Progress Report 2003-2008

Striving to Raise the Bar to Higher Levels

Supported by the U.S. National Science Foundation
Computational Math, Science, and Technology (C-MST) Institute

A Strategy to Improve Workforce Skills and Pedagogy to Improve Math & Science Education

Partnership of Institutions of Higher Education & K-12 School Districts

Partnership of Multiple Disciplines

Partnership of College Faculty & Schoolteachers
Investing in Science, Technology, Engineering, and Mathematics (STEM)

A New World of Increasing Global Competitiveness

The United States moves at a quick pace, but science moves even quicker. Economists estimate that half of our growth in gross domestic product (GDP) per capita during the last 50 years can be attributed to scientific and engineering achievements. While scientists and engineers today make up only 4% of the work force, their contributions lead to the creation of jobs for the other 96% [1]. Alan Greenspan, former Federal Reserve chairman, credited innovation for significant gains in productivity growth since 1995 [2]. In recent decades, 60-80% of all newly created jobs have been in small to medium-sized companies. According to studies by the Task Force on American Innovation, basic research performed at leading U.S. universities created 4,000 spin-off companies that have hired 1.1 million employees and generated annual world sales of $232 billion [3]. Unfortunately, the Task Force also found that federal funding for research in physical and mathematical sciences and engineering, as share of GDP, has declined by 37% between 1970 and 2004. Behind such a lack of congressional support for research may be a fairly low scientific literacy in the USA [4].

A GATHERING STORM

- While there are only a handful of members with a science background in the U.S. Congress, 90% of China’s top leaders are engineers & scientists.
- The World Economic Forum dropped America from 1st to 7th place in its ranking of nations prepared to use advances in information technology.
- America ranks 16th in fractions of its citizens having broadband and 61st in use of mobile telephony per capita.
- GM, Chrysler, and Ford are closing 26 plants while Japan-based companies are opening new plants in America.
- Toyota is selling more vehicles in the United States than The Big Three.
- Chemical companies closed more than 100 facilities in the US since 2004. Of the 120 new plants under construction, 50 were in China and one was in the United States.
- There are now 12 energy companies in the world whose reserves exceed those of the largest US energy firm.

See “Is America Falling Off the Flat Earth” by Norman Augustine for a complete list.

References:
The occupational projections by the Bureau of Labor Statistics [5] for the period 2002-2012, predict that STEM jobs would increase about 3 times faster than the growth rate for all occupations. Furthermore, 86% of this increase is expected to be in computer-related occupations. The importance of math and computer skills is also noted in a National Science Board report [6] that the percent of math and computer science graduates who find a job in their own field is much higher than those in physical sciences: PhD (74% vs. 57%) and BS (35% vs. 22%). While this shows that there is a great demand for math and computer skills, it also indicates that science majors are adaptable to jobs outside of their area of specialization. **A broad education combining math and computer skills with a science field, then, could be the key for the 21st Century STEM workforce.** This is consistent with the below vision outlined by national reports such as [7].

> “Computational science and technology can serve the nation as a powerful tool for improving teaching and learning, enhancing nation’s competitiveness, and fundamentally altering for the better how tomorrow’s workforce is prepared.”

President’s PITAC Committee states [7] that “**computational science is one of the most important disciplines of the 21st Century and progress in this field is necessary to ensure America’s competitiveness in a new world of increasing global competition.**” As computing technology becomes increasingly pervasive, however, there is a decline in the quality and quantity of students seeking STEM degrees. This is very alarming! Lack of interest and preparation by high school students are said to be partly responsible for this decline. Performance of the 12th graders in math and science are at the bottom of the international ranking [8]. Universities now spend significant resources just to bring their freshmen classes to college level. National organizations have now all published new sets of K-12 standards to improve learning and teaching to remedy the situation. Many states, including New York, have also developed new standards. **Common threads among these standards include the call for integration of technology into the curriculum, for classrooms to become learner-centered and inquiry-based and for all students to become critical-thinkers and problem-solvers.** Computational science can also be an important pedagogical tool for K-12 education. Simulations can indeed often elucidate concepts difficult to explain in other media. The dual role of computational science as a workforce strategy and an educational pedagogy bridges higher education and K-12 in a way that it might be the remedy we are looking for in STEM education.

Computational Science Education

Computational science has emerged as a new discipline. It is home to computer simulation and visualization to model real-world problems; all the way from simple to complex systems such as global climate changes, financial systems, and design of new engines, airplanes, cars, and drugs. What started as a few specialized courses in research institutions 2 decades ago slowly attracted wide recognition and formal acceptance at the doctoral level in late 80s, master’s level in late 90s, and bachelor’s level at the turn of the new century. As computers became more powerful and affordable, what was once a privilege of national labs became a common place. Use of technology involves training, nevertheless. As much of a new strategy it is to offer an integrated STEM education, this is also where the challenge lies, particularly at the early grades. Since computational modeling and simulations involve knowledge of 3 separate fields (mathematics, computer programming, and sciences), the prerequisites may be overwhelming unless there exist a whole new set of software tools and courses that make the transition easier and practical. The lower the grade level, the more challenging this gets.

The College at Brockport (SUNY) started the first undergraduate degree program in this field. Given the diverse skill set and marketability (all the way from industrial programming to teaching) of its alumni, the program engaged in outreach to K-12 through the support of the National Science Foundation (see next page). Today, there are a dozen undergraduate programs and K-12 initiatives nationwide. For a complete list of these programs, see [9]. The program (department) at Brockport offers BS, MS, and combined BS/MS degrees to its majors. Students take courses in computer programming, mathematics, and application sciences. Brockport students often declare more than one major during their study and some students have managed to combine computational science with another STEM discipline to go beyond minimum credits. In cooperation with other STEM and education departments, the Computational Science faculty have also offered a variety of summer workshops and courses to teachers and teacher candidates (see the following pages).

Computational Math, Science, and Technology (C-MST) Pedagogy

The traditional method of teaching science has a strong reliance on theory. On the other hand, the methods, images, and course materials developed from computers make science and math concepts more easily comprehensible, thereby significantly enriching the science curriculum. Computer simulations employ math models to describe physical phenomenon, therefore bringing a new perspective to students about the usefulness of math as a tool in real life. They enable one to perform sensitivity experiments, similar to laboratory experiments, and allow one to gain insights about real-life problems that are too complex to study analytically, too expansive to observe, and too dangerous to experiment. Teachers and students can create and navigate through visual representations of natural phenomena, engaged in inquiry-driven learning while gaining more content in math and science. At the same time, visualization also allows rapid understanding of relationships and findings that are not readily evident from raw data.

Computational approach to math, science, and technology (C-MST) carries characteristics of a learner-centered or constructivist approach recommended by the national and state standards. The action of integrating technology into the curriculum itself can be the impetus to creating a constructivist-learning environment. According to the evidence [10], technology applied to classroom education can support higher-order thinking by engaging students in authentic, complex tasks within collaborative learning contexts. Using models and simulations, students can learn better since they are actively engaged in “doing” rather than passively engaged in “receiving” knowledge. The C-MST approach might even transform uninvolved, at-risk students into active and invested learners. It can be used to teach a scientific topic via a series of student-controlled experiments and simulations without having the student initially know the mathematical and scientific details of the phenomenon being studied. This simple framework allows one to introduce a topic, then move deeper with more mathematical tools after students gain a higher level of interest and knowledge. This motivational and layered aspect of technology is a principal reason that educators strive to master and apply it.
SCOLLARCITY is a partnership of: subject areas math, science, and technology; institutions of higher education and school districts; college faculty and school teachers; educational institutions and business; and urban and suburban districts.

**Core Institutions:**
- SUNY College at Brockport [www.brockport.edu](http://www.brockport.edu)
- Brighton Central School District [www.bcsd.org](http://www.bcsd.org)

**Principal Investigators**
- Dr. Osman Yaşar
- Margaret Crowley
- Dr. H. Peris / Dr. Chris Manaseri

**Supporting Institutions:**
- Shodor Education Foundation [www.shodor.org](http://www.shodor.org)
- Krell Institute [www.krellist.org](http://www.krellist.org)
- Texas Instruments [education.ti.com](http://education.ti.com)
- IBM Corporation [www.ibm.com](http://www.ibm.com)
- SMART Technologies [smarttech.com](http://smarttech.com)

**Supported by the National Science Foundation since 2003**, SCOLLARCITY offers C-MST training for teachers and project-based activities for students, as listed on next pages [Photo: Project Director, Dr. Osman Yaşar, and school teachers (Ed ChiBrighton and Jeff Mikols-City) at a hearing on Capitol Hill]. For more information, visit www.brockport.edu/cmst.
C-MST Training and Outreach

TRAINING FOR TEACHERS
Four to five weeks of intensive training (12 hours/week) has been offered to more than 80 middle and high school teachers each year in the areas of mathematics, science, and technology. The training comes in three levels (Beginner, Advanced, and Expert) at Rochester (MetroCenter) and Brockport campuses during the summer as well as the academic semesters. Among other benefits, teachers have received professional development credits, technology support, and access to a growing database of lesson plans. C-MST tools (see pages 10-16) have been incorporated into more than twenty courses in the College, including a dozen new courses for teachers and teacher candidates. These tools have also been incorporated into district PD training sessions taught by C-MST teachers.

MENTORING BY COLLEGE FACULTY
A year-long mentoring program by college faculty has been offered to C-MST teachers as a follow-up to the content and pedagogy training offered through summer programs. According to the National Science Foundation, the partnership between college faculty and school teachers is one of the most effective ways to raise teacher and student quality at K-12. This partnership works both ways; college faculty have also recognized that interaction with teachers and K-12 students help them improve their own pedagogical skills. Also, it is no secret, that any improvement to quality of teachers & students will send better-prepared students to college.

PROJECT-BASED COMPETITION FOR STUDENTS
A project-based Challenge has been implemented to promote collaborative work among project teachers, their students, and college faculty mentors. Annually, more than 300 students have attended this outreach program through which they get access to technology and training from C-MST teachers that may not be available in a regular classroom or state-mandated curricula. Students team up to do projects using modeling tools (see pages 20-21 for more details).

COLLEGE FIELD TRIPS FOR STUDENTS
Day-long trips during academic year and week-long programs during summer have been offered to 40-80 at-risk students from urban settings. Students who have never been to a college campus and never used a computer or graphing calculator before have shown strong appetite for quick learning during these trips and pursued follow-up activities beyond these short programs.
Excel is a well-known software tool, mainly used as a spreadsheet for doing budgets, graphs, and other statistical computations. It is also an effective and simple tool to understand and perform modeling and simulations. Details that are hidden in other modeling software tools, such as those in the next pages, can be transparent to an Excel user. Computational modeling is basically to predict the behavior of a system based on the old information and the change that is expected; new = old + change. If we want to predict the position (x) and velocity (v) of a particle, we could use two simple algebraic equations such as below,

\[ x_{\text{new}} = x_{\text{old}} + dx \quad v_{\text{new}} = v_{\text{old}} + dv \]

where \( dx \) and \( dv \) represent change in \( x \) and \( v \). Since we know that velocity is the rate of change in position with respect to time, and acceleration is the rate of change in velocity with respect to time, we can write \( v = dx/dt \) and \( a = dv/dt \). Combining these with above algebraic equations, we get the following that can be computed in Excel as we march in time with steps of \( dt \):

\[ x_{\text{new}} = x_{\text{old}} + v \cdot dt \quad v_{\text{new}} = v_{\text{old}} + a \cdot dt \]

Let’s compute position and velocity of a rock thrown with upward velocity of 10 meters/second. Since the rock is subject to a downward acceleration of 9.8 meter/s\(^2\) due to gravity, we can type the above two equations in Excel as in the colored table. For \( dt=0.1 \), one gets the following extended table & graph. Note that the time step (dt) is very important for accuracy of the computation.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Position (m)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>0.1</td>
<td>1</td>
<td>9.02</td>
</tr>
<tr>
<td>0.2</td>
<td>1.902</td>
<td>8.04</td>
</tr>
<tr>
<td>0.3</td>
<td>2.706</td>
<td>7.06</td>
</tr>
<tr>
<td>0.4</td>
<td>3.412</td>
<td>6.08</td>
</tr>
<tr>
<td>0.5</td>
<td>4.02</td>
<td>5.1</td>
</tr>
<tr>
<td>0.6</td>
<td>4.53</td>
<td>4.12</td>
</tr>
<tr>
<td>0.7</td>
<td>4.942</td>
<td>3.14</td>
</tr>
<tr>
<td>0.8</td>
<td>5.256</td>
<td>2.16</td>
</tr>
<tr>
<td>0.9</td>
<td>5.472</td>
<td>1.18</td>
</tr>
<tr>
<td>1</td>
<td>5.59</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Interactive Physics (IP) is a visual tool to do scientific experiments without having to use the math and physics required for modeling with Excel. One does not need to remember laws of physics and can even modify them through an option list. Virtual images and graphing tools allow students to monitor location, speed, energy, and time. IP offers many options, including control parameters to change initial conditions and accuracy requirements (such as the integration time step \((dt)\) in Excel example). A database of ready examples is available for use at the C-MST Institute and interactivephysics.com. The below example shows a roller coaster experiment to study energy forms. The user can display measured quantities through graphs or single values as shown.

"I believe tools such as IP are helping me in my classroom because students are able to visualize and even create their own models to further their understanding of a concept. Visual aids are always beneficial and this year I have added more models to my repertoire." From 2006-07 Teacher Survey.
C-MST Training Tools: AGENTSHEETS

AgentSheets (AS) allows non-programmers to create agents with behaviors and missions, teach them to react to information and process it in personalized ways, and combine agents to create sophisticated interactive simulations and models. AS can be used to create interactive games, virtual worlds, training simulations, and other interactive content such as the spread of a virus as shown below. The example below defines three agents, including a healthy person, a sick person, and a doctor. The number of people and doctors as well as the probability of contacting the virus can all be defined by the user. Creation of AS models is known to be a straightforward task, however, there are plenty of ready-made ones for classroom use and other purposes. Researchers have been using agent-based modeling tools to study collective behavior of many systems, including the V-shaped pattern of flying birds [11].

“CMST is causing me to turn to computer simulation to explain things that have been difficult for the students to understand previously. This has given me specific tools to use when this happens and has trained me on how to use it.” CMST Teacher.

C-MST Training Tools: STELLA

Stella is a dynamic modeling system allowing creation of a pictorial diagram of a system with controllable values for functions, variables, and input components. It might need some knowledge of algebraic equations to define relationships and probabilities. The following model illustrates successive stages for plant growth in the ecosystem.

“...C-MST tools have given me more options in presenting materials and expanding my teaching techniques...”

-Teacher

“...Through C-MST, we can now see how our curriculum in the classroom relates to the real world and bring the real world into the classroom using technology...”

-Teacher
The Geometer’s Sketchpad (GSP) is a dynamic tool which computes distances, angles, areas, and other measurements to teach mathematical tools or prove scientific concepts. It allows images to be pasted from other tools such as IP for further study. To prove one of the Kepler’s Laws (planets sweep equal areas in equal time intervals), students from Brighton High School downloaded the following IP snapshot (a planet’s orbit around the Sun) into the GSP and measured the areas with much ease.

“...We had not taken any physics and we were not fully knowledgeable about laws of universe that govern planetary motion. That is not different from the situation of Kepler; as no one quite knew how gravitational forces worked until Newton came. Kepler had access to data compiled by Tycho Brahe and he looked for patterns. We had access to modern tools and we looked for miracles! In the end, we did not make a discovery in physics, but we certainly discovered that physics was not a threatening or boring subject...” Team of 3 high school students (9th graders at the time)
C-MST Training Tools: PROJECT INTERACTIVATE

Project Interactivate (PI) is a set of online computational science courseware from The Shodor Education Foundation (a non-profit organization) for exploring scientific and mathematical concepts.

Activities: A list of over 100 interactive activities to explore areas of mathematics and view and analyze data for scientific exploration.

Dictionary: A dictionary of math terms encountered throughout the Interactivate site.

Tools: A number of interactive tools that can be used in Geometry, Algebra, Probability, Statistics, and Modeling.

Lessons: A list of over 70 lessons aligned to National Council of Teachers of Mathematics (NCTM) standards (grades 3 through 12).

Discussions: Background material written in the form of a dialogue. It leads learners to concepts, introduce vocabulary, and help develop important formulas and structure.

Standards: A variety of NCTM and State Standards and related Interactivate activities and lessons to use in addressing those standards.
Texas Instruments has been a supporting partner of the SCOLLARCITY project to promote use of graphing calculators that have been either recommended or mandated by the State Regents exams in mathematics. A growing body of research (see below for some examples) supports use of graphing calculators to improve math skills, particularly in Algebra and other topics covered by the NY State Math-A and Math-B exams.

<table>
<thead>
<tr>
<th>TITLE/AUTHOR</th>
<th>STUDY DESCRIPTION</th>
<th>KEY FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Impact of Handheld Graphing Calculator Use on Student Achievement in Beginning Algebra&quot; *</td>
<td>A correlational study looking at the relationship between graphing calculator use and student standardized test scores in grades 9-11. Students were instructed with varying levels of graphing calculator use, and they did not use graphing calculators during testing.</td>
<td>▪ When teachers incorporated graphing calculators into their curriculum more frequently and with greater intensity, including during less frequent math topics, student achievement was higher. ▪ The more access students have to graphing calculators and more frequent use during instruction, the higher their end-of-course test scores. ▪ Increased use of graphing calculators during instruction resulted in higher test scores even when students did not use graphing calculators during testing.</td>
</tr>
<tr>
<td>January 2006&lt;br&gt;Heller Research Associates&lt;br&gt;Joan Heller, Deborah Curtis (San Francisco University), Rebecca Jaffe and Carol Verboncoeur (Heller Research Associates)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Effectiveness of Graphing Calculators in K-12 Mathematics Achievement&quot; *</td>
<td>A systematic review of rigorous scientifically-based research addressing the impact of graphing calculator use on student achievement. A meta-analysis of eight individual studies specific to graphing calculator use found a large pooled effect size (.85) that is statistically significant. This review supports the findings of other studies regarding the impact of graphing calculator use on student achievement, such as the meta-analysis conducted by Almea J. Ellington and reported in the November 2003 issue of Journal of Research in Mathematics Education.</td>
<td>▪ Strong evidence showed that student use of graphing calculators increased performance in algebra.</td>
</tr>
<tr>
<td>November 2005&lt;br&gt;Empirical Education Incorporated (EEI)&lt;br&gt;Madhur Khooj and Gloria Miller (EEI), Palo Alto, California and Andrea Jaciw (Stanford University)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Integrating C-MST into Teaching & Learning: Teacher Training

Not readily available a decade ago, the new modeling tools make simulations easier to construct. They remove the need to deal with differential equations, computer programming, and full knowledge of scientific laws. Through the Summer Institute, the College at Brockport offered beginner-level training (80 hours) to more than 180 math, science, and technology (MST) teachers. About half came back for advanced-level training (additional 60 hours) and also half of those came back for expert-level training (60 more hours). Despite the high frustration associated with learning new tools and being exposed to fields beyond one’s own, the retention rate for the Summer Institute has been an average of 95% over a 5-year period. The training content was the same for all MST teachers and it required them to team up to do joint lesson plans. According to some of the School Districts, the C-MST Summer Institute has had the highest retention rate of any voluntary PD in their history. As challenging as the training was, it drew both new and experienced teachers. C-MST engagement has been credited by districts to help recruit new teachers and delay retirements of veteran teachers. The beginner-level training was incorporated into district-run PD programs and turnkey training (10-20 hours) at Rochester City and Brighton SDs, resulting in an outreach to more than 160 teachers. The C-MST teacher training was institutionalized as credit-bearing courses (NAS 401, 501, 601, and 701, and LST 726) at Brockport, serving an additional ~200 more teachers from a dozen school districts. **Overall, more than 500 teachers were touched.** Experience with C-MST tools and pedagogy occurred in four overlapping stages: acquisition of skills, practice, implementation, and assimilation. Surveys suggest, however, that not until teachers practiced with the tools and modeling in their classrooms did they feel confident about implementing them. While teachers reported encouraging results on infusing modeling into curriculum and classroom instruction (see next pages), the data also suggests that it took at least 3 years for most teachers to feel comfortable with the new pedagogy.

| Enrollments at the C-MST Summer Institute (2003-2007) |
|-----------------|------------------|------------------|-------------------|-------------------|-------------------|
| Subject         | Beginner-Level Teachers | Advanced-Level Teachers | Expert-Level Teachers | Total             |
| Math            | 96                | 11                | 107               | 42                | 2                | 44               | 22                | 0                | 22               | 173               |
| Science         | 38                | 15                | 53                | 17                | 9                | 26               | 12                | 5                | 17               | 96                |
| Tech            | 7                 | 0                 | 7                 | 5                 | 1                | 6                | 2                 | 1                | 2                | 16                |
| Spec. Ed        | 14                | 1                 | 15                | 2                 | 0                | 2                | 1                 | 0                | 1                | 18                |
| Subtotal        | 155               | 27                | 182               | 66                | 12               | 78               | 37                | 6                | 42               | 303               |
Integrating C-MST into Teaching: Lesson Plans

To implement C-MST tools and pedagogy in the classroom, teachers attending the summer institute were required to develop 2-3 lesson plans aligned with NY State standards and ready to be used in the following school year. At the beginning, there were no such resources for teachers. College faculty and C-MST professionals from Shodor, Krell, Maryland Virtual High School and software vendors helped develop an initial repository of lesson plans. Since 2003, a vast bank of lesson plans (500+) have been developed by teachers themselves and used in the classrooms. The database is regularly maintained by the C-MST Institute staff for quality control and other requirements. Access to the database (www.brockport.edu/cmst) is available upon request and users can copy zip files which include both the lesson plan and associated assessment tools in the classroom (see picture below).

The lessons were designated as Level I and Level II lesson plans. Level I focused on tools such as the TI 83+ calculator, Excel, Powerpoint and Project Interactivate. Level II focused on tools such as Agent Sheets, Stella, GSP, and Interactive Physics. Lessons are categorized according to subject and grade levels, however, some can be used in both math and science classrooms. Teachers can now access additional resources at the National Science Digital Library (NSDL) and Shodor Education Foundation websites.
Integrating C-MST into Teaching: Access to Technology

Teachers need access to computer labs or LCD Projectors (at the minimum) to maximize the utilization of CMST lessons in the classroom. Funds from the SCOLLARCIETY project and partnering school districts provided teachers with laptops, Smartboards, graphing calculators, and site licenses to use the new tools. As a result of training and greater access to new technology, the C-MST approach manifested in the classroom in many ways, ranging from general use of laptops for power-point presentations to specific lesson plans to teach via modeling tools such as Interactive Physics, AgentSheets, Stella, Geometer’s Sketchpad, Excel, or TI 84+ graphing calculators and smartboards. In particular, programs like Interactive Physics and Geometers Sketchpad have been used to simulate fundamental principals of math and science allowing students to input variables that affect the falling of objects, the orbiting of planets and the charge of subatomic particles, all in colorful, illustrated ways. Each year, C-MST teachers and their students participated in an annual C-MST Challenge Project where they solved problems of math and science, from understanding how to tip a waiter to the intricacy of how the human circulatory system works and interacts with the rest of the body.

Graphing calculators have been used to study basic computation, measure the results of experiments and share with classroom basic models of their results. Use of a laptop and an LCD Project enables teachers to streamline their teaching materials and also visually demonstrate simulations. The use of electronic smartboards (which requires a computer and an LCD Projector) served as an interactive learning tool where students come to the board and add to a class discussion by changing a parameter in a controlled simulation or visual presentation.

Professional evaluators (Linda Reid and Marion Arlauckas) have thoroughly examined the impact of C-MST pedagogy on teaching and learning. Professionals from other federal projects and Program Managers from national agencies have visited classrooms taught by C-MST trained teachers. Some of the recent results, along with teacher testimonies, are listed in the rest of this report.
Integrating C-MST into Project-based Learning: Challenge Competition

SCOLLARCITY partnership is based on the premise that improving teacher quality would help improve student success. Since the focus has been on teacher training so far, no systematic and sustained efforts were undertaken by the C-MST college faculty to teach K-12 students. However, several student outreach activities were undertaken, including participation of a handful of students in the C-MST summer workshop, field trips to the College at Brockport and annual CMST Challenge and Math Triathlon competitions. There are limits to how much a teacher can do to reach out to students in a classroom environment and there are challenges for teachers to implement a new pedagogy in the classroom because of a steep learning curve and limited availability of lesson plans and technology tools.

C-MST Teachers and students participated in year-long projects and presented their results at an annual event. Judges from other organizations, particularly the Shodor, Krell and Oregon State University, reviewed 50-100 entries for originality, teamwork, and presentation. Several categories were organized depending on the level of training by participating teachers and students’ grade levels and subject areas. Top winners in each category and authors of Best Paper and Best Poster received special recognition and got invited to the Scholars Day at the College at Brockport. Several of the student papers, published by the National Science Foundation Math and Science Partnership community (www.mspnet.org), clearly show the potential of the C-MST to improve readiness and participation of students in STEM. The Challenge projects set good examples for integration of technology into the classroom learning and how modeling can be applied to solution of real world problems.

Students played an important role not only as end-users but also contributors to training of their teachers. In the first summer institute (2003), teacher attendees found C-MST tools to be difficult and some teachers were about to give up until a middle school student showcased on the stage how he created a pool table (within 45 minutes) from the Interactive Physics software. This was a turning point for teachers.
An annual Math Triathlon has been conducted by the C-MST Institute Faculty and Staff to test the use of graphing calculators in problem solving, particularly in relation to the State Regents Math exams. As a form of student outreach, the goals of this program, later called TI Triathlon due to the use of Texas Instruments graphing calculators, have been to involve students in meaningful mathematics, provide them opportunities to interact with others, and use hand held calculators as meaningful tools. This contest is about mathematical literacy and excellence in achievement. It is based on a student’s ability to comprehend and solve problems. It tests student awareness about advantage and limitations of graphing calculators. Time is a factor as the event moves quickly. Team work is also an important factor as there are 3 competitions: an individual set of questions, a team set of questions, and a team relay event. About 250-300 students have participated annually from a dozen school districts. Problems focus on ability to compute with a calculator, interpret the meaning of the computations, decide when and how to use a machine as a computational aid, use the machine to facilitate routine problem solving, and use the machine as an aid in investigating non-routine problems.
Impact of C-MST on the Classroom

Teachers were asked: How has your involvement in C-MST impacted your teaching? Below are some excerpts.

**Participation in CMST has improved my comfort level in using new technologies. My classes are much more interactive, kids are moving around more and interfacing with the technology. The SmartBoards are still new in our building and kids are eager to get up and try new things in front of their peers. Another plus has been the constant reinforcement in the CMST Institute to integrate the science concepts with data collection and analysis, and the creation and manipulation of computer models. Every day new activities are being added to the web. I now have a significant library of new websites to use with my lessons. I’ve found that if I bring new technology to my students, they take what I bring to them to a whole new level. Watching how much more invested my students are in learning has inspired me as a teacher, and in the process, I’m modeling for them what it looks like to be a lifelong learner.**

**To teach technology education is to teach problem solving. Every technology laboratory based activity is developed following the six steps of the problem solving process. The most difficult part for the students to internalize is the importance of brainstorming; coming up with various and very different set of ideas without being concerned by the constraints and limitations to the specific technological problem. The CMST has given me the new tools and the courage to use them. The students brainstorm and research, and actually, come to select from their various alternative solutions to the same problem. In the process of using the modeling tools to develop multiple ideas, the students formally integrate mathematical and scientific concepts into the solution of the specific technological problems that without the modeling tools they wouldn’t have had the opportunity to do. The results of the technology based laboratories became more complex (technically speaking) because the students were able to test their solutions before they actually had the opportunity to build them.**

**Learning the CMST pedagogy and tools are really two different things. I don’t think that I really understood the CMST pedagogy during my first summer institute. It took me some time to get the idea that computational science was using computer tools to solve real world problems and simulate real world phenomenon. I don’t know why I didn’t get it during the first summer, but once I understood the idea, I then knew that the goal was not necessarily to use the tools as display teaching tools, but to get students to use the computers and learn the tools to create models themselves.**
Impact of C-MST on the Classroom

Teachers were asked: Do you believe that C-MST tools & techniques are helping you?
Below are some excerpts.

“The tools have given me more options in presenting materials and expanded my teaching techniques. Students become more involved with their learning. They create products that display what they have learned and are able to communicate to others their knowledge. I am able to incorporate differentiated learning in the classroom to the various levels of students using some of the tools and equipment available. We can see how our curriculum in the classroom relates to the real world and bring the real world into the classroom using technology. “

“CMST is causing me to turn to computer simulation to explain things that have been difficult for the students to understand previously.”

“CMST training has improved my lessons and instruction. I have found more success with units that I use technology and modeling techniques with than when I taught the same unit before.”

“The students are always more engaged when we use the models. It makes some of the math topics we cover come to life. My only concern is the lack of technology we have available to have all students work with the software.”

“I think that when the students see a teacher excited about a lesson using technology they get excited as well. Using the Smartboard was very powerful in my classroom. When completing our Challenge Project, most of the students did not know what Stella was or how to use it. They began to think differently when we had to put our information and equations into the model. The whole project became more meaningful to the students.”

“I believe the tools and techniques I am learning are helping me in my classroom instruction because students are able to see and even create their own models furthering their understanding of a concept. Visual aids are always beneficial, and this year I was introduced to additional models that I can add to my repertoire.”

<table>
<thead>
<tr>
<th>Grades &amp; Subject</th>
<th>Regularly</th>
<th>Only, special times</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-8 Math</td>
<td>46%</td>
<td>46%</td>
<td>8%</td>
</tr>
<tr>
<td>7-8 Science</td>
<td>25%</td>
<td>60%</td>
<td>15%</td>
</tr>
<tr>
<td>9-12 Math</td>
<td>60%</td>
<td>35%</td>
<td>5%</td>
</tr>
<tr>
<td>9-12 Science</td>
<td>54%</td>
<td>38%</td>
<td>8%</td>
</tr>
</tbody>
</table>

The percentage of teachers implementing modeling increases with each year of experience and availability of technology. In 2007, Teachers reported their use of modeling as depicted in table above.
Teachers who regularly use C-MST modeling in their lessons observed significant impact on student engagement as the grade level increases. Evaluators verified these through classroom observations and surveys.

Some observations by C-MST practitioners are given below:

“Using the technology is a visual enhancement in the classroom and therefore captures student attention. When I worked on Interactive Physics with my students it reinforced the concepts they had learned in the science club, such as motion of particles in solids, liquids, and gases. Seeing concepts presented in a different way helps it "click" for some students.”

“I saw significant improvement of student behavior and participation. The students did not skip the class as often, because they wanted to know what we were doing on a particular day. The use of technology eliminated a lot of outside conversations among the students because they were so involved in the activity for that day.”

“My lectures have become explorations of the concepts. The role of the students has changed from passive to active and my role has also transformed from being the expert to become the guide during the explorations. These changes have had very positive consequences on student learning. Student participation has increased and they are more engaged and excited using the tools provided by the CMST institute.”
"My students had fun with the technology and showed a greater understanding of the concept being taught. I cannot tell you how many times I had covered percents with my students and they still had a hard time with the concept. But, when I used Agent Sheets along with other CMST Technology, I saw the "light" go off in their heads. I saw a marked improvement not only in behavior but in comprehension." Math Teacher
Problem Solving in Math

Using multiple sources for data collection, project evaluators have reported a positive impact on teaching and learning which resulted from the new pedagogy. The evaluation design utilized a treatment and control model. As the number of participating teachers in a school increased in size, the interest in and experimentation with C-MST concepts and methodologies also increased. By the end of the 5th year, we ran out of the control groups and it became difficult to sort out the influence of the C-MST pedagogy on student success in a targeted way. However, we were able to conduct some targeted experiments to compare classrooms taught by C-MST and non-CMST teachers. One of these experiments involved use of the Geometer’s Sketchpad software in a high school mathematics class. Use of the GSP by trained teachers showed a correlation to improvements in class average in comparison to other similar classrooms taught without GSP by non-CMST teachers:

<table>
<thead>
<tr>
<th>Group</th>
<th>Math Class Average (Unit Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMST</td>
<td>82.5</td>
</tr>
<tr>
<td>Non-CMST</td>
<td>49.5</td>
</tr>
</tbody>
</table>

Other studies included Regents-level testing between teams of students taught graphing calculator skills by C-MST teachers versus non-CMST teachers. Although other factors, such as size of the class and the overall experience of the teacher, should be considered, results consistently showed C-MST students outperforming non-CMST students (see table below).

<table>
<thead>
<tr>
<th>Group</th>
<th>Average Math Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Math A</td>
</tr>
<tr>
<td>CMST</td>
<td>60.26</td>
</tr>
<tr>
<td>Non CMST</td>
<td>49.54</td>
</tr>
</tbody>
</table>

Compared to the baseline data from 2002, partnering districts experienced significant gains in State Regents exams (see next page).

“I believe CMST has improved my students’ learning. This year I had my best results ever on my Math B exam. 96% of my 78 students who sat for the exam passed it. I never had these results before! I think that using the technology in upper level classes engages students better and also prepares them better for college.” Math Teacher
Statements by evaluators, teachers, students, and administrators indicate a cultural change throughout the participating districts as a result of the C-MST teacher training and student outreach program. We find a correlation between the size of the C-MST team in a building and student scores and report cards.

At the Rochester City School District, the majority (75%) of trained teachers and curriculum leaders were in the area of mathematics. Almost all of the math teachers have been trained. This shows a strong commitment by the math curriculum director and credit for improvement has been attributed by school administrators to the impact of new pedagogy, teacher training, and partnership with the higher education. In addition to the limited participation (25%) of science teachers and curriculum leaders, lack of sufficient number of science examples and lesson plans using the C-MST approach and limited access to computer labs for science courses may have been other factors preventing a significant impact on science achievement scores. We should note that there is a significant progress in physics and chemistry scores; consistent with the fact that physics is now being taught in some City schools after 25 years of non-existence.

At Brighton, there has been a balanced participation from mathematics and science teachers (45% vs. 55%). The district is heavily committed to integration of technology into curriculum. It has as much contributed to the success of C-MST in other districts as it has gained from it. Brighton has linked curriculum maps to C-MST lesson plans, particularly in physics. District’s 2020 vision is an exemplary 21st century road map. The Core Plus math curriculum is a good ground for use of technology and modeling. The Physics curriculum has incorporated the Interactive Physics software modules into its lab component. Student achievement in Math A and Regents Physics has improved as a result. Contrary to what is happening elsewhere in the country, the number of students taking physics at Brighton has increased from 50% to almost 100%. The number of students taking AP Physics has also doubled.
Since 2003, about 25 Special Education math teachers participated in the program. A special education teacher experimented by putting herself and her students into a regular education classroom where she conducted demonstration lessons using the C-MST tools. According to the teacher, students were surprisingly responsive and they functioned well with regular education students in the Challenge competition. The teacher is now training other Special Education teachers in her district about the use and application of graphing calculators. The Special Education high school students are also “tutoring” the 8th grade students about graphing calculators.

“This technology has been a real equalizer for the Special Education students. I used this tool with my students and they were the only students in the special education category to successfully pass the State Math Exam and the only special education students using graphing calculators in the exam.” Special Education Teacher

Majority of teachers agreed that females and males responded differently to technology. While male students showed more interest in playing with technology and plowing through the details with less regard to the big picture, females students initially seemed reluctant and timid but excelled when details (curriculum) were put into context of real-world problems, projects and applications.
Limitations & Future Directions

Teachers, students, and evaluators reported several limitations to use of modeling and computer simulation in the classroom. Following is a list of areas for improvement.

- **Technology Access for Students**: Despite the improvements to the technology infrastructure, some teachers and students report having limited or no access. For those who had access, the highest improvement to student engagement and achievement was observed to be in the technology classrooms which shows that access to computer labs is important for the C-MST approach to have a similar impact in mathematics and science courses. Access limitation, particularly for high-parameter students who may benefit most from CMST-enhanced teaching, might lead to a loss of potential for tomorrow’s STEM workforce. Teachers also claim that using models would be much more effective (and interesting) if the students themselves are able to build and manipulate them. While districts continue to improve their technology infrastructure, **it is important to offer full access, through a summer program, to interested and able students at a place where such access is not a problem.**

- **Preparation Time and Content Training For Teachers**: Teachers report not having enough time and flexibility for preparation and use of new approaches within the current State curriculum framework. Although the new software tools have made simulation an easy task, teachers do not have enough examples and lesson plans to offer an intensive CMST-based teaching. Some teachers also report not having enough practice to understand ready made models or create their own in their subject areas. Not until the C-MST pedagogy is fully married with content knowledge can we be sure of a sustained impact. **It is important to offer teachers additional CMST-based content training to better understand mechanics of modeling and simulations and marry such understanding with deeper content knowledge.**

Research Questions:

1. Could the C-MST approach help deepen teacher content knowledge?
2. Can the C-MST approach be effectively and systematically used as an early intervention strategy to improve student engagement, readiness and participation in mathematics, science and technology?
3. Can the impact of the C-MST be expanded to the elementary level grades, particularly grades 3-6?
4. Would a combined STEM education help address the workforce needs?
5. Is it feasible and practical to offer a combined MST certification through which to prepare and enable one single person to teach multiple subjects, including mathematics, science, and technology?
## Teachers Who Attended Summer Institute

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Area</th>
<th>School</th>
<th>Level</th>
<th>First Name</th>
<th>Last Name</th>
<th>Area</th>
<th>School</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellery</td>
<td>Palma</td>
<td>Math</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Tina</td>
<td>Thomas</td>
<td>Math</td>
<td>F-Douglas</td>
<td>Beg</td>
</tr>
<tr>
<td>Paula</td>
<td>C-Gillies</td>
<td>Math</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Helen</td>
<td>Fox</td>
<td>Math</td>
<td>F-Douglas</td>
<td>Beg</td>
</tr>
<tr>
<td>Brigitte</td>
<td>Cerra</td>
<td>All Core</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Samuel</td>
<td>Simpson</td>
<td>Math</td>
<td>F-Douglas</td>
<td>Beg</td>
</tr>
<tr>
<td>Brian</td>
<td>Cheyne</td>
<td>Special Ed.</td>
<td>Charlotte</td>
<td>Exp</td>
<td>Diane</td>
<td>Wells</td>
<td>Math</td>
<td>F-Douglas</td>
<td>Beg</td>
</tr>
<tr>
<td>Kimberly</td>
<td>Lombard</td>
<td>Math</td>
<td>Charlotte</td>
<td>Beg</td>
<td>Karie</td>
<td>Shaw</td>
<td>Math</td>
<td>F-Douglas</td>
<td>Beg</td>
</tr>
<tr>
<td>Jennifer</td>
<td>Hallows</td>
<td>Special Ed.</td>
<td>Charlotte</td>
<td>Beg</td>
<td>*James</td>
<td>Phillips</td>
<td>Math</td>
<td>Franklin</td>
<td>Adv</td>
</tr>
<tr>
<td>Jennifer</td>
<td>R-Edwards</td>
<td>Math</td>
<td>Charlotte</td>
<td>Beg</td>
<td>John</td>
<td>Goodwin</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>David</td>
<td>Iacchetta</td>
<td>Math</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Dion</td>
<td>Rahill</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Margaret</td>
<td>Hastings</td>
<td>Math</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Chioma</td>
<td>Owunwanne</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Robert</td>
<td>Arrendell</td>
<td>Science</td>
<td>Charlotte</td>
<td>Beg</td>
<td>Mark</td>
<td>Chomyn</td>
<td>Science</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Bonnie</td>
<td>Bush</td>
<td>Science</td>
<td>Charlotte</td>
<td>Beg</td>
<td>Uma</td>
<td>Mehta</td>
<td>Science</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Jason</td>
<td>Kuehn</td>
<td>Math</td>
<td>Charlotte</td>
<td>Adv</td>
<td>Mary</td>
<td>Davey</td>
<td>Math/Tech</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Jeffrey</td>
<td>Mikols</td>
<td>Math</td>
<td>Charlotte</td>
<td>Exp+</td>
<td>John</td>
<td>Zoller</td>
<td>Technology</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Margaret</td>
<td>Brazwell</td>
<td>Science</td>
<td>East High</td>
<td>Adv</td>
<td>Sara</td>
<td>Walter</td>
<td>Special Ed.</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Lynn</td>
<td>Fanton</td>
<td>Science</td>
<td>East High</td>
<td>Adv</td>
<td>Annette</td>
<td>Pennella</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Steven</td>
<td>Colabufo</td>
<td>Math</td>
<td>East High</td>
<td>Exp+</td>
<td>Frank</td>
<td>Rinere</td>
<td>Science</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Valerie</td>
<td>Huff</td>
<td>Math</td>
<td>East High</td>
<td>Exp</td>
<td>Jacqueline</td>
<td>Keily</td>
<td>Sci-Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Brian</td>
<td>DiNitto</td>
<td>Math/Tech</td>
<td>East High</td>
<td>Adv</td>
<td>Stephen</td>
<td>Pudiak</td>
<td>Biology</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Allison</td>
<td>Leckinger</td>
<td>Math/SE</td>
<td>East High</td>
<td>Exp+</td>
<td>John</td>
<td>Picarella</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Brian</td>
<td>Bizzigotti</td>
<td>Math</td>
<td>East High</td>
<td>Beg</td>
<td>Michael</td>
<td>Schudel</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Logan</td>
<td>Newman</td>
<td>Science</td>
<td>East High</td>
<td>Exp</td>
<td>Sandy</td>
<td>Zalewski</td>
<td>Math</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Douglas</td>
<td>Brown</td>
<td>Math</td>
<td>East High</td>
<td>Adv</td>
<td>Erin</td>
<td>Owara</td>
<td>Science</td>
<td>Franklin</td>
<td>Beg</td>
</tr>
<tr>
<td>Kristen</td>
<td>Frank</td>
<td>Math</td>
<td>East High</td>
<td>Exp</td>
<td>Caroline</td>
<td>Rodriguez</td>
<td>Science</td>
<td>F-Thomas</td>
<td>Exp</td>
</tr>
<tr>
<td>Socorro</td>
<td>Sanchez</td>
<td>Math</td>
<td>East High</td>
<td>Beg+</td>
<td>Michael</td>
<td>Baskin</td>
<td>Math-Tech</td>
<td>F-Thomas</td>
<td>Exp+</td>
</tr>
<tr>
<td>Kristen</td>
<td>Baker</td>
<td>Earth Sci</td>
<td>East High</td>
<td>Beg</td>
<td>Christopher</td>
<td>Sheffer</td>
<td>Science</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Tanya</td>
<td>Wilson</td>
<td>Math/SE</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Michael</td>
<td>Jodice</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Jamie</td>
<td>Foos</td>
<td>Special Ed</td>
<td>Edison Tech</td>
<td>Exp</td>
<td>Jennifer</td>
<td>Rees</td>
<td>All Core</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>*Gerald</td>
<td>Moon</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Exp+</td>
<td>Heather</td>
<td>Lagas</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Patricia</td>
<td>Herman</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Cleveland</td>
<td>Evans</td>
<td>Math</td>
<td>Franklin</td>
<td>Exp</td>
</tr>
<tr>
<td>Roger</td>
<td>Hakes</td>
<td>Science</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Mark</td>
<td>MacLaughlin</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Carneatha</td>
<td>Nelson</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Jody</td>
<td>Nagle</td>
<td>SE/Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Courtney</td>
<td>Bruyea</td>
<td>Special Ed</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Jennifer</td>
<td>Roe</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Lorraine</td>
<td>Sheck</td>
<td>Science</td>
<td>Edison Tech</td>
<td>Beg+</td>
<td>Sarah</td>
<td>Jacka</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Carolina</td>
<td>Machuca-Dall</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Adv</td>
<td>Patrick</td>
<td>Chierichella</td>
<td>Science</td>
<td>F-Thomas</td>
<td>Adv</td>
</tr>
<tr>
<td>Marie</td>
<td>Jenkins-Cox</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Carrie</td>
<td>Seitz</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Francine</td>
<td>Desiato</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Kathryn</td>
<td>Zurowski</td>
<td>SE</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Reggie</td>
<td>Sherrill</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Adv</td>
<td>Karen</td>
<td>Samis</td>
<td>Math</td>
<td>F-Thomas</td>
<td>Beg</td>
</tr>
<tr>
<td>Jacqueline</td>
<td>McClaney</td>
<td>Technology</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Maria</td>
<td>Roman</td>
<td>Math</td>
<td>J-Marshall</td>
<td>Adv</td>
</tr>
<tr>
<td>Renee</td>
<td>Gambino</td>
<td>Math</td>
<td>Edison Tech</td>
<td>Beg</td>
<td>Natalie</td>
<td>Barnum</td>
<td>Science</td>
<td>J-Marshall</td>
<td>Beg</td>
</tr>
<tr>
<td>Daniel</td>
<td>Esler</td>
<td>Science</td>
<td>F-Douglas</td>
<td>Beg+</td>
<td>Jennifer</td>
<td>Lucieer</td>
<td>Special Ed.</td>
<td>J-Marshall</td>
<td>Beg</td>
</tr>
<tr>
<td>First Name</td>
<td>Last Name</td>
<td>Area</td>
<td>School</td>
<td>Level</td>
<td>First Name</td>
<td>Last Name</td>
<td>Area</td>
<td>School</td>
<td>Level</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>-------</td>
<td>---------</td>
<td>-------</td>
<td>------------</td>
<td>------------</td>
<td>-------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Joann</td>
<td>Bell</td>
<td>Math</td>
<td>Monroe</td>
<td>Adv</td>
<td>Chad</td>
<td>Markel</td>
<td>Math</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Miriam</td>
<td>S-Valadez</td>
<td>Math</td>
<td>Monroe</td>
<td>Exp+</td>
<td>Laurence</td>
<td>Federman</td>
<td>Math</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Natasha</td>
<td>Bell</td>
<td>Science</td>
<td>Monroe</td>
<td>Beg</td>
<td>Julia</td>
<td>Maloney</td>
<td>Science</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Joann</td>
<td>Bell</td>
<td>Math</td>
<td>Monroe</td>
<td>Adv</td>
<td>Jaclyn</td>
<td>Shantler</td>
<td>Math</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Juan</td>
<td>Betancourt</td>
<td>Math</td>
<td>Monroe</td>
<td>Beg</td>
<td>Janet</td>
<td>Siegel</td>
<td>Science</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Sarah</td>
<td>Heigl</td>
<td>Math</td>
<td>Monroe</td>
<td>Beg</td>
<td>Dennis</td>
<td>Moriarty</td>
<td>Tech</td>
<td>SWW</td>
<td>Beg</td>
</tr>
<tr>
<td>Elizabeth</td>
<td>Watkins</td>
<td>Math</td>
<td>Monroe</td>
<td>Beg</td>
<td>*Sounthone</td>
<td>Vattana</td>
<td>Math/tech</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Pablo</td>
<td>Lopez</td>
<td>Math</td>
<td>Monroe</td>
<td>Adv</td>
<td>*Moneth</td>
<td>Burney</td>
<td>SE/Math</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Michelle</td>
<td>Dale</td>
<td>Math</td>
<td>Monroe</td>
<td>Beg</td>
<td>*Lisa</td>
<td>Dennison</td>
<td>Sci/Tech</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Harry</td>
<td>Mackey</td>
<td>Science</td>
<td>NRCS</td>
<td>Beg</td>
<td>*Vanessa</td>
<td>Youmans</td>
<td>Math/tech</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Nicole</td>
<td>Crocker</td>
<td>Math</td>
<td>Admin</td>
<td>Beg</td>
<td>Darcy</td>
<td>Barrant</td>
<td>Math/tech</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Larry</td>
<td>Bedgood</td>
<td>Math</td>
<td>T-Jefferson</td>
<td>Exp+</td>
<td>Peggy</td>
<td>Foss</td>
<td>Math/tech</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Susan</td>
<td>Cooper</td>
<td>Math</td>
<td>T-Jefferson</td>
<td>Beg</td>
<td>Thomas</td>
<td>McCarthy</td>
<td>Math</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Beverly</td>
<td>Lawson</td>
<td>Special Ed.</td>
<td>T-Jefferson</td>
<td>Beg+</td>
<td>Stephanie</td>
<td>M-George</td>
<td>Science</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>William</td>
<td>Andrecolich</td>
<td>Math</td>
<td>T-Jefferson</td>
<td>Beg</td>
<td>*Bruce</td>
<td>Mellen</td>
<td>Math</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>Rose</td>
<td>Kosswow</td>
<td>Math</td>
<td>T-Jefferson</td>
<td>Adv</td>
<td>*Henry</td>
<td>Elich</td>
<td>Math</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>Thaddeus</td>
<td>Kciuk</td>
<td>Math</td>
<td>T-Jefferson</td>
<td>Beg</td>
<td>Garfield</td>
<td>Taylor</td>
<td>Math</td>
<td>Wilson-F</td>
<td>Beg+</td>
</tr>
<tr>
<td>Samuel</td>
<td>Ibezim</td>
<td>Science</td>
<td>T-Jefferson</td>
<td>Beg</td>
<td>Scott</td>
<td>Koch</td>
<td>Math</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>Colleen</td>
<td>O'Mara</td>
<td>Math</td>
<td>SOTA</td>
<td>Beg</td>
<td>Thomas</td>
<td>DeMonde</td>
<td>Tech</td>
<td>Wilson-F</td>
<td>Exp</td>
</tr>
<tr>
<td>Margarette</td>
<td>Douyon</td>
<td>Science</td>
<td>SOTA</td>
<td>Beg</td>
<td>Joseph</td>
<td>Zuniga</td>
<td>Science</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>Paul</td>
<td>Geary</td>
<td>Science</td>
<td>SOTA</td>
<td>Exp</td>
<td>Sabrina</td>
<td>Johnson</td>
<td>Tech</td>
<td>Wilson-F</td>
<td>Beg</td>
</tr>
<tr>
<td>Meagan</td>
<td>Harris</td>
<td>Multiple</td>
<td>SOTA</td>
<td>Adv</td>
<td>Beth</td>
<td>Hall</td>
<td>Math</td>
<td>Wilson-F</td>
<td>Adv</td>
</tr>
<tr>
<td>Kristen</td>
<td>Larsen</td>
<td>Math-Sci</td>
<td>SOTA</td>
<td>Beg</td>
<td>Stephen</td>
<td>Ezell</td>
<td>Math</td>
<td>Wilson-M</td>
<td>Beg</td>
</tr>
<tr>
<td>Lakashmi</td>
<td>Rao</td>
<td>Science</td>
<td>Brighton</td>
<td>Beg</td>
<td>Amy</td>
<td>Cifelli</td>
<td>Math</td>
<td>Albion HS</td>
<td>Beg</td>
</tr>
<tr>
<td>Vincent</td>
<td>Vitale</td>
<td>Science</td>
<td>Brighton</td>
<td>Beg</td>
<td>Jane</td>
<td>Bowdler</td>
<td>Math</td>
<td>Brockport</td>
<td>Beg</td>
</tr>
<tr>
<td>Jeffrey</td>
<td>McKinney</td>
<td>Science</td>
<td>Brighton</td>
<td>Beg</td>
<td>Brian</td>
<td>Minchen</td>
<td>Science</td>
<td>Brockport</td>
<td>Beg</td>
</tr>
<tr>
<td>Sean</td>
<td>Metz</td>
<td>Science</td>
<td>Brighton</td>
<td>Exp</td>
<td>Brian</td>
<td>McCue</td>
<td>Science</td>
<td>Brockport</td>
<td>Beg</td>
</tr>
<tr>
<td>Steven</td>
<td>Whitman</td>
<td>Science</td>
<td>Brighton</td>
<td>Exp</td>
<td>Neil</td>
<td>Paul</td>
<td>Science</td>
<td>Brockport</td>
<td>Beg</td>
</tr>
<tr>
<td>Dawn</td>
<td>Vergari</td>
<td>Math</td>
<td>Brighton</td>
<td>Beg</td>
<td>Tracy</td>
<td>Boughter</td>
<td>Math</td>
<td>Churchville</td>
<td>Beg</td>
</tr>
<tr>
<td>Cassandra</td>
<td>camman</td>
<td>Math</td>
<td>Brighton</td>
<td>Beg</td>
<td>Amy</td>
<td>Patric</td>
<td>Science</td>
<td>East Ridge</td>
<td>Beg</td>
</tr>
<tr>
<td>Kim</td>
<td>Ward</td>
<td>Science</td>
<td>Brighton</td>
<td>Beg</td>
<td>Nathaniel</td>
<td>Ruder</td>
<td>Science</td>
<td>Fairport HS</td>
<td>Adv</td>
</tr>
<tr>
<td>Keri</td>
<td>Rouse</td>
<td>Math</td>
<td>Brighton</td>
<td>Exp</td>
<td>Kristen</td>
<td>Flint</td>
<td>Science</td>
<td>Kendall</td>
<td>Exp</td>
</tr>
<tr>
<td>Ed</td>
<td>Chi</td>
<td>Science</td>
<td>Brighton</td>
<td>Beg</td>
<td>Aaron</td>
<td>Harrington</td>
<td>Science</td>
<td>Newark</td>
<td>Exp</td>
</tr>
<tr>
<td>Kimberly</td>
<td>Meek</td>
<td>Math</td>
<td>Brighton</td>
<td>Beg</td>
<td>Bruce</td>
<td>Peachey</td>
<td>Science</td>
<td>Pittsford HS</td>
<td>Adv</td>
</tr>
<tr>
<td>Maria</td>
<td>Huot</td>
<td>Tech</td>
<td>Brighton</td>
<td>Exp</td>
<td>Marc</td>
<td>Coffie</td>
<td>Math</td>
<td>Spencerport</td>
<td>Adv</td>
</tr>
<tr>
<td>Evan</td>
<td>Brauer</td>
<td>Math</td>
<td>Brighton</td>
<td>Beg</td>
<td>Sandra</td>
<td>McGreevy</td>
<td>Math</td>
<td>Spencerport</td>
<td>Adv</td>
</tr>
<tr>
<td>Suzanne</td>
<td>Wade</td>
<td>Science</td>
<td>Brighton</td>
<td>Exp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### CMST Instructional Team @ Summer Institutes

<table>
<thead>
<tr>
<th>Name</th>
<th>Department &amp; Institution</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The College at Brockport, State University of New York</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osman Yaşar</td>
<td>Computational Science Faculty</td>
<td>Lead Instructor, Director of the C-MST</td>
</tr>
<tr>
<td>Leigh Little</td>
<td>Computational Science Faculty</td>
<td>Workshop Coordinator, Instructor on Modeling, Assistant Director of C-MST</td>
</tr>
<tr>
<td>Robert Tuzun</td>
<td>Computational Science Faculty</td>
<td>Scholarship Coordinator</td>
</tr>
<tr>
<td>Jeff Commaroto</td>
<td>CMST Institute Staff</td>
<td>Program Manager</td>
</tr>
<tr>
<td>Jerry Moon</td>
<td>CMST Institute Staff</td>
<td>Technology &amp; Coaching Coordinator</td>
</tr>
<tr>
<td>Soun Vattana</td>
<td>CMST Institute Staff</td>
<td>Lead Instructor at the MetroCenter</td>
</tr>
<tr>
<td>Mohammed Tahar</td>
<td>Physics Faculty</td>
<td>Lead Instructor for Interactive Physics</td>
</tr>
<tr>
<td>Mark Heitz</td>
<td>Chemistry Faculty</td>
<td>Lead Instructor for AgentSheets, PowerPoint &amp; Excel, Faculty Advisor</td>
</tr>
<tr>
<td>Dawn Jones</td>
<td>Mathematics Faculty</td>
<td>Instructor for GSP</td>
</tr>
<tr>
<td>Jose Maliekal</td>
<td>Earth Sciences Faculty</td>
<td>Instructor for PowerPoint, Excel, Modeling; Course Registration Expert</td>
</tr>
<tr>
<td>James Zollweg</td>
<td>Earth Science Faculty</td>
<td>Lead Instructor for GIS</td>
</tr>
<tr>
<td>Kulathur Rajasethupathy</td>
<td>Computer Science Faculty</td>
<td>Assistant Instructor for Geometers Sketchpad, Faculty Advisor</td>
</tr>
<tr>
<td>Conrad Van Voorst</td>
<td>Education at SUNY Brockport</td>
<td>Instructor for GSP, Math Educator</td>
</tr>
<tr>
<td>Peter Veronesi</td>
<td>Education at SUNY Brockport</td>
<td>Evaluation Expert, Science Educator</td>
</tr>
<tr>
<td><strong>Other Institutions and Partners</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garret Love</td>
<td>Shodor Foundation</td>
<td>Instructor for all C-MST tools</td>
</tr>
<tr>
<td>Robert Panoff</td>
<td>Shodor Foundation</td>
<td>Judge for the C-MST Challenge</td>
</tr>
<tr>
<td>Monty Evans</td>
<td>Shodor Foundation</td>
<td>Assistant Instructor for all C-MST tools</td>
</tr>
<tr>
<td>Jenna Ingersoll</td>
<td>Shodor Foundation</td>
<td>Assistant Instructor for all C-MST tools</td>
</tr>
<tr>
<td>Karthik Sekar</td>
<td>Shodor Foundation</td>
<td>Assistant Instructor for all C-MST tools</td>
</tr>
<tr>
<td>Julie &amp; Jim Ealy</td>
<td>TI Contractors</td>
<td>Using Graphing Calculators in Sciences</td>
</tr>
<tr>
<td>Susan Ragan</td>
<td>Maryland Virtual High School</td>
<td>Assistant Instructor for STELLA</td>
</tr>
<tr>
<td>Margaret Crowley</td>
<td>Rochester City School District</td>
<td>Recruitment Coordinator</td>
</tr>
<tr>
<td>Steve Colabufo</td>
<td>East High School</td>
<td>Lead Instructor for TI-84+ Calculators</td>
</tr>
<tr>
<td>Valerie Huff</td>
<td>East High School</td>
<td>Stella, Project Interactivate</td>
</tr>
<tr>
<td>Allison Leckinger</td>
<td>East High School</td>
<td>Stella, Project Interactivate</td>
</tr>
<tr>
<td>Mike Meise</td>
<td>Wilson-Magnet High School</td>
<td>Assistant Stella Instructor</td>
</tr>
<tr>
<td>Patty Herrman</td>
<td>Edison Tech High School</td>
<td>Assistant GSP Instructor</td>
</tr>
<tr>
<td>Courtney Bruyea</td>
<td>Edison Tech High School</td>
<td>Assistant GSP Instructor</td>
</tr>
<tr>
<td>Ray Yeaton</td>
<td>John Marshall High School</td>
<td>Assistant AS Instructor</td>
</tr>
<tr>
<td>Ed Chi</td>
<td>Brighton Middle School</td>
<td>Assistant IP Instructor</td>
</tr>
<tr>
<td>Steve Whitman</td>
<td>Brighton High School</td>
<td>Lead Instructor for Interactive Physics</td>
</tr>
<tr>
<td>Alex Reppening</td>
<td>AgentSheets, Univ. of Colorado</td>
<td>Visiting Lecturer, Advanced AS</td>
</tr>
<tr>
<td>Rubin Landau</td>
<td>Oregon State University</td>
<td>Judge for the C-MST Challenge</td>
</tr>
<tr>
<td>Chad Thompson</td>
<td>Krell Institute</td>
<td>Judge for the C-MST Challenge</td>
</tr>
<tr>
<td>Barbara Helland</td>
<td>Krell Institute</td>
<td>Judge for the C-MST Challenge</td>
</tr>
</tbody>
</table>

32
The National Science Foundation heavily emphasizes involvement of college faculty in the K-12 education. K-12 work is often not regarded as “scholarship” within the STEM community, however, this needs to change now as we are facing unprecedented problems with our youth that have challenged even great minds such as of late Richard Feynman. The SCOLLARCITY Alliance responded to such challenge in a collective way by sharing of ownership. Teachers were told that they were partners, not just participants. The content, format, and delivery of the summer training was adjusted based on input from teachers, administrators, and students. College faculty were initially going to train teachers on how to use supercomputers for problem solving, but after listening to the needs of the K-12 and what the latest technology tools offer, it was decided that tools such as those in earlier pages would serve better. The institute initially began with the college faculty being the primary instructors, however, it was later decided to invite experienced C-MST teachers as additional instructors in the future. Teachers responded with enthusiasm and viewed this as an acknowledgement of their experience and authentic validation of their status as valued partners. It contributed to increased collegiality between K-12 and IHE. Through their interaction with teachers, college faculty also developed a much better appreciation of the realities of today’s classroom and the challenges faced in implementing the C-MST approach. Trainees had an easier time to learn from their colleagues while college faculty found more time to prepare course materials and act as advisors and lead instructors. This allowed the content of the workshop to expand beyond its original framework and include more coverage of and alignment with the State curriculum and examples from classroom.

The subject-matter competence for teachers is the key to success in K-12. Technology and research may open up new opportunities to tackle the ongoing decline in K-12 student achievement and STEM enrollments. It is time to revive the enthusiasm and disciplinary spirit of the past NSF Teacher Institutes to prepare master teachers.

I would love to be able to teach using my handheld device with the SmartBoard. Can you imagine the “wow” factor?
Faculty Leadership & Scholarship

Annual reports by college faculties show that they have played significant roles not only as instructors but also partners and mentors to teachers as well as leading players in their departments and the college to adapt CMST-based tools and pedagogy.

In their role as mentors during the school year, college faculty experienced many obstacles, including cultural issues and long commuting times between college campus and schools. Coordination of faculty teaching schedules and district school schedules was not an easy task. Teachers describe faculty as very influential in bringing students to the campus and for providing activities and making connections with students that encouraged them to pursue studies in STEM related areas.

Faculty members not only reached out to K-12 teachers and students but also brought new elements to teaching and learning in their own classes. C-MST pedagogy was promoted as part of ‘best practices’ within the college, leading to modifications in more than 20 courses. Junior faculty members in the project have now all obtained tenure and their C-MST work has been cited as important accomplishment of scholarship and community service. Below are some excerpts from faculty reports:

“… The use of CMST tools, such as Excel and IP, is being incorporated into College Physics labs and lectures respectively. Mathematica and Maple have been used as visualization tools in upper level courses for the past five years. LabView and Excel have been used in the laboratory for the past six years. Exposure to pupils and interactions with school teachers has promoted the College’s image with area schools and the public. This has resulted in an increased enrollment of higher caliber students some of whom chose Physics as a major…”

“… My research into how GIS fits into CMST-based teaching revealed to me several free or inexpensive technologies and software that I was previously unaware of. While they are not sufficient to meet the fundamental goal of my GIS sequence (professional training) their accessibility and usefulness has warranted their inclusion in my courses…”

“… My focus is to identify ways to use the technology to enhance the learning of mathematics. Working with other CMST faculty who have expertise in certain areas of technology and had the ability to train others on the tools and how to use the tools, was extremely beneficial to me. This wonderfully supportive group was also open to suggestions for improving instruction. I intend to use the GSP and graphing calculators to help teachers add a new dimension to their teaching by engaging students in investigations and exploration. Some of my research interests lie in this area, and the added knowledge and experience gained from the CMST Institute will support my scholarship in teaching. I now have a clearer sense of the needs and interests of secondary school teachers with regards to the use of technology.”
Building A Culture of Evidence

SUNY Brockport faculty have been at the forefront of the national computational science education, as stated by the outside reviewers. They have helped other institutions launch similar programs, including Siena College (NY), Stockton College (NJ), Oregon State University, Bennett College For Women (NC), and North Carolina Central University in Durham.

C-MST faculty and teachers have attended many national and regional conferences to report on their field experiences. The following articles have been published in the scientific community as contribution to the evidence base on the role of technology and integrated approach to math and science education.


Contact Information:
Tel: (585) 395-2595, FAX: (585) 395-8117, oyasar@brockport.edu