed to translate workshop ideas and meeting discussions into instructional practice.

> The lack of transfer between workshops and instructional practice can be traced to limitations in the framework underlying the resource partners' initial plan. The most salient of these was the expectation that teachers would be able to recognize the usefulness of knowledge and skills learned in workshops and be able to access and use this knowledge at appropriate moments during the planning and delivery of lessons. The interactivity and competing goals that characterize classroom settings, however, made this transfer of knowledge a learning experience in and of itself. The resource partners were not prepared to scaffold this kind of teacher learning. Indeed, they had never had to do this in the past. (p. 45)

In addition, the authors above noted that restrictions of teacher background knowledge, student background knowledge, and district constraints were taken at face value, without a full understanding of how these might seriously hamper everyone's best intent to implement. For ACTS, we did not necessarily predict the extent to which limited math background of teachers would interact with minimal home experiences and academic readiness of the students, particularly in teaching a conceptually-based approach to mathematics. These shortcomings become additional hurdles in a statewide accountability race that focuses on test performance in math skills. Under these conflicting circumstances, the efforts of the ACTS teachers observed to try the conceptually-based strategies noted in Figure 4 (albeit with limited success), is almost heroic.

## Summary and Conclusion

This paper has presented an overview of the NSF-funded MSP Mathematical ACTS (a targeted mathematics education project between the University of California, Riverside and a unified school district in Southern California) with a specific focus on its research and evaluation design, and the use of an classroom observation measure to assess teachers' use of instructional strategies presented in the ACTS professional development. The observation measure used was developed by the ACTS Core Team with the assistance of an external evaluator. Preliminary analyses of the observation data show higher mean ratings for eight of 11 dimensions of the ACTS instructional approach in treatment classrooms over control classrooms. None of the differences are statistically significant, however.

Additional analyses to be conducted include: (a) examination of which aspects of the different key indicators were being implemented well and which aspects were not being implemented well, (b) consideration of any possible influence of the type and frequency of teacher activity in the lesson observed (lecture, problem modeling, assessment) and the level of student engagement on observations ratings, (c) linkages between ratings and pre-professional development to post-professional differences in content knowledge, (d) linkages between observation ratings and the degree of post-professional development content knowledge, and (e) linkages between observation ratings and teachers' classroom practices prior to professional development (i.e., at baseline) and after one year of professional development.

Possible explanations for the lack of expected differences between treatment and control teachers' instructional practices include: (a) effects being underrepresented due to sampling errors in terms of the teachers who volunteered to be observed, and the limited time period when observations took place, (b) insufficient sensitivity of the observation measure and rating scale, and (c) weaknesses in the link between the professional development and supports for implementation**.**

The analyses described above in conjunction with further consideration of reasons for the current findings are being undertaken by the ACTS Core Team: to make any indicated revisions in instrumentation and sampling plans for future data collection, to uncover effects as yet undetected, and to make improvements in professional development activities and supports for classroom implementation.

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**Figure 1. ACTS logic model.**

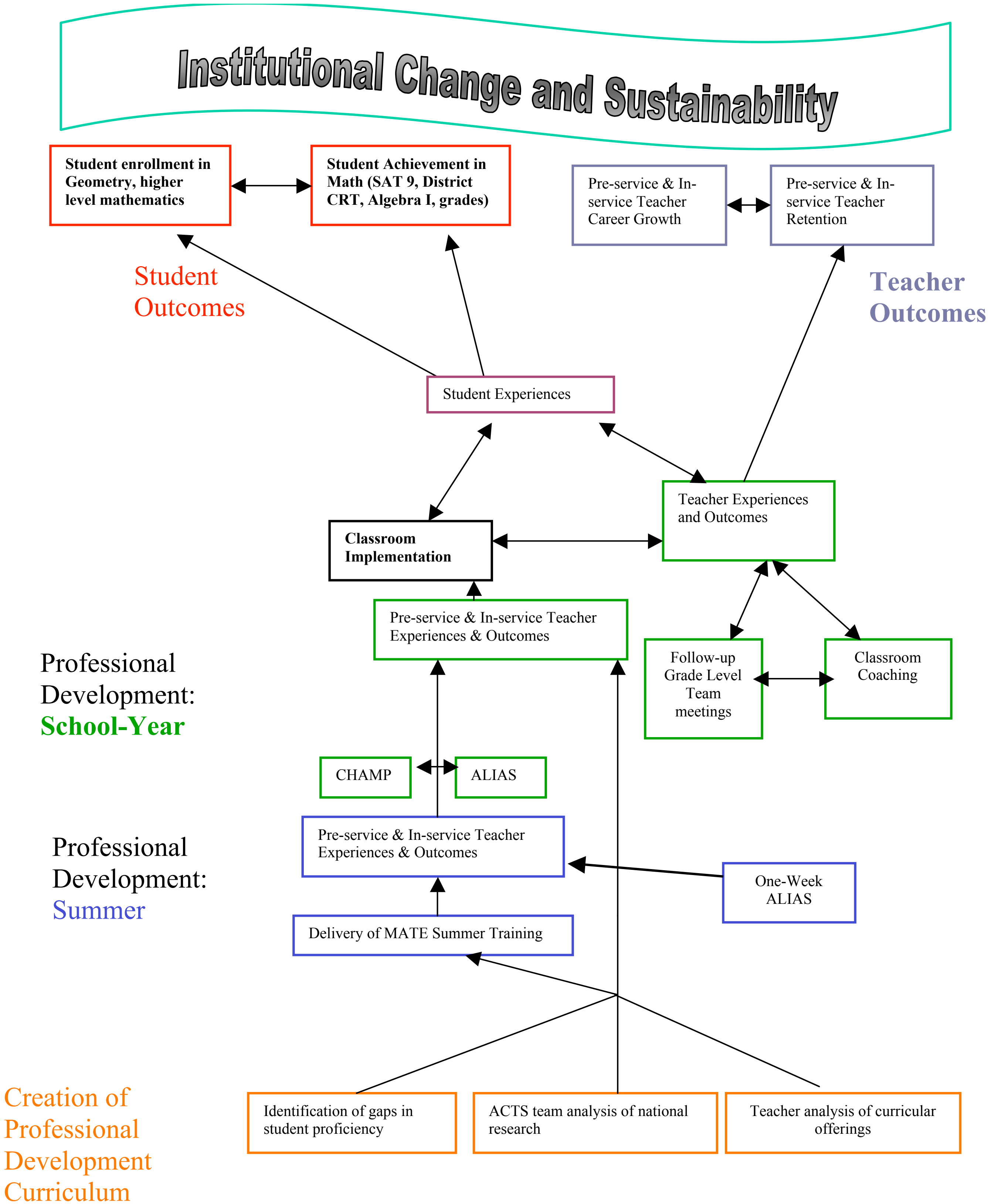

**Figure 2. Rating scheme for *prior knowledge/experiences* indicator of observation instrument.**

| **Promote Students' Conceptual Understanding: Use Prior Knowledge/Experiences** | | | | | |
|---|---|---|---|---|---|
| A cornerstone of reformed teaching is taking into consideration the prior knowledge that students bring with them. The term "respected" is pivotal in this item. It suggests an attitude of curiosity on the teacher's part, an active solicitation of student ideas, and an understanding that much of what a student brings to the mathematics or science classroom is strongly shaped and conditioned by their everyday experiences. It also recognizes that iterative, ongoing reference to students' prior learning reinforces that learning and connects it to new learning. | | | | | |
| ***Teacher Behaviors*** | | | | | |
| | **1** | **2** | **3** | **4** | **5** |
| **2a.** **Reference to and emphasis on prior relevant learning experiences** | Refers to student prior experiences (models, examples, data also), but these are not appropriate and have little connection to concept or lesson introduced OR begins lessons and activities without any reference to relevant student experiences or prior work/learning in the classroom | | | | Begins lessons with explicit reference to previous work related to the lesson, e.g. teacher calls students' attention to the similarity between a previous lesson or problem and a new problem, using the previous learning to help students understand the new problem. Used mostly for motivation or introduction |
| **2b.** **Questions or prompts to elicit relevant prior experience** | Does not ask students about relevant prior experiences or lessons. Class atmosphere and control of lesson limits student volunteering of ideas, thoughts that could be related to lesson at hand. | | | | Actively solicits information about students' prior experiences with the topic of the lesson (or experiences related to the topic). e.g., bringing in a real world object and having the students use it. |
| **2c.** **Prior understand-ing as basis for lesson** | Does not reference prior knowledge/understanding as basis for the lesson, and/or does not pursue student references to prior knowledge/ understanding in discussions; ignores and dismisses student ideas that could be related to the topic. | | | | Uses student references and terms as a starting point in referencing prior knowledge, and then expands vocabulary and idea to make connection more explicit and easy to understand…" I watched the boys and girls play Battleship,… can someone explain what they were doing when they called out A1?" Uses these conceptions as the basis for the lesson., e.g., "Dividing numbers is really sorting into groups… and when we work with numbers other than whole numbers, you will see that the quotient is sometimes larger than the dividend." |
| **2d.** **Clarification of prior conceptions or misconcep-tions** | Ignores obvious prior conceptions OR misconceptions that students would have about particular operations or terms in mathematics that could interfere with new learning (e.g. work in fractions, work with negative integers, work with metric system, work with clock face vs. digital clock.) Handles student prior conceptions that are in error by dismissing them quickly, ridiculing student, or ignoring opportunity to use instance as a building tool. | | | | Elicits the students' prior conceptions OR misconceptions and makes the students aware that these are prior conceptions: "When you divide numbers like this: 27/9, is the quotient smaller or bigger than the dividend?" (Many students' understanding is that the quotient is ALWAYS smaller than the dividend.) "So can you say that division is an operation where the quotient is always smaller than the dividend? … When you divide with fractions that is not the case (3 divided by 1/2 = 6 and 6 is larger than 1/2). |

| Promote Students' Conceptual Understanding: Use Prior Knowledge/Experiences | | | | | |
|---|---|---|---|---|---|
| **2e.** **Recording system for prior under-standing** | Absence of any means of recording prior knowledge, using knowledge outside of classroom, etc. | | | | Creates a system to build on student expression of prior knowledge through recording responses, vocabulary wall, games, charting predictions, etc. |
| ***Student Behaviors/Experiences*** | | | | | |
| **2f.** **Relating lesson to prior knowledge, learning, experiences** | Have no opportunity to express or draw on prior knowledge or experiences. | | | | Student responses and questions show that they are connecting learning to previous learning. |
| **2g.** **Comfort/ familiarity with accessing prior knowledge, experiences** | Students do not routinely build on prior knowledge; isolated requests to do so from teacher make students uncomfortable (eg. silence, squirms, off the wall comments.); students ; students are slow to follow instructions, engage in tasks designed to access prior knowledge/experiences | | | | Demonstrate familiarity/comfort with system for recording prior knowledge. (eg. students comfortable with returning to journals to look for connections to new learning; examine posted work or projects for same) |
| **2h.** **Volunteering references to prior knowledge, experiences** | Students do not volunteer references to previous work or related experiences. | | | | Students volunteer prior knowledge; students explicitly refer to prior learning in a response or question to the teacher (no 'it's like when we…..'). |

At a minimum, using prior knowledge would include a connection by the teacher to previous work that the current lesson will review or build upon. The more that students volunteer their past knowledge and experiences, the higher the rating. The devices that the teacher uses to elicit prior knowledge can be dull or creative: questions, quizzes, games, real objects, examples. Prior knowledge can often provide the motivation for the current lesson, and can help the students see connections of various types. The teacher's use of prior knowledge is deliberate, and occurs before the introduction of a concept, skill, etc. or is elicited or 'told' to students during individual teaching moments (this occurs frequently with mixed practice lessons and worksheets). However, use of prior knowledge is different than assessing student understanding. Prior knowledge is recalling and using what has been taught prior to the current lesson to motivate, to connect, to extend, to build. Assessment of student understanding deals with what is being taught in the current lesson, and necessary adjustments to instruction based on that assessment.

A '1' in this area would be when the teacher begins lessons and activities without any reference to relevant student experiences or prior work/learning in the classroom. "Today we are working with decimals. It is so important that you are going to see it several times over. (students groan and teacher laughs)."

A '1' in this area would be when the teacher dismisses obvious prior conceptions that students would have about particular operations or terms in mathematics that could interfere with new learning. "You know before that when you added two numbers together the sum would always be bigger than either of the addends. Well, forget all about that for today, we are going to add with negative and positive integers."

A '2' in this area might be the review of homework that provides a foundation for the lesson, but the teacher does not make explicit reference to this prior work or learning in the classroom.

A '2 ' in this area might be teacher recognition of a misconception that is simply overruled (e.g. 'generalizing about equality' where students saw = sign as meaning the answer comes next ___ + 5 = 12 and students are stumped. Teacher might say.. "You are not paying attention.. what plus 5 = 12, that is the question"… then shows the class how to subtract five from twelve and moved on. The opportunity to teach about equality and inverse operations is lost.

A '3' in this area might be presentation of a familiar problem to students and calling attention to its relationship to the current lesson*: solicits information about students' prior experiences with the topic of the lesson or experiences related to the topic.* An example might be the use of white boards with students to create figures demonstrating different geometric terms. The teacher sequences the questions in order to explain a new term that is a natural comparison or contrast: rectangles, squares, parallelograms, then a rhombus. In this instance of a 3 however, the teacher points out how the figures are the same or different however, instead of asking the students to make the comparisons.

A '3' in this area *might be use of a formal or informal strategy (e.g.,, questions, games) to acknowledge prior knowledge:* Mentions previous work in area and solicits from students the rules: Teacher notes that *we've added signed numbers before. What are some of the rules?* Student responds and struggles with terms.. when the number is inta.. inta… Teacher interrupts *what term is S trying to think of ?* Ss respond *absolute value,* T states *when we have positive and negative numbers in an addition problem they go to war, and the one with the greatest absolute value determines the sign of the answer.* Immediately moves to stating new rules. Although the teacher is *using student references and terms as a starting point in referencing prior knowledge, and then expands vocabulary and idea to make connection more explicit and easy to understand,* in this instance, the misunderstandings that were part of prior knowledge were ignored.

A '4' in this area might be teacher use of student references and terms as a starting point in referencing prior knowledge, and then expands vocabulary and idea to make connection more explicit and easy to understand…" I watched the boys and girls play Battleship,… can someone explain what they were doing when they called out A1?" *Uses a formal or informal strategy (e.g.,, questions, games) to acknowledge prior knowledge* as the teacher poses real questions of how the game is played 'how do they know where the strike is?' *Uses these conceptions as the basis for the lesson*. "Does it matter if they say 1A? Why? Can you show me if this graph was like a battleship game and I called C5, where would the strike be? *Student responses and questions show that they are connecting learning to previous learning*. "The letters and numbers tell you where to land…'*so if I asked you Jose to come up and place this symbol on (5,3), could you do it?* Student responds correctly, using teacher's cue.

A '5' in this category incorporates 75% of the bullets under '5'. The teachers *elicits the students' prior conceptions and makes the students aware that these are prior conceptions: e.g. Teacher uses student prior conception that the 'answer' always follows the equal sign to draw out the students' discovery of equality: equivalent number sentences on either side of the equal sign.* A distinguishing feature of a '5' rating is the quality and frequency of student responses to teacher questions or student questions*: Use prior knowledge consciously in expression., i.e., students explicitly refer to prior learning in a response or question to the teacher (e.g. Teacher consciously sets up subtraction problem with decimals incorrectly (4 -.46) to check for understanding of place value.. students volunteer need to add decimals and 0s to complete subtraction. Student volunteers that "Teacher, you said 0s don't matter but when you do subtraction 0s do count." "Fantastic.. can you tell me why I need these 0s for subtraction?"* There is evidence in the type of student work displayed or charts, etc. or in the structure of the classroom discussion "how many of you think that we will solve this problem using common denominators?" that students are used to volunteering, recording, and referring back to their own understandings.

**Figure 3. Rating scheme for *classroom environment* indicator of observation instrument.**

<table>
<tr><th colspan="5">Classroom Environment</th></tr>
<tr><td colspan="5">The classroom environment conveys the teacher's attitude and appreciation of both mathematics and the students' learning of the same. Within the classroom, the display of student work and the type of student work displayed promotes pride and continued effort. Displays of student work reflect the approach to mathematics in the classroom, and as such include evidence of student explanations and reasoning, and multiple representations: geometric shapes, charts, models, graphs, etc.. The portrayal of mathematics within the room as a vibrant and useful tool across disciplines, and to everyday life and real problems, needs to be continually reinforced with visual displays and literature books. Student access to tools, manipulatives, science equipment, etc. also conveys that mathematics is a subject beyond basic computation, and reinforces different learning styles. The big picture of mathematics, the essential concepts, and the interrelatedness of significant concepts can also be displayed visually and in prominent postings of student work. Ongoing investigations (collection of data, recording and charting/graphing) that are related to mathematics also remind students that math is a dynamic subject.</td></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Absence of any of the indicators for 5</td><td>Any combination of two of these three factors:<br>Some type of student work is displayed.<br>1 or more mathematical aids are evident.<br>Room arrangement facilitates group work and discussion.</td><td>Any combination of these three factors:<br>Student work is creatively displayed;<br>Several different kinds of mathematical aids are displayed.<br>Room arrangement facilitates group work and discussion.</td><td>Conditions of 3 are met, and several types of student work in problem solving and reasoning were evident, and teacher and or student use of manipulatives and or science equipment is clear.</td><td>The majority (75%) of the following present:<br>• Room arrangements permanently or as needed facilitate group work, discussion, etc.<br>• Evidence that mathematics is explicitly connected to other disciplines: science, history, art, multicultural studies is evident in posters, decorations, murals displayed in the room.<br>• Evidence that mathematics is explicitly connected to practical applications and real world problems: the math in current events, newspaper ads, maps, etc.<br>• Student math work is displayed in the room with creativity, color and explicit appreciation of mathematics<br>• The student math work displayed in the room is problem solving rather than worksheet.<br>• Student creations of graphs, plotting of data, charts, etc. displayed in the room. Recording systems for collecting data, charting, graphing around a variety of activities evident (e.g. recording activity of hermit crab and charting of same; weather patterns; student opinions, etc.)<br>• Student creations of geometric shapes, three dimensional objects, etc. related to mathematics and/or science is displayed in the room.<br>• Mathematics manipulatives are evident and used.<br>• Science equipment models are evident and used.</td></tr>
</table>

In elementary classrooms where multiple subjects are covered, space is at a premium. Attention to mathematics should be equal that given to other subjects in visual displays, student work should be displayed, and if possible, the room arrangement should facilitate group work. Different ratings are determined both by the creativity and relevance of math visual displays, the type of student work valued and displayed, the interconnections displayed between mathematics and other disciplines, and the use of manipulatives by teachers and students. While most elementary classrooms cannot allow students free access to manipulatives, if algebra tiles, cuisennare rods, etc. are tucked behind papers in a cupboard, they will rarely be used. Teacher/ student created posters of rules and demonstrations of concepts are highly valued.

**Figure 4. Rating scheme for *capsule description* of the lesson observed.**

*Level 1: Ineffective Instruction*

There is little or no evidence of student thinking or engagement with important ideas of mathematics. Instruction is *unlikely* to enhance students' understanding of the discipline or to develop their capacity to successfully "do" mathematics/science. The lesson was characterized by either (select one below):

*Passive "Learning"*

Instruction is pedantic and uninspiring. Students are passive recipients of information from the teacher/faculty member or textbook; material is presented in a way that is inaccessible to many of the students.

*Activity for Activity's Sake*

Students are involved in hands-on activities or other individual or group work, but it appears to be activity for activity's sake. Lesson lacks a clear sense of purpose and/or a clear link to conceptual development.

*Level 2: Elements of Effective Instruction*

Instruction contains some elements of effective practice, but there are *substantial problems* in the design, implementation, content, and/or appropriateness for many students in the class. For example, the content may lack importance and/or appropriateness; instruction may not successfully address the difficulties that many students are experiencing, etc. Overall, the lesson is *quite limited* in its likelihood to enhance students' understanding of the discipline or to develop their capacity to successfully do mathematics.

*Level 3: Beginning Stages of Effective Instruction (Select one: Low 3 Solid 3 High 3)*

Instruction is purposeful and characterized by quite a few elements of effective practice. Students are, at times, engaged in meaningful work, but there are *some weaknesses* in the design, implementation, or content of instruction. For example, the teacher/faculty member may short-circuit a planned exploration by telling students what they "should have found"; instruction may not adequately address the needs of a number of students; or the classroom culture may limit the accessibility or effectiveness of the lesson. Overall, the lesson is *somewhat limited* in its likelihood to enhance students' understanding of the discipline or to develop their capacity to successfully do mathematics.

*Level 4: Accomplished, Effective Instruction*

Instruction is purposeful and engaging for most students. Students actively participate in meaningful work (e.g., investigations, teacher/faculty member presentations, discussions with each other or the teacher/faculty member, reading). The lesson is well-designed and the teacher/faculty member implements it well, but adaptation of content or pedagogy in response to student needs and interests is limited. Instruction is *quite likely* to enhance most students' understanding of the discipline and to develop their capacity to successfully do mathematics.

*Level 5: Exemplary Instruction*

Instruction is purposeful and all students are highly engaged most or all of the time in meaningful work (e.g., investigation, teacher/faculty member presentations, discussions with each other or the teacher/faculty member, reading). The lesson is well-designed and artfully implemented with flexibility and responsiveness to students' needs and interests. Instruction is *highly likely* to enhance most students' understanding of the discipline and to develop their capacity to successfully do mathematics.

**Figure 5. Example of completed observation protocol.**

Mathematical ACTS Observation Protocol
Supported by NSF Grant EHR0226948
Professor Richard Cardullo, Biology Dept., University of California, Riverside
Principal Investigator

<table>
<tr><th colspan="2">BACKGROUND INFORMATION</th></tr>
<tr><td>Name of teacher<br>XX</td><td>Room #<br>XX</td></tr>
<tr><td>School<br>XXX</td><td>Grade Level<br>6</td></tr>
<tr><td>Observer Name<br>XXX</td><td>Date of Observation<br>XXX</td></tr>
<tr><td>Start Time<br>XXX</td><td>End Time<br>XXX</td></tr>
<tr><td>Length of observation<br>1 hr. 15 min. (75 min.)</td><td># of students in classroom<br>31 (6 English Language Learners)</td></tr>
<tr><th colspan="2">Classroom Context (Gathered from teacher interview and observation)</th></tr>
<tr><td colspan="2">What are the main topics or mathematical concepts for today’s lesson?<br><br>1) Surface area of a cylinder<br>2) Volume of a square pyramid (if time permitted but it did not)</td></tr>
<tr><td colspan="2">What are your major objectives for today’s lesson?<br><br>1) Finding the surface area of a cylinder<br>2) Connect concept to formula</td></tr>
<tr><td>About how long (or until what time) will this lesson go?<br><br>1 hour</td><td>Is this the first time you have covered this material with students? If no, is it practice, revisit after several days or weeks, etc?<br><br>Ss have covered surface area once this week but its application to cylinders is new.</td></tr>
<tr><td colspan="2">Description of classroom environment:<br><br>Room arrangement: Desks in 6 groups of 4-6 Ss<br><br>Evidence of practical application of math: No<br><br>Evidence of math connected to other disciplines: No<br><br>Student math work displayed: Yes, 8 examples of Ss demonstrating how the angles of a triangle (when cut up) can be aligned to create a straight angle of 180.<br><br>Graphs, charts, evidence of student research/data collection displayed in room: No<br><br>Student created geometric shapes, 3-d objects related to math/science displayed in room: No<br><br>Mathematical manipulatives on student desks or elsewhere accessible to students: Yes. On T’s desk, a sample 3-D pyramid (made of toothpicks and jelly beans) for next lesson.<br><br>Science equipment on student desks or elsewhere accessible to students: No</td></tr>
</table>

## Summary of Lesson Segments

<table>
<tr><th>Segment</th><th>Description</th><th>Length</th><th>Type of Instruction*</th><th>Extent of Student Engagement*</th></tr>
<tr><td></td><td>T translated into Spanish at times b/c of ELLs</td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>Math Warm Up (10:15 - 10:27)<ul><li>On OH (overhead), 5 problems (finding missing angle, subtract and divide w/ decimals, multiplication w/ integers). See examples on hardcopy.</li><li>Pattern of T asking, “What is absolutely necessary in order to answer this Q?” “What do you need to know?” “What’s the rule you need to know?”</li><li>T tended to guide Ss’ attention to what they needed to know and made the extraneous information overt.</li><li>Slight pattern of T Qs and S answers (computational and/or 1-3 word answers).</li><li>Some Ss able to articulate computational process but not conceptual. S- “Add the 2 numbers and subtract 180.”</li><li>T praised correct answers and accepting of incorrect ones (“more or less, but…” “almost, but…”)</li><li>T used hints to assist Ss (e.g., vertical arm movement hinting to align the decimals when adding).</li><li>T didn’t model any computations for Ss. All oral.</li><li>T informally assessed Ss understanding via hand raising, thumbs up.</li></ul></td><td>12 min.<br>(4 min. IP,<br>8 min.<br>review ans)</td><td>Written Seat<br>Work<br>Lecture<br>Problem<br>Modeling<br>Assessment</td><td>High to start<br>Medium later</td></tr>
<tr><td>2</td><td>Introduction (10:27 - 10:33)<br>T- “… been working w/ area. This lesson we’ll figure out area of a cylinder.”<ul><li>Ss asked to point out cylindrical shapes in room. (Coffee Mate canister)</li><li>T- “We’ll construct and see why the area is so.”</li><li>T- “Some already know and that’s okay. I may show you another way.” “…a formula, but I won’t give it to you. By the end, we’ll see if you can find the formula w/o looking it up.”</li><li>T- “Write it down on paper.”</li></ul></td><td>6 min.</td><td>Lecture</td><td>Medium</td></tr>
<tr><td>3</td><td>Instruction and modeling (10:32 – 10:41). See handout hardcopy.<ul><li>T modeled and guided Ss through each step via 1) simple T Qs and Ss’ answers and 2) specifically pointing & gesturing to parts.<ol type="a"><li>T held up white 9 x 12 paper, asked how to find its area (S- “l x w” “108 in_”).</li><li>T modeled how a rectangular paper can be curved to make the outer walls of a cylinder. T and Ss noted that the shape appeared to change</li></ol></li></ul></td><td>9 min.</td><td>Lecture<br>Demonstration</td><td>Medium to<br>fair</td></tr>
</table>

| | | | | |
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| | but the area of rectangle did not.<br>c. T held up orange 4.5 x 12 paper next to and on top of white 9 x 12. T asked what the area of the orange paper was and how to do it using what Ss already knew ("54 in_").<br>d. T modeled again how to curve the orange paper into a cylinder, noted the circular shape at the end, opened it up again and drew attention to how the outside line of the circle is the same line used in finding the rectangle's area (the length). Ss and T identified outside line of a circle as the circumference.<br>T explained that when using the same size of paper, the area will not change, even though the cylinder shape can. Ss experimented w/ this. | | | |
| **4** | **Independent practice small groups (10:41 – 10:51)**<br>• Materials for each group (heterogenous):<br>- White 9 x 12 paper - Orange 4.5 x 12 (_ of white)<br>- Orange 8 x 6 (_ of white) - Black 4.5 x 6 (_ of white)<br>• Directions: Find the area of each paper, do not measure, can "figure all out by comparing w/ white one." "Experiment w/ these and once we really, really know these, we will come back."<br>• Ss are then to make cylinders w/ each piece.<br>• 1 S cautioned group, "Don't overlap, won't be correct." | **10 min.** | **Small Group Work**<br>**Hands On Activity**<br>**1:1 one on one support** | High w/ group work |
| **5** | **Independent practice review (10:51 – 11:00)**<br>T cont. modeled and guided Ss through each step via 1) writing formula steps on white board (in parenthesis), 2) simple T Qs and Ss' answers and 2) specifically pointing & gesturing to parts.<br>a. Began w/ area of rectangle (A = l x w)<br>b. For the area of a circle, another name for length is… circumference (C). (A = C x w)<br>c. Another name for width is… height (h). (A = C x h)<br>d. Formula for C is… T- "Don't look it up."…π2r. (A = π2r x h)<br>e. What is 2r? Ss- "diameter."<br>f. End w/ formula: πd x h.<br>g. Area of orange… _ of white.<br>h. Area of black… _ of white.<br>i. Ss told to write formula down. | **10 min.** | **Lecture**<br>**Problem**<br>**Modeling**<br>**Demonstration** | **Fair**<br>**Low w/ specific Qs** |
| **6** | **Independent practice (11:00 – 11: 07)**<br>• Ss are to apply formula in finding surface area of all pieces of paper as if they were cylinders, but a little unclear to Ss.<br>• T caution if Ss overlapped too much, answers may be a little off. Find "diameter to closest half an | **7 min.** | **Small Group Work**<br>**Hands On** | **Medium** |

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| | inch."<br>• T sat w/ observer (me) and stated, "I know I'm forgetting something. I almost blew it by getting to the answer too quickly."<br>• T gave each group real object to find the surface area of using the algorithm. | | **Activity**<br><br>**1:1 one on one**<br><br>**support** | |
| **7** | **Independent practice review & closure (11:07– 11:17)**<br>• T realized numerical value of π not defined and did so.<br>• T asked group 1 the dimensions (diameter, length) and had other groups calculate. Once found, group 1 confirmed if answer correct.<br>• Cont. same process w/ 2 more groups.<br>• S had answer that was very high and T redirected S through process of estimation (step by step) to highlight her answer was not reasonable. Encouraged mental math.<br>• T- "How did the formula for a rectangle help you find the one for a cylinder?" S- "… both use '9'. 9 for width, 9 for height." T- "connection w/ letters?" No response. T- "What does a rectangle have in common w/ a circle, circumference?" No response. T- "Com'on guys." S- "Circumference is like length." T- "one group didn't let me down. Circumference was like length." | **10 min.** | **Lecture**<br><br>**Problem**<br><br>**Modeling** | **Fair to low** |
| **8** | **Plotting Ordered Pairs (11:17 – 11:30)**<br>• Ss plotted positive ordered pairs on coordinate plane in order to make an Easter picture (see hardcopy handout). T noted all pairs positive and in $1^{st}$ quadrant.<br>• T stated to observer that not all got it well, some needed to look at reasonableness of answers and be careful setting up decimals. | **13 min.** | **Written Seat Work**<br><br>**1:1 one on one support** | **High** |

Student level of engagement: ***High* (80% or more); *Medium* (79-60%); *Fair* (59-40 % or more); *Low* (39% or less)

| Key Indicator | Justification for each rating |
|---|---|
| Accuracy and Clarity of Concept | Ranking of 1<br>• **Concrete manipulatives attempted and abstract level (algorithm) addressed.** -1d<br>• Language of mathematics expressed in grade level appropriate terms (i.e., *area, surface are, pi, circumference, radius, diameter, divisor, quadrant, etc.).* **+1h**<br>However:<br>• **Concepts of area & surface area not clearly differentiated. T- "… been working w/ area. In this lesson we'll figure out area of a cylinder." T stated *area* not *surface area.*** -1b<br>• Presentation of surface area unclear. Ss did not appear to clearly understand. **-1a -1b; -1j**<br>• Inaccurate formula for surface area of cylinder. T ended w/ "πd x h" but it should have been "2(πr_) + h(2πr or πd)" **-1c** |

| | |
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| Use Student Prior Knowledge | Ranking of 2<br>• At start of lesson, T accessed prior knowledge of Ss in a brief review of area w/ a rectangle. T- "… been working w/ area. In this lesson we'll figure out (surface) area of a cylinder." **+2a; +2b**<br>• **Ss' prior math knowledge and vocabulary was accessed when T guided Ss through formula process (even if formula was inaccurate). T- "What is 2r?" Ss- "diameter."** +2a; +2b; +2c<br>• **T also incorporated knowledge of fractions (Area of orange… _ of white. Area of black… _ of white.).** +2c<br>• **In math warm up, T tapped prior knowledge when asking, "What is absolutely necessary in order to answer this Q?" "What's the rule you need to know?"** +2c; +2f |
| Create Explicit Connections within Mathematics | Ranking of 1<br>• **Attempt to link construction paper (concrete) and algorithms (abstract).** +3b<br>• **Attempt to incorporate knowledge of fractions (Area of orange… _ of white. Area of black… _ of white.).** +3b; -3a; -3f<br>• **Limited connections by Ss due to lack of scaffolding & inaccurate information.** -3g |
| Create Explicit Connections across Disciplines | Ranking of 1<br>• **No connections noted.** |
| Create Practical, Real World Applications | Ranking of 1<br>• **Although Ss pointed out cylindrical shapes in room (Coffee Mate canister), conceptual connections to real life unclear.** -5a<br>• **Although Ss given real life objects to explore, formula inaccurate. -5a, +5b** |
| Encourage Student Expression of Thinking | Ranking of 1<br>• T praised correct answers and accepting of incorrect ones ("more or less, but…" "almost, but…"). **+6a**<br>However:<br>• Opportunities for elaboration present but follow up Qs not solicited. T corrections made but not use opportunity to re-teach/adjust. **-6a; -6b; -6l; -6m**<br>• Ss worked in partners and shared their answers, however, when a few Ss explained computational procedure, their explanations lacked thinking process and reflection. S- "Add the 2 numbers and subtract 180." +6h; -6o; -6t |
| Encourage Alternative Models of Problem Solving | Ranking of 1<br>• **T- "Some already know and that's okay. I may show you another way."** +7a<br>• **T modeled how a rectangle can be curved to make the outer walls of a cylinder. T and Ss noted that the shape appeared to change but the area of rectangle did not.** +7d; -7e; -7f |
| Encourage Predictions | Ranking of 1<br>• Opportunity for prediction skills not utilized [e.g., predicting which quadrant would be used if only using positive ordered pairs (or vice versa), using mental math to predict reasonable surface area totals]. **-8a; -8f** |
| Teacher Assessment of Student Understanding | Ranking of 1<br>• **T informally assessed Ss understanding via hand raising, thumbs up.** +9a; -9b<br>• T voluntarily stated to observer that not all got it well, some needed to look at reasonableness of answers and be careful setting up decimals. **+9a**<br>However:<br>• T clarified activity directions when confusion became evident toward end. **-9a, -9d**<br>• Called on individual Ss and the class as a whole, but responses limited to correct/incorrect answers and engagement to questions tended to be low. **-9b**<br>• Pace too quick and insufficient modeling for Ss. T not adjust pace given Ss lack of participation, confusion, and errors made. **-9d; -9h** |

| | |
|---|---|
| Teacher Style that Encourages Motivation and Persistence | <u>Ranking of 2</u><br>• T attempts to make lesson interesting (hands-on activity). **+10g**<br>• Obvious wait time used and T encouraged persistence of thinking when S errors made. **+10d**<br>• **T praised correct answers and accepting of incorrect ones ("more or less, but…" "almost, but…").** +10a; +10f<br>• **T used hints to support Ss (e.g., vertical arm movement hinting to align the decimals when adding).** +10b<br>However:<br>• High achieving Ss called on when few volunteered. **-10h** |
| Classroom Environment | <u>Ranking of 2</u><br>• **Two indicators present: 1) room arrangement can facilitate group work/discussion and 2) math work displayed reflected Ss had to either construct or confirm area of triangle = 180 degrees. The use of manipulatives for next lesson also visibly evident on T's desk.** |

<u>Capsule Description of the Lesson</u>

Synthesize all the available information about the lesson and select a capsule rating that best describes the overall quality of the lesson you observed. Provide a brief rational for the selected capsule rating as well.

■ Level 1: Ineffective Instruction: □ Passive "Learning" ■ Activity for Activity's Sake

Justification for Capsule Description Rating:

Positives:

- ❖ The lesson itself had some engaging elements and could have led to a strong base of understanding surface area.
- ❖ Creative concrete approach, Ss enjoyed the hands-on
- ❖ T's energy and enthusiasm within lesson were above normal.

Problems:

- ❖ Several key flaws: 1) inaccuracy of surface area formula, 2) unclear description of surface area, and 3) differentiation between surface area and area vague. The concept was inaccessible to Ss.
- ❖ Even if concept was accurately presented, the lesson lacked sufficient modeling and explicit instruction, specifically at early concrete stage.
- ❖ T was not able to build on and connect essential math concepts.
- ❖ General lack of S thinking and reflecting on mathematical processes.