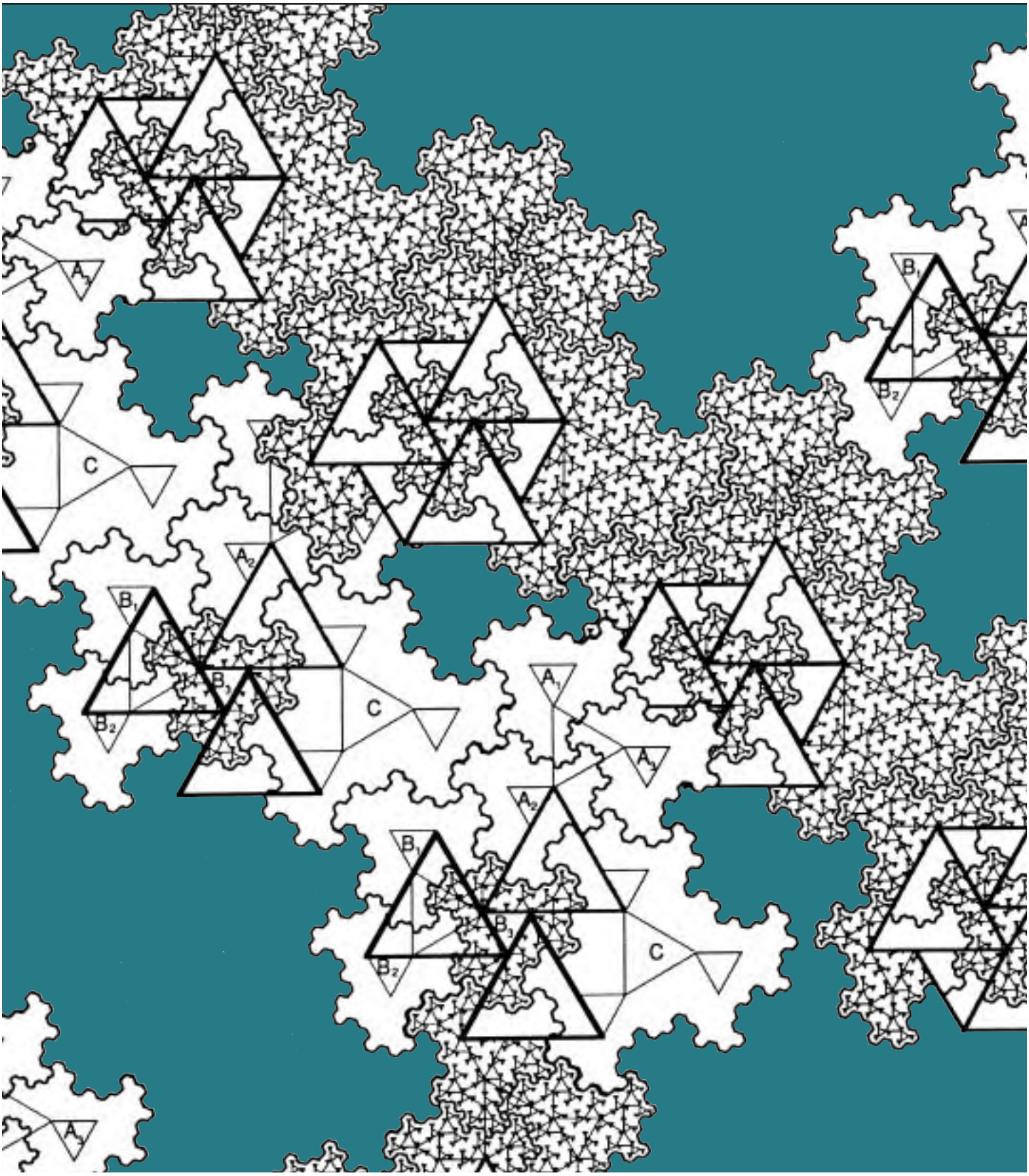
NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS

NCSM JOURNAL

of Mathematics Education Leadership

VOLUME 7, NUMBER 1 SPRING 2004



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Professional Development to Support the NCTM Standards:
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In the high school class, small groups of teachers are investigating the geometries on a variety of surfaces — balloons they had inflated, polyhedra they had constructed, and fruits and vegetables that were arranged at different centers. Down the hall, in one of the middle school classes, groups of teachers with stopwatches, meter sticks, marbles, toy cars, and ramps are collecting data to determine distance/time relationships for different scenarios. In one of the elementary classes, teachers are participating in a courtroom drama defending the impact of Standards-based instruction on students' understanding of mathematics concepts. Outside the building, pairs of teachers armed with digital cameras are walking around campus photographing different structures to illustrate their definitions of mathematical terms for a poster.

Above is a snapshot of activities that typically occur throughout the four-week Rice University School Mathematics Project (RUSMP) Summer Campus Program. The Summer Campus Program, held each June since 1987, creates communities of learning that increase PreK-12 teachers' mathematical knowledge while assisting them in the development of the pedagogical skills necessary to ensure that their increased understanding is transferred to student mathematical learning.

Providing professional development that encourages teachers to examine their beliefs and practice while providing support in mathematics content and pedagogy is an on-going challenge for programs designed to promote implementation of the National Council of Teachers of Mathematics (NCTM) *Standards* (1989, 1991, 1995, 2000). *Some teacher educators and researchers have suggested that in order to meet these goals traditional professional development activities must be restructured* (Darling-Hammond & McLaughlin, 1995; McLaughlin & Oberman, 1997; Gray, 2001; Lewis, 2002). This restructuring must move away from top-down teacher training strategies that emphasize acquisition of new skills or knowledge. Rather, professional development must provide occasions for teachers to reflect critically on their practice, to fashion new knowledge and beliefs about content, pedagogy, and learners, and to build collaborative, professional relationships. Furthermore, a successful professional development program cannot be prescriptive, but must be adjusted to the context in which it operates (Darling-Hammond & McGlaughlin, 1995).

One such program is RUSMP's (http://rusmp.rice.edu) Summer Campus Program, an annual professional development program that provides opportunities for PreK-12 teachers to enhance their mathematical knowledge, to develop more effective teaching practices that promote greater student involvement, and to develop skills in critical reflection through collaboration with peers. From its inception in 1987 as a single class for 48 middle and high school teachers, the Summer Campus Program today has expanded to five different classes for PreK-12 teachers engaging approximately 120 teachers each summer.

All RUSMP programs are guided by the fundamental belief that sustaining wide-scale instructional reform can only be accomplished through the development of the skills and knowledge of individual teachers. These efforts are framed in terms of developing professionalism among teachers. International studies of teachers' roles reveal that teachers

in European and Asian countries have many more opportunities to develop professionalism through on-going training, collaboration with peers, and participation in administrative decision-making than their United States counterparts (Darling-Hammond, 1996; Kinney, 1998; National Institute on Student Achievement, Curriculum, and Assessment, Office of Educational Research and Improvement, & U.S. Department of Education, 1998; Stevenson, Lee, & Nerison-Low, 1998; Stevenson & Stigler, 1992). Through opportunities such as these, teachers develop skills and expertise that allow them to make informed decisions about their practice and enhance their teaching.

The Summer Campus Program is designed to improve teachers' content knowledge in mathematics, in conjunction with an examination of the teaching methods embodied in the NCTM *Standards*. Fostering professionalism and creating a network of teachers who have extensive knowledge of both mathematical content and pedagogy is essential for supporting sustained instructional change (Nease, 1999; Papakonstantinou, 1995; Schweingruber, 1999). RUSMP activities are designed to support the development of teachers' professionalism by focusing on three major areas: (1) solid knowledge of mathematics, including key concepts that students must master; (2) awareness of a variety of approaches to instruction and their appropriate use; and (3) the ability to plan and reflect on instruction together with other teachers. The overarching goal of RUSMP is to improve each teacher's mathematical knowledge and teaching methodology in order to boost teacher effectiveness. This goal is especially urgent in light of the scarcity of mathematics teachers, which is resulting in more novice teachers (Alternative Certification Program, substitute, and first-year) and teachers with less training entering the profession and teaching out of their field. It is essential for them to have strong content knowledge and teaching skills.

The RUSMP approach rests on the assumption that professionalism among mathematics teachers must include: a solid knowledge of mathematics, including the key concepts students must master; awareness of a variety of approaches to instruction and their appropriate use; and the ability to plan and reflect on instruction together with other teachers. RUSMP has developed key mechanisms for achieving these goals.

While the Summer Campus Program focuses on mathematics content and pedagogy, an equally important goal is to raise the level of professionalism among in-service

Former National Council of Supervisors of Mathematics President Iris Carl participating in RUSMP activities.

teachers. The Summer Campus Program has received state and national recognition (Cannon, Parr, & Webb, 2003; Killion, 1999; Toenjes & Garst, 2001; Killion, 2002a; Killion, 2002b) for its positive impact on teachers' understanding of mathematics, their classroom practices, their students' achievement on standardized tests, and their expanded contributions to their school districts. Lessons learned over its eighteen years of operation provide valuable insight for teachers, principals and district level administrators interested in supporting quality Standards-based mathematics instruction. A discussion of the current operations of the Summer Campus Program, the curriculum developed for the program, and the RUSMP *Learning Plan*, a graphic organizer that serves as a tool to allow teachers to translate their program experiences into the classroom, is intended to catalyze discussion and provide guidance to those interested in establishing similar programs.

Operation of the Summer Campus Program

RUSMP was jointly conceptualized by Rice University mathematics faculty and Houston-area school district personnel. With an initial grant from the National Science Foundation, RUSMP was established in 1987 to serve as a bridge between the Rice University mathematics research community and Houston-area mathematics teachers. In addition to the original grant, RUSMP has received generous funding under the Dwight D. Eisenhower Higher Education and Teacher Quality Grants Programs and from corporations, foundations, and local school districts.

The growth of RUSMP owes much to its unique relationship with Houston-area schools and school districts. Throughout its history, RUSMP has striven to be responsive to the needs expressed by teachers, principals, mathematics directors, and superintendents in area schools. This responsiveness has resulted in constant changes and improvements in RUSMP and has led to its continued expansion. Though university based, RUSMP has an intimate knowledge of the schools in the Houston area and seeks to nurture a long-term, collaborative relationship with them. As a result, over the eighteen years of operation, several additional components have been added under the umbrella of RUSMP. These programs are described on the RUSMP web site (http://rusmp.rice.edu) and in other papers (Eaves, 2000; Killion, 2002c; Papakonstantinou, Berger, Wells, & Austin, 1996).

The Summer Campus Program remains the centerpiece of RUSMP. It is founded upon the principle that teachers learn best from their fellow teachers. In keeping with the view that successful professional development must take seriously the need to develop teachers themselves as experts, the Summer Campus Program incorporates Master Teachers (Austin, Herbert & Wells, 1990; Cruz, Turner, & Papakonstantinou, 2003) who have demonstrated sustained success with innovative instructional practices in their own classrooms. Master Teachers, under the direction of RUSMP's Directors and university mathematics faculty, are responsible for planning the content of the Summer Campus Program.

A team of two Master Teachers works together to provide instruction for teachers who are grouped by grade level. The two Master Teachers are assigned such that one has experience teaching at the designated grade level and the other has experience teaching in the grades above that level. The intent is to provide participating teachers with instruction relevant to their grade level, but also to give them exposure to material beyond that grade level. Using the RUSMP curriculum as a guide, Master Teachers identify the key mathematical concepts that will be developed, discuss activities that will be provided, and select the materials to be used. The Master Teachers' extensive knowledge of current practices in education ensures that the teachers they are instructing receive information that is relevant to them. Master Teachers serve as role models for how teachers can effectively perform in the classroom. They provide teachers with implicit examples of how a lesson can be developed and taught, how to involve students in discussions, how to work with other educators in the planning and implementation of a lesson, etc., through the way they lead classes in the Summer Campus Program.

In recent years, five class levels (PreK-2, 3-4, 5-6, 7-Algebra I, and Geometry and Above) have been offered to teachers. Enrollment is limited to approximately 120 teachers across the grade bands. The four-week program runs Mondays through Thursdays (8:30 a.m. - 3:30 p.m.) during the month of June. Each day before classes begin, breakfast is served to the entire group to promote a collegial atmosphere that builds relationships among teachers, Master Teachers, university faculty, and RUSMP staff. To foster the RUSMP's philosophy "teachers teaching teachers," classes begin with thirty-minute share sessions during which teachers make brief presentations of exemplary activities or share teaching tips. This forum provides opportunities for veteran teachers to share successful classroom practices with novice teachers and for teachers from different schools to share ideas.

During the rest of the day, teachers engage in carefully planned, conceptually-based instructional activities. RUSMP has developed a content/process framework that supports student creativity and active learning. This curriculum rests on an underlying philosophy of how children learn mathematics and is coherent with guidelines developed by NCTM. Since RUSMP believes that mathematics development is a social activity, collaboration is a hallmark of almost all Summer Campus Program activities. The purpose of instructional activities is two-fold. Teachers are provided with meaningful collaborative activities that they can modify for use in their classrooms, but more importantly, they also develop a deeper understanding of mathematics and mathematics teaching through in-depth dialogue that accompanies each activity. This dialogue is meant to help teachers see the activity not as an isolated event but as an important piece in the process of developing mathematical thinking in their students.

Master Teachers develop concepts over several grade levels and discuss the vertical alignment of instruction with participants. As a result, teachers see not only what mathematics should have preceded an activity but also what mathematics connections will be made later. They keep journals with daily entries explaining how they felt about the day's lesson and what they learned that day. These writing experiences enhance their mathematical understanding of the concepts presented. The journals are read and responded to weekly by the Master Teachers.

Teachers use manipulatives and technology as tools: (1) to address various learning styles, (2) to model or represent mathematical concepts, (3) to abstract from the concrete manipulative to symbolic representation, and (4) to generate authentic data. Teachers receive training in the use of the latest graphing technology, data collection devices, and computer software, as well as in the use of the Internet and its application to mathematics instruction. Technology instruction is conducted by Master Teachers together with RUSMP's Director of Educational Technology and Secondary Education. A computer lab is open before and after classes and during lunch for teachers to complete assignments, check email, and email daily reflections to Master Teachers. A Rice University graduate student staffs the computer lab to assist teachers.

The curriculum also includes classroom-based assessments that aim to improve instructional decision making, as well as student learning. Teachers are encouraged to explore a wide range of assessment strategies — student writing, performance tasks, student self-assessment, observations, interviews — and to develop assessment activities that are natural outgrowths of classroom work. Master Teachers use a variety of assessment techniques to evaluate teachers' work in the program including discussions, work on long-range problems and open-ended questions, projects, dramatizations, homework, journals, essays, and portfolios. Use of computers, calculators, and manipulatives are included in assessments.

Teachers have a variety of opportunities to collaborate with colleagues, including opportunities to plan instructional activities for particular mathematical concepts. Teachers plan concept-based instruction focusing on the Texas Essential Knowledge and Skills (TEKS) using RUSMP's *Learning Plan*. RUSMP's Directors and Master Teachers assist teachers in the writing of the plans. Time for teachers to collaborate and create learning plans is provided weekly during class time. Teachers work together to create learning plans to use in their classrooms during the academic year. During the last week of the program, teachers present their learning plans to their peers.

During lunch, teachers participate in small group discussions on topics of interest or need, such as assessment strategies, classroom management, motivating students to learn mathematics, or they view selected videos appropriate for classroom use. RUSMP's Director leads these sessions. These informal sessions provide further opportunities for teachers to learn from each other and build more personal and lasting connections to RUSMP.

Each Wednesday morning, the groups meet jointly for a one-hour colloquium talk presented by university mathematics faculty, post-docs, or other national leaders in mathematics and mathematics education on mathematics and its applications, curriculum, school reform, and minority and gender issues in mathematics education. The colloquia speakers serve as a bridge between the research and teaching communities. Lunch is provided for all to promote discussion of the colloquium topic of the day. Last summer's colloquia topics were "Area, Angle, and Curvature," "The Many Hats of a Mathematics Teacher," "The Language of Mathematics," and "NCTM Principles: The 'Character' of School Mathematics."

On the third Wednesday of the program, RUSMP hosts an Administrators' Day, a meeting for school and district-level administrators and business partners. Guests learn about the latest research in teaching and learning mathematics, participate in round-table discussions, visit classes with their teachers, preview learning plans and centers that their teachers are developing, and make plans with their teachers on how to improve the mathematics programs at their schools.

An important goal of the Summer Campus Program is to produce teacher-leaders who will make an impact in their school districts, statewide, and nationally. To encourage this, teachers receive assistance in preparing and making presentations in schools or at conferences. Each year several RUSMP participating teachers share their renewed excitement for teaching by presenting at the Texas Conference for the Advancement of Mathematics Teaching (CAMT). In addition RUSMP hosts Fall and Spring Networking Conferences for all past participants. At these networking conferences, after a keynote address by a university faculty member, Summer Campus Program Master Teachers and teachers make presentations to share new resources and teaching ideas.

For their work during the Summer Campus Program, teachers receive four hours of university graduate credit in education and 30 clock hours of credit toward state gifted and talented certification. In addition, teachers receive stipends, travel money to CAMT, materials, books, and technology, as well as follow-up support from the RUSMP Directors. The university waives the tuition and fees for

Rice University School Mathematics Project
Curriculum Matrix
Summer Campus Program 2003

MATHEMATICAL CONCEPTS						PROCESSES
	Number & Operations	**Patterns, Functions, & Algebra**	**Geometry & Spatial Sense**	**Measurement**	**Data Analysis & Statistics Probability**	Concept Sequencing Problem Solving Reasoning & Proof Communicating Connecting Representing
Pre K - 2	• Whole number concepts & operations • Numeration • Place value	• Balance & equalities	• Shapes & their properties	• Standard & non-standard systems • Time & temperature	• Chance	
3 - 4	• Whole number concepts & operations • Fraction concepts & operations	• Factors & multiples • Patterns	• Plane figures • Congruence, similarity • Transformations	• Measurement systems • Perimeter, area	• Simple probability • Interpretative data	
5 - 6	• Fractions, decimals, percents, concepts & operations • Integer concepts & operations	• Variable • Patterns	• Polygons • Transformations • Spatial geometry	• Perimeter, area, volume • Measurement systems	• Central tendency • Theoretical & experimental probability	
7 - Algebra I	• Ratio & proportion • Integer concepts & operations	• Polynomials • Slope • Linear & non-linear functions	• Area, surface area, perimeter, volume • Logic • Nets • Transformations • Pythagorean Theorem	• Area, surface area, perimeter, volume • Pythagorean Theorem	• Statistics • Theoretical & experimental probability	
Geometry and Above	• Limits • Direct & inverse variation • Proportionality	• Parent functions • Transformations • Rate of change • Function development & application • Proportionality	• Proportionality • Area • Pythagorean Theorem • Logic	• Perimeter, area, volume • Circumference • Precision • Indirect measurement	• Mathematical models • Regression analysis • Residual analysis	

teachers as the university's cost-sharing for the federal grants that help support the activities of the Summer Campus Program. Major funding for the program currently comes from Teacher Quality Grants Program under the No Child Left Behind Act of 2001, with additional support from schools, school districts, corporations, and foundations.

Summer Campus Program Curriculum

In the current efforts to align instruction with the NCTM Standards, the focus is often on practices, such as cooperative grouping or use of manipulatives, without providing a framework or rationale for selecting a particular activity. Simon (1998) notes that there is a need to attend to the key ideas in mathematics and to organize instruction to help students grapple with these ideas. At RUSMP, all programs are conducted with the primary assumption that successful mathematics instruction will occur only when teachers and students are engaged in meaningful discussion and exploration of essential mathematics concepts. In order to structure their classes in this way, teachers must have a thorough knowledge of mathematics that will enable them to identify the key concepts and how they are linked.

RUSMP Directors, other university faculty, and Master Teachers have developed a curriculum framework around which instruction is organized. The Curriculum Matrix identifies five major strands for mathematics instruction in grades PreK-12: number, measurement, geometry, statistics and probability, and patterns and functions.

RUSMP teachers prepare a presentation poster.

Within each strand, the key concepts to be covered at each grade level are identified. This provides a basic framework for Master Teachers to work with as they plan instruction. The Curriculum Matrix for the 2003 Summer Campus Program appears on page 7. (Other curriculum matrices may be found on the RUSMP web site.)

The RUSMP Learning Plan

To support teachers in planning instruction, RUSMP has also developed a *Learning Plan* template, which aids in organizing daily instruction around central mathematical concepts. The plan guides teachers to design activities that are in keeping with the NCTM Standards and the philosophy of RUSMP. An individual plan is intended to focus on a single concept and elaborate on how this concept may be presented in the classroom. The *Learning Plan* template is divided into eight main sections: the concept to be focused on; materials and resources needed; exploratory activities; activities to develop the concept further; basic facts and standard algorithms connected to the concept; student products to demonstrate understanding of the concept; assessment; and alignment to school and district curricular objectives. The curriculum and the *Learning Plan* together serve as an anchor point for the coherence of all RUSMP programs and have allowed RUSMP to maintain focus as the number of programs has increased or grown in scope. The *Learning Plan* is intended to formalize a lesson blueprint and timeline for instruction. (For an in-depth description of the *Learning Plan* as well as completed learning plans, go to http://rusmp.rice.edu/curriculum/learning_plan.htm.) The *Learning Plan* asks teachers to begin with an important concept, find a challenging and interesting introduction to this concept, gather a set of activities that will deepen students' understanding of the concept, and develop assessments and student products (oral, written, and visual) that can aid in the assessment of students' understanding. This is all accomplished with the required skills and knowledge related to the concept as prescribed by the TEKS in mind. The annotated *Learning Plan* appears on page 9.

Evaluation and Impact

Every year the RUSMP Summer Campus Program undergoes rigorous assessment of the impact it has on participating teachers. All teachers are administered surveys at the beginning and the end of their participation, with questions that assess their confidence in several areas of mathematics instruction and their beliefs about teaching and learning mathematics. Teachers are given tests of their content knowledge, geared for their grade level, at the

ANNOTATED LEARNING PLAN

Exploratory Activities
Introductory "hands-on" activities that introduce students to a concept, e.g. a two-team mathematical Tic-Tac-Toe game that leads students to graph ordered pairs. These activities need to provide thinking and are preferably not of the textbook or worksheet variety.

Concept
An idea important in the main body of mathematics, e.g. multiplication, linear equations, area, slope. Concepts are used to organize instructional units. Concept-based organization encourages broad, rich units with connections among concepts.

Concept Development Activities
Activities/problems aimed at providing students with experiences to explore and think about the concept in many situations so that formal learning and understanding can take place.

Materials and Resources
Examples: Algebra tiles, geoboards, Cuisenaire rods, etc., as well as, any necessary printed materials needed for the entire unit.

Basic Facts and Standard Algorithms Formalized
Taken from the TEKS, the basic facts and standard algorithms are the computational strand of the instructional unit. Once students have a foundation of interesting experiences and explorations with a concept, then the basic facts and standard algorithms can be formalized — with greater success, one hopes. Textbook exercises and sets of concept-related problems are needed here.

Originality and Creativity

Student Products

Written
Verbal
Kinesthetic
Visual

Encourage the development of products — written articles, etc. — that have students organize what they have learned in new ways that make sense to them. Providing opportunity for creativity in the classroom tends to increase interest and motivation.

Assessment
Teacher-made tests and alternative assessments (i.e. observations, student writing, portfolios, student self-evaluations, interviews, demonstration tasks) provide information about student learning and thinking, as well as, information upon which to base instructional decisions.

Related TEKS
These are the Texas Essential Knowledge and Skills objectives covered by teaching this concept.

beginning and end of the program as well. They are also asked to evaluate the design and structure of the program itself in the post-survey. In the academic year following the program, RUSMP personnel observe a random sample of the participating teachers in their classrooms. Data collected from the 2002 program indicated that, upon completion of the program, over 90% of the teachers reported feeling fairly well prepared or very well prepared in using cooperative learning groups, using hands-on activities, using a variety of methods to assess students' mathematical knowledge, presenting applications of concepts, taking into account students' prior conceptions about mathematics, managing a class using manipulatives, and using technology. Paired samples t-tests performed on the available data indicated that teachers' sense of preparedness in all these areas had increased significantly ($p < .001$) over the course of the program, and scores on the tests of content knowledge also significantly increased from the beginning to the end of the program across grade levels. It also appeared that teachers' beliefs about teaching and learning mathematics had become more in line with the ideas promoted by the NCTM Standards, as they agreed more strongly after completion of the program that students should write about how they solve math problems ($p < .001$), that it is important to begin with a concrete example ($p < .001$), that teachers should let students figure things out for themselves ($p < .001$), and that students learn best when they study mathematics in the context of everyday situations ($p < .05$). Teachers were less likely to agree, however, that students need to master basic computational skills before they can engage effectively in mathematical problem solving ($p < .05$) and that a great deal of practice is necessary for students to get better in mathematics ($p < .001$). These results are typical of the data obtained annually from the Summer Campus Program.

RUSMP's eighteen-year partnership with Houston-area school districts to improve mathematics instruction affords RUSMP the experience and qualification to develop an effective module that meets the needs of current and future teachers. As noted by RUSMP's external evaluators, "increased cooperation between local school districts and RUSMP has resulted in greater compatibility between RUSMP programs and curricula and school districts' pro-

grams and curricula. Through this kind of collaboration with schools and the school districts, RUSMP's impact has moved beyond the individual classroom teacher to improvement of mathematics programs at the school and district level." (See Austin, Wells, & Herbert, 1990; Cannon, Parr, & Webb, 2003; Eaves, 2000; Killion, 2002a; Killion, 2002b; Killion, 2002c, Killion, 1999; Nease, 1999; Papakonstantinou, Berger, Wells, & Austin, 1996; Schweingruber, 1999; Toenjes and Garst, 2001.)

Reflections and Conclusion

The Summer Campus Program supports RUSMP's efforts to raise the level of teachers' professionalism, thereby improving mathematics instruction in the Houston area. It is important to stress that the development of the Summer Campus Program has evolved out of RUSMP's experiences with teachers and schools. As the Summer Campus Program has evolved, so has RUSMP's role in the development of mathematics teachers in the Houston area has grown. Other successful endeavors such as the RUSMP/Houston Independent School District Algebra Initiative, the RUSMP Urban Program, and the RUSMP academic-year courses: Algebra for Elementary Teachers, Geometry for Elementary Teachers, Algebra for Middle School Teachers, Geometry for Middle School Teachers, Advanced Topics for Middle and High School Math Teachers, Calculus for High School Teachers, and Technology Institutes for Middle School, Algebra I, and Calculus teachers have strengthened and improved Houston-area mathematics teaching. As in any successful partnership (Miller & O'Shea, 1996), in order to be successful and for work to stay relevant, one needs to be responsive to the needs of collaborating partners — teachers, principals, district administrators, and students. The current configuration of the Summer Campus Program is effective and has been nationally recognized. However, RUSMP remains open to the possibility that programs may need to be altered in order to adapt to changes in collaborating school-district partners.

As the Summer Campus Program approaches twenty years of providing successful professional development and support to PreK-12 teachers in the Houston area, perhaps RUSMP's experience and successes can inform other organizations desiring to create and present similar mathematics professional development programs.

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