# Mathematics Master Plan

## Utah State Office of Education

Patti Harrington
State Superintendent of Public Instruction

Brenda Hales, Associate Superintendent
Student Achievement and School Success

Lynne Greenwood, Director
Curriculum and Instruction

Gerolynn Hargrove, Coordinator
Curriculum and Instruction

Diana Suddreth, Specialist
Secondary Mathematics

Lois Richins, Interim Specialist
Elementary Mathematics

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## Committee Members

| | |
|---|---|
| Diana Suddreth, Chair | Utah State Office of Education, Curriculum & Instruction |
| | |
| Craig Ashton | Cache School District |
| Aaron Bertram | University of Utah, Mathematics Department |
| Kenley Brown | Alpine School District |
| Joy Coates | Iron School District |
| Jennie DeFriez | Utah State Office of Education, Assessment |
| Nolan Fawcett | Utah State Office of Education, Assessment |
| Shari Goodman | Granite School District |
| Gerolynn Hargrove | Utah State Office of Education, Curriculum & Instruction |
| Barbara Kuehl | Salt Lake City School District |
| Lois Richins | Utah State Office of Education, Curriculum & Instruction |
| Janet Sutorius | Juab School District |
| Logan Toone | Davis School District |

# Mathematics Master Plan

## Introduction

In September 2008, a committee of mathematics educators, mathematicians, and education administrators met to draft a Mathematics Master Plan for the Utah State Office of Education (USOE). This plan outlines a vision and defines objectives and strategies that will guide the USOE in decision-making and program development.

The committee began by assessing some of the current difficulties in mathematics education in Utah. These challenges include funding, the availability of highly qualified teachers, state diversity, a need for professional development, and the attitudes of students and the community. The committee also noted the difficulty of assessing student growth, the limited availability of student interventions, and increasing teacher responsibilities.

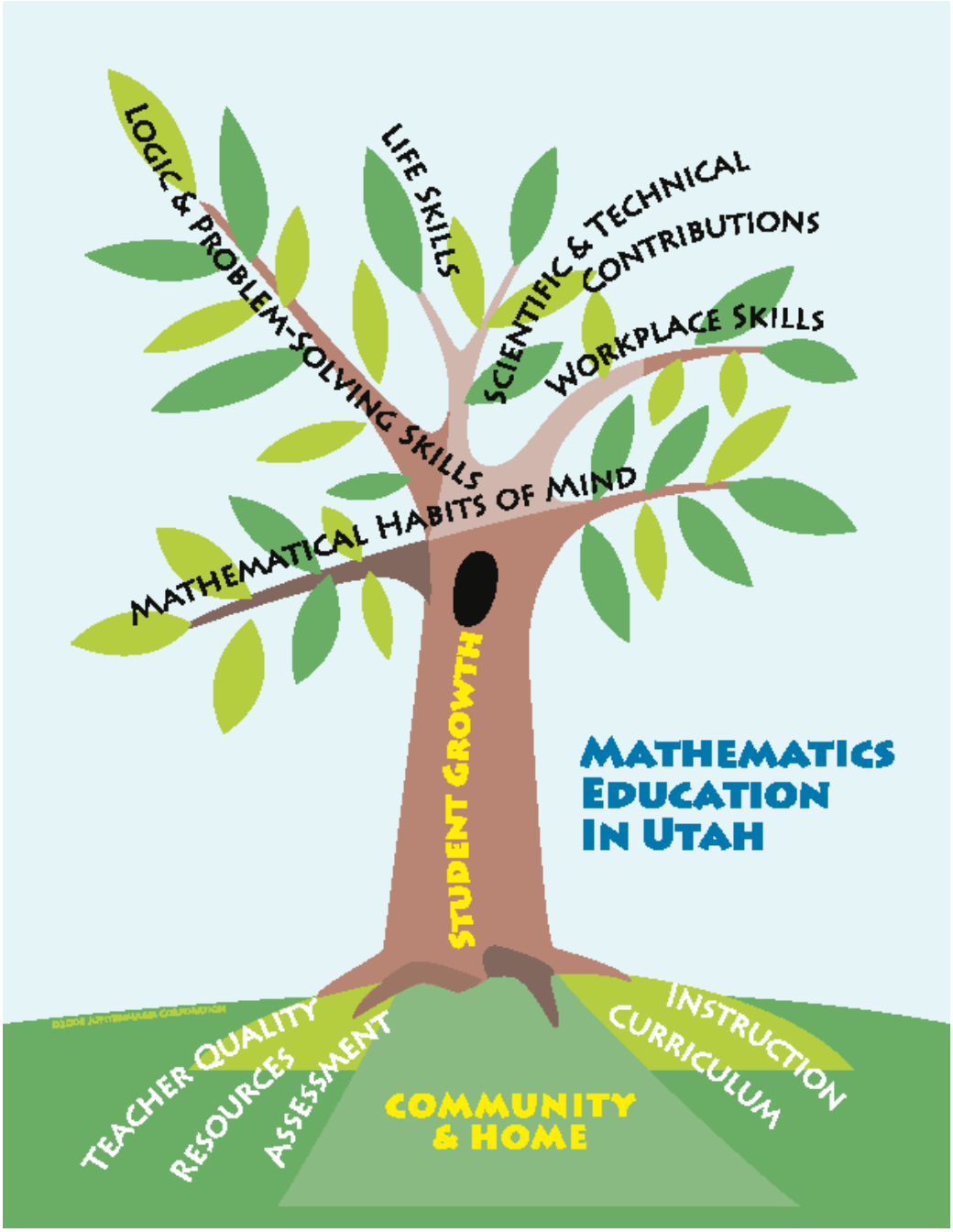
The committee identified several strengths of Utah mathematics education, including committed and professional teachers, an increasing focus on mathematics, a community commitment to education, strong mathematics education associations, growing connections with higher education and the wider community, and quality professional development. They also noted an intense state interest in technology and economic development. In general, the education community is committed to mathematics education and has participated widely in the improvement process.

The committee also recognized several unique opportunities for Utah to enhance mathematics education. These opportunities include the Park City Math Institute, USTAR, and programs for increasing teacher quality such as UMEP, as well as an increased capacity within districts to support teachers through professional learning communities and mentoring.

The committee established a mission statement and adopted a living tree as a metaphor for student growth in mathematics. The branches represent the desired outcomes for student learning: mathematical habits of mind, logic and problem-solving skills, life skills, workplace skills, and scientific and technical contributions. The roots provide the sustenance for student growth: teacher quality, resources, assessment, curriculum, and instruction. The community and home support the entire tree of student growth in mathematics.

## Our Mission

**The mission of mathematics education in Utah is to promote student growth and learning in mathematics in order to prepare students to thrive and contribute in the global economy of the 21st Century.**



# The Branches

The living tree provides a metaphor for thinking about our mission and organizing our goals. The branches of the tree represent our vision for the results of mathematics education in Utah. Fundamentally, mathematics education in Utah should lead students to develop mathematical habits of mind. These habits support more visible outcomes, including logic and problem-solving skills, life skills, workplace skills, and scientific and technical contributions.

## Mathematical Habits of Mind

Mathematical habits of mind support the acquisition of mathematical understanding and skills. These habits include the five process standards, which have become common parlance in mathematics classrooms: problem solving, communication, reasoning, connections, and representation. Students with mathematical habits of mind also possess a disposition and willingness to approach mathematics, to persevere in the face of mathematical difficulties, and to appreciate the accomplishment that comes with finding solutions and understanding concepts.

This branch also represents an appreciation for the beauty of mathematics, understanding of underlying structures, and recognition of the importance of mathematics in aesthetics such as art and music. This branch of the tree supports the acquisition of all other mathematical abilities. Each student will flourish with these habits.

## Logic and Problem-Solving Skills

Logic and problem-solving skills, although included in mathematical habits of mind, are distinctive enough to form their own branch of mathematics learning. The acquisition of reasoning skills uniquely developed in the mathematics curriculum is an essential preparation for responsible adult thinking. Inductive and deductive reasoning emphasized in mathematics classes extend to student decision making based on legitimate logic. Problem-solving skills facilitate the extension of mathematical concepts to real life as students and adults analyze finances, build structures, and approach problems from multiple angles. Strategies learned in mathematics classes—such as drawing pictures, reasoning backward, writing equations, thinking visually—apply to many situations. The logical thinking and problem-solving skills developed in mathematics classes are not only applicable to mathematics contexts, but can serve as a foundation for wise decision-making throughout life.

It is impossible to pursue mathematics beyond basic arithmetic without the ability to form logical arguments and solve problems. These skills open doors of understanding to higher learning and enhance student ability to reason about mathematical truths illuminated through proof. Skills in logic and problem solving guide mathematical exploration, justify conjectures, and prove the efficacy of mathematics algorithms.

## Life Skills

It is not uncommon for the general public to cite anecdotes about clerks who are unable to make change without the aid of a computerized cash register. It is equally clear that many economic woes are the result of poor mathematics application, and particularly of misunderstandings regarding exponential functions in credit applications. Adults and students alike face daily decisions that involve the application of mathematical thinking, from the arithmetic of shopping to the geometry of construction to the algebra of economics. Mathematics education must support the acquisition of skills necessary for adult independence.

Statistics is an area of mathematics that has an increasing impact on everyday life. Improved statistical methods have increased the reliability and availability of statistical analysis affecting everything from politics to medicine. It is important for adults to be able to read and understand statistical claims, especially recognizing statistical misuse and misdirection.

## Workplace Skills

Life skills expand to include the application of mathematics in specific employment situations. Nurses use algebra to determine the proper dosage of medicines based on patients' weights. Engineers use calculus to design bridges and civic infrastructure. Artists use geometry to capture perspective. Authors use discrete mathematics to weave codes into best-selling novels. It is nearly impossible to find a profession that does not use some branch of mathematics.

Education is a critical piece of our economic development. An educated populace contributes to the economy through creativity and productivity, both of which depend on a strong foundation in mathematics. The 21$^{st}$ century presents workers with challenges never before faced. Society is progressively more technological, and workplace skills increasingly include abilities most often learned in mathematics courses.

## Scientific and Technical Contributions

America's pre-eminence has historically been based on scientific and technical ingenuity. U.S. leadership in a global society is dependent on the ability to compete in a technical world. "Mathematics is the mother of science" (Plato), and so supports the society in which we live. We have become accustomed to computers, cell phones, radiology, air travel, overnight delivery services, digital entertainment, and numerous other recent advancements that enhance our lives. Mathematical discoveries in universities lead to practical applications in industry and society.

It is also important to realize that the study of mathematics for its own sake is a worthy enterprise. Recent advancements in chaos theory, fractal geometry, and differential equations contribute to the scientific community and are beautiful in their own right.

# The Roots

Five roots support the Utah Mathematics Master Plan: teacher quality, resources, assessment, curriculum, and instruction. Drawing their energy from the soil of community and home, these roots provide support for student growth and understanding in mathematics.

## Community and Home

Sustenance for student growth comes from the rich soil of our community and homes. Parents promote student learning by providing an atmosphere of encouragement and participating in school activities such as locally sponsored family math nights. The education community sustains student growth through a network of interested and committed individuals and organizations such as the Utah Council of Teachers of Mathematics (UCTM), parent-teacher associations, and school community councils. Nevertheless, success of the Mathematics Master Plan depends on wider community support and a general commitment to the importance of mathematics education, along with a sincere belief that all students can learn mathematics. It is the community that helps promote the vision of mathematics as reasoning, problem solving, communication, application, and other mathematical habits of mind.

## Teacher Quality

Besides parental influence, research clearly shows that the primary factor affecting student achievement is the quality of the teacher in the classroom. Differences in student achievement can be traced more commonly to teacher quality than any other factor, including socioeconomic status (NMAP, 2008). Teacher quality depends on the mathematics education of preservice teachers as well as the ability to provide classroom teachers with ongoing opportunities for professional growth. Equally important is the ability to retain effective teachers. Support for both existing teachers and adults wishing to become elementary and secondary mathematics teachers is critical to improving instruction for all students.

## Curriculum

Curriculum, instruction, and assessment form the triumvirate of any mathematics program. The Utah State Mathematics Core Curriculum was developed in 2007 with the goal of setting world-class standards for the children of Utah, and was based on a variety of current documentation and research on curriculum. This Core Curriculum provides teachers with direction on the skills and concepts students should learn as they progress through the curriculum. Online documents provide examples for parents and curriculum mapping guidance.

The goal now is to sustain the implementation of that curriculum through the creation of additional resource documents and continued professional development. Continued refinement and improvement are always advisable, and further work will clarify objectives and align the curriculum with post-secondary expectations.

## Instruction

Teachers use the Core Curriculum in conjunction with district and locally adopted curriculum materials to provide quality instruction for all students. Implementation of the curriculum through instruction is primarily the duty of the classroom teacher, but it is the responsibility of the USOE and district and school administrators to provide the necessary resources and training to assist teachers in improvement.

Our increasingly diverse society and the diversity of learning environments require teachers to practice differentiated instruction to meet the needs of a wide range of student abilities. English language learners, special education students, and other students at risk for underachievement in mathematics need alternative approaches and targeted assistance. Teachers must take ownership of student achievement and modify instructional practices to meet the needs of all students. Although students must engage in the curriculum with persistence, teachers must supply the tools for student engagement. Effective instruction is the most useful tool in the box.

The USOE is currently developing a Tiered Model of Mathematics Instruction. This document will be available in draft form in the summer of 2009 and will be particularly useful to educators looking to provide alternative instruction for students who have not yet attained proficiency, and for those who are ready for enrichment. It will provide instructional guidance for all levels of proficiency.

## Assessment

Teachers can improve student achievement by using formative assessment and data to recognize areas in which students need additional instruction. Tools such as the Utah Test Item Pool Service (UTIPS) and quality classroom assessments help teachers ascertain student knowledge of mathematics as outlined in the Utah Core Curriculum. The use of appropriate differentiated and targeted assessment strategies increases in importance as our schools continue to grow in diversity.

## Resources

Teachers must have and know how to use resources to deliver quality mathematics instruction. The USOE is committed to equity in access to mathematics resources, and is developing a variety of resources for use in rural districts that may not have the infrastructure to develop these tools themselves. In addition, the Utah State Legislature and Governor's Office are focused on the importance of mathematics, and work with the USOE to support and improve mathematics education in Utah.

Utah endeavors to decrease class size and provide additional technology, software, and Internet access. Scarcity of funding resources is a persistent issue in Utah. The Utah State Office of Education is committed to helping teachers access resources by working as a mathematical community and accessing the wider economic, technical and scientific communities.

# Our Goals

## Community and Home

- Create a community of mathematics educators K-16.
- Increase professionalism and respect for mathematics education.
- Support administrators in instructional leadership in mathematics.
- Communicate a vision of mathematics that includes reasoning, problem solving, communication, application, and other mathematical habits of mind.
- Encourage family involvement in mathematics.
- Encourage students' interest in maximizing their mathematical potential.

## Teacher Quality

- Create more interest in mathematics teaching careers.
- Review the endorsement system.
- Improve teacher content knowledge and classroom practice through professional development.
- Develop improved teacher communication networks statewide.

## Curriculum

- Maintain ongoing improvement and revision of the Core Curriculum.
- Improve curriculum alignment and articulation.
- Create curricular support for core implementation.
- Ensure that secondary course offerings meet the needs of all students.

## Instruction

- Improve classroom instruction.
- Provide a system of differentiated instruction to meet the needs of all students of mathematics.

## Assessment

- Improve classroom assessment practices.
- Pursue the development of improved assessments that align with the Core Curriculum and demonstrate understanding.

## Resources

- Improve working conditions for teachers.
- Promote equity in access to mathematics resources.
- Seek funding and other resources to support the implementation of the Mathematics Master Plan.

# Our Plan

## Community and Home

### Create a community of mathematics educators K-16.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Connect mathematics educators through professional organizations like the Utah Council of Teachers of Mathematics (UCTM), and the Utah Association of Mathematics Teacher Educators (UAMTE). | Organizational boards, promotion through Utah State Office of Education (USOE), district support and promotion | Ongoing |
| Facilitate grade-level and interdepartmental collaboration, including collaboration with English language learner (ELL) and science, technology, engineering, and mathematics (STEM) experts. | Districts, USOE | Ongoing |
| Create opportunities, such as public lecture series, to bring K-16 educators and administrators together in academic discussions about mathematics. | Universities, districts, community organizations | Start in fall 2009 |

### Increase professionalism and respect for mathematics education.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Define, collect and interpret accurate data and information about mathematics education in Utah. | USOE, Utah System of Higher Education (USHE), Local Education Agencies (LEAs) | Ongoing |
| Disseminate accurate data and information about mathematics education in Utah. | USOE, USHE, LEAs | Ongoing |
| Communicate a coherent USOE plan for mathematics education supported by data and research. | USOE Mathematics Specialists and Math Master Planning Committee | 2009-2010 |

### Support administrators in instructional leadership in mathematics.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Create an administrative leadership academy that supports mathematics education. | USOE | Upon completion of the 3-Tier Model of Instruction |

## Communicate a vision of mathematics that includes reasoning, problem solving, communication, application, and other mathematical habits of mind.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Create a web site with FAQs, research links, career links and resources. | UCTM or USOE Committee | Ongoing |
| Propose a public service media campaign that highlights mathematics. | UCTM | 2010 |

## Encourage family involvement in mathematics

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Create the ideas and resources for parents to support student achievement in mathematics, such as family math nights. | USOE Elementary and Secondary Mathematics Committees | 2009-2010<br>2010-2011 |
| Collaborate with community and school libraries to identify and promote mathematics literature and identify materials that link mathematics to the literature. | USOE Elementary and Secondary Mathematics Committees | 2009 |
| Translate parental support documents into commonly spoken home-languages. | USOE | 2010 |

## Encourage students' interest in maximizing their mathematical potential.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Create a document to help parents understand the mathematical development process, inform them about the importance of proper placement in mathematics course registration, and help them support mathematical learning for their students. | Committee with mathematics and counseling professionals, K-16 Alliance | Ready by January 2010 |
| Create a document highlighting careers and opportunities for guidance counselors to use to encourage students to pursue mathematics. | USOE-led committee with mathematics and counseling professionals, K-16 Alliance | Ready by January 2010 |

# Teacher Quality

## Create more interest in mathematics teaching careers.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Support multiple pathways that assist qualified individuals who wish to enter mathematics teaching. | USOE, Governor's Math Advisory Committee, USHE, universities | Ongoing |
| Encourage students to pursue post-secondary mathematics education. | USOE, UCTM, school partnerships with higher education | Ongoing |
| Recruit promising mathematics students from universities into elementary and secondary teaching. | School partnerships with higher education | Ongoing |
| Foster enthusiasm for mathematics teaching, including teaching mathematics in elementary schools. | Teachers, USOE, State Mathematics Coordinating Committee (SMECC), UCTM, teacher education departments | Ongoing |

## Review the endorsement system.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Provide funding to support teachers working toward elementary and secondary mathematics endorsements. | Districts, USOE | Ongoing |
| Work toward statewide uniformity in endorsement requirements from university to university. | USOE, USHE, universities | Ongoing |
| Provide an ongoing review of the mathematics endorsement system. | USOE | Ongoing |
| Revise the state-wide elementary mathematics endorsement. | USOE | 2010 |
| Create an endorsement for elementary and secondary mathematics leaders. | USOE | 2011 |

## Improve teacher content knowledge and classroom practice through professional development.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Encourage job-embedded professional development with adequate compensation, including participation in learning communities. . | Districts, USOE, Legislature | Ongoing |
| Provide professional development that increases teacher content knowledge and improves classroom practice. | Districts, USOE, universities | Ongoing |
| Offer professional development that provides teachers with strategies to close achievement gaps. | Districts, USOE, universities | Ongoing |
| Identify and communicate the components of effective professional development in mathematics. | USOE, professional development committee | 2010 |

## Develop improved teacher communication networks statewide.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Support organizations such as UCTM that network teachers statewide. | Teachers, districts, USOE, USHE | Ongoing |
| Encourage and facilitate a network of individual teachers engaging in collaboration and professional development through electronic means. | Districts, USOE, Intech | Ongoing |

# Curriculum

## Maintain ongoing improvement and revision of the Core Curriculum.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Sponsor a forum of stakeholders to review and refine the core based on research. | USOE, USHE, universities | Regularly scheduled beginning 2010 |

## Improve curriculum alignment and articulation.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Continue district and state support of current efforts to improve curriculum alignment and articulation. | USOE, USHE, universities | Ongoing |

## Create curricular support for core implementation.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Continue the instructional materials review process. | USOE | Ongoing |
| Facilitate the sharing of district-developed core support materials. | State Mathematics Education Coordinating Committee (SMECC) | Ongoing |
| Hyperlink the core to resources. | USOE | 2010 |

## Ensure that secondary course offerings meet the needs of all students.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Review current offerings on an ongoing basis. | Secondary core review committee | Regularly beginning 2010 |

# Instruction

## Improve classroom instruction.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Recognize and support effective teaching practices for improving overall achievement and closing achievement gaps. | USOE, districts, universities | Ongoing |
| Provide professional development consistent with NCTM's *Mathematics Teaching Today*. | Districts, USOE, universities, UCTM | Ongoing |

## Provide a system of differentiated instruction to meet the needs of all students of mathematics.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Develop a K-12 tiered model of instruction and intervention for mathematics. | USOE | 2010 |

# Assessment

## Improve classroom assessment practices.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Provide professional development that supports the writing and use of quality assessments and rubrics. | USOE Curriculum and Assessment Sections, districts, universities | Ongoing |
| Provide quality resources to support the use of formative, benchmark, performance, and summative assessments. | USOE Assessment, Utah Test Item Pool Service (UTIPS) | Ongoing |
| Develop tools for teacher use in classroom assessment systems. | USOE | 2010 |
| Promote the use of data-driven decision-making. | Districts | Ongoing |

## Pursue the development of improved assessments that align with the Core Curriculum and demonstrate understanding.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Advocate for sound assessment policy. | USOE, assessment directors | Ongoing |
| Collaborate with the USOE Assessment Section to ensure alignment with core content. | USOE Curriculum and Assessment Sections | Ongoing |

# Resources

## Improve working conditions for teachers.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Advocate for a decrease in preparation loads for mathematics teachers. | Mathematics stakeholders, business and industry, and the wider community | Ongoing |
| Advocate for an increase in preparation time for elementary teachers. | Mathematics stakeholders, business and industry, and the wider community | Ongoing |

## Promote equity in access to mathematics resources.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Provide resources and opportunities for smaller districts. | USOE in collaboration with districts, SMECC | Ongoing |
| Provide and link resources that meet the needs of diverse populations of students. | USOE, districts, Legislature (Utah Science Technology and Research: USTAR) | Ongoing |
| Promote district collaboration. | USOE, districts | Ongoing |

## Seek funding and other resources to support the implementation of the Mathematics Master Plan.

| Strategy | Role/Responsibility | Timeline |
|---|---|---|
| Encourage and support critical and ongoing funding from policymakers. | State Board of Education, community, districts, business, local school boards, Trust Lands Committees, teachers' associations | Ongoing |
| Work with district and local administrators in prioritizing the use of available resources. | USOE, Principals' Academy, curriculum directors, professional associations, Utah School Superintendents Association (USSA), SMECC | Ongoing |

## Summary

The Utah State Office of Education and the wider community must band together to support student growth and learning in mathematics in order to prepare students to thrive and contribute in the global economy of the 21st century. Our challenges are many, but our opportunities are greater. Utah's commitment to students and to student growth is strong. This plan constitutes an ongoing, living document that will guide mathematics education through improvements in teacher quality, curriculum, instruction, assessment, and resources to help our students achieve their maximum potential. The investment by Utah's communities and homes will bear the fruit of mathematics thinking, processing, and application skills that will advance our society through economic, scientific, and technical growth.

# Resources

Education Commission of the States. (2008) From competing to leading: an international benchmarking blueprint. Retrieved February 29, 2009 from http://www.ecs.org/html/meetingsEvents/NF2008/resources/ECS-InternationalBenchmarking.pdf.

National Council of Supervisors of Mathematics. (2008) Prime leadership framework: principles and indicators for mathematics education leaders. Denver, CO.

National Council of Teachers of Mathematics. (1989) Curriculum and evaluation standards for school mathematics. Commission on Standards for School Mathematics. Reston, VA.

National Council of Teachers of Mathematics. (2006) Curriculum focal points for prekindergarten through grade 8 mathematics: a quest for coherence. Reston, VA.

National Council of Teachers of Mathematics. (2000) Principals and standards for school mathematics. Reston, VA.

National Mathematics Advisory Panel. (2008) Foundations for Success: The Final Report of the National Mathematics Advisory Panel. U.S. Department of Education: Washington, DC.

National Research Council. (2001) Adding it up: Helping children learn mathematics. J. Kilpatrick, J. Swafford, and B. Findell (Eds). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council. (2005) How students learn: mathematics in the classroom. Committee on how people learn, a targeted report for teachers, M.S. Donovan and J.D. Bransford, Editors. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Utah State Office of Education. (2007) Elementary core curriculum: K-6 mathematics. Salt Lake City, UT.

Utah State Office of Education. (2007) Secondary core curriculum: 7-12 mathematics. Salt Lake City, UT.