

2008 Evaluation Report

**The Southwest Center for Microsystems
Education**

NSF # 0830384

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**2008 Evaluation and Assessment Report
for
The Southwest Center for Microsystems Education
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This evaluation report covers the period February 15, 2007, to August 31, 2008, but also includes cumulative data for The Southwest Center for Microsystems Education since its inception in 2004. This evaluation report is divided into the following parts:

1. SCME Mission and Goals
2. SCME at CNM
3. SCME Project Team
4. Faculty Enhancement
5. Educational Materials Development
6. SCME Regional Center Continuation at UNM

SCME Mission and Goals

SCME Mission Statement:

“The Southwest Center for Microsystems Education will serve as a sustainable resource center that identifies Microsystems technologist competencies, creates and disseminates educational materials and models, and provides professional development activities to develop a skilled microsystems workforce that can support research and development and manufacturing environments.”

SCME Goals:

- Increase educational capacity to produce technologists skilled in assisting microsystems research, design, and commercialization activities.
- Increase the general public’s awareness of the microsystems industry.

SCME at CNM

The SCME is unique among the established ATE Regional Centers. Since its 2004 inception at the Albuquerque Technical Vocational Institute (TVI), the Center has closely partnered with the University of New Mexico School of Engineering and the Manufacturing Engineering Program through a sub-award. This history of close partnership dates back to the mid 1990’s when TVI began its Semiconductor Manufacturing Technology program. In early 2006, TVI began to evolve culminating in a name change to Central New Mexico Community College (CNM).

In April 2007, a pre-proposal was submitted, and encouraged, for a continuation grant for the SCME. However, shortly before the October deadline for the continuation proposal, the CNM administration thought it best not to submit a new proposal, citing a shift in vision as the primary reason. It should be noted that the administration had completely changed from the Associate Dean level up through the President of the College, and what was formerly called the Trades and Technology divisions were merged into one School of Applied Technologies housing over 20 programs. This is not meant to imply that CNM and the School of Applied Technologies no longer supports the MEMS program, only that they no longer wish to administer such a large regional grant, but rather focus more on internally-focused endeavors.

Rather than phasing out the SCME, the PI, Director, and Co-PI's as well as CNM, UNM and NSF agreed it was best to transition the SCME administration and PI to the University of New Mexico, which is better equipped and eager to support this endeavor. This transition also coincided with a one-year, no-cost extension.

During the first four years, the SCME not only had sub-awards to UNM, but also Maricopa ATE Center (MATEC) and City College of San Francisco based BioLINK under DUE #0402651. The Center has increased the regional and national capacity to produce technologists skilled in MEMS fabrication (manufacturing), research and design. On April 1, 2008, the SCME formally moved from CNM to UNM in order to better serve the MEMS community at large under DUE #0830384.

Dr. John Wood, Co-PI on the NSF grant, agreed to sponsor the transfer of SCME to the University of New Mexico and the Manufacturing Engineering Department. A proposal was submitted to NSF to use the remaining funds in CNM's grant to operate SCME at UNM through August of 2009. The proposal was approved and the new grant started officially on April 1, 2008. However, from April 1, 2008, to May 30, 2008, SCME had no real operating funds.

Dr. Matthias Pleil, Principal Investigator, was hired by the Manufacturing Engineering Department at UNM, and kept SCME operating. Of primary concern during this time was the preparation for SCME's pre-conference workshop at the 2008 SAME-TEC Conference hosted by the Maricopa Advanced Technology Education Center (MATEC). The pre-conference workshop was held on July 29, 2008, and was attended by 40 participants. More information on this workshop is given in the "Faculty Enhancement" section of this report.

At first, it was difficult to see the "blessing" in this sequence of events, but it has produced an opportunity for Dr. Pleil and Dr. Wood to continue the regional A.T.E. center at UNM that will build upon the success of SCME at CNM.

SCME Project Team

During the past year, Dr. Matthias Pleil, P.I., faced several major challenges. First of all, in the face of fading administrative support for SCME at CNM, he needed to find another home for the Center and get NSF approval for the transfer. Based on a strong existing partnership with Dr. John Wood at UNM, the transfer to UNM was approved by NSF.

Second, Dr. Pleil had to keep SCME operating during the transition period. He left CNM and accepted a Research Associate Professor position in the Mechanical Engineering Department at UNM. Dr. Wood is the Co-PI and Director of the Manufacturing Engineering Program. Dr. Pleil was able to continue the SCME activities, e.g. preparation for SCME MEMS pre-conference workshop at the 2008 SAME-TEC Conference and recruitment for a "Pressure Sensor" Workshop that was held in July, 2008, as well as completing the transition of staff and team members. This was done under no support until June, 2008.

The Project Team lost Dr. Thor Osborn as SCME Director. As CNM began to phase out SCME, Dr. Osborn went from full-time to half-time on January 1, 2008, and at the end of March, 2008, returned to Sandia National Laboratories, leaving SCME without a Director. However, Sandia still is an ardent supporter and advocate of the SCME.

Ms. Anna Garden, Administrative Assistant, was laid-off by CNM on March 31, 2008, and was not rehired by UNM until June, 2008. This left Dr. Pleil without administrative support for two months.

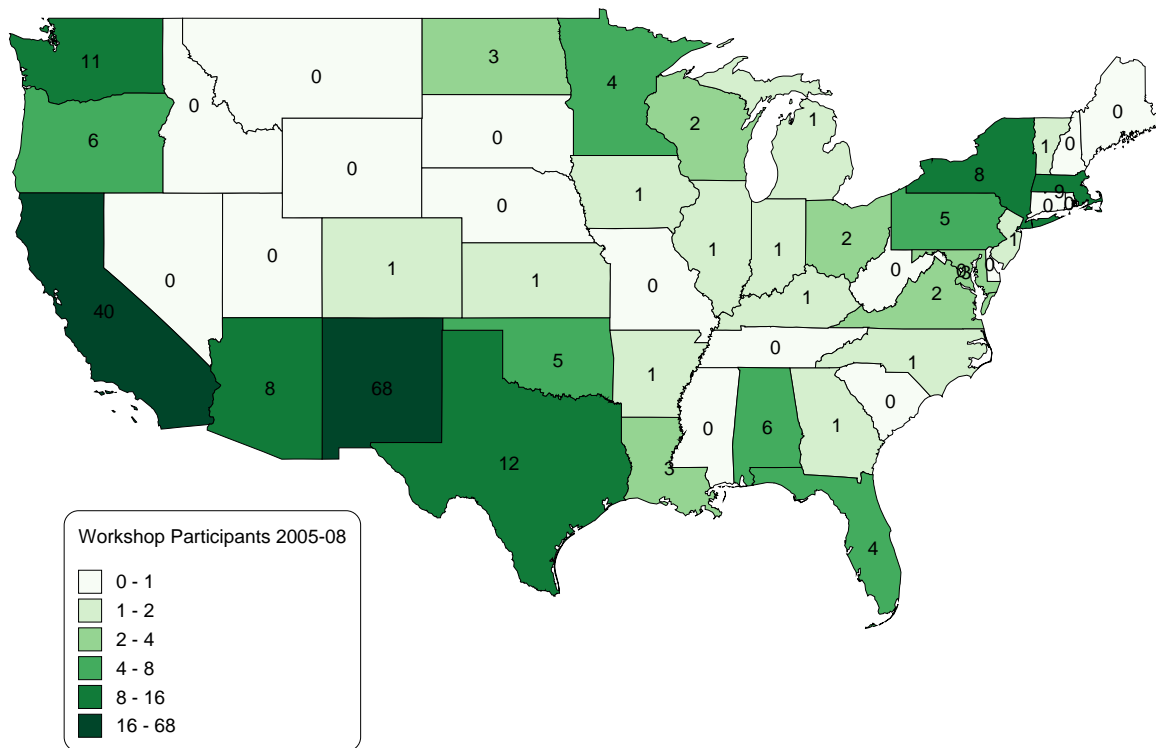
Educational materials development was scaled back during the transition period, as were other SCME activities. Most of these activities were re-started by the end of the summer. The budget is being managed carefully, and remaining funds should enable SCME to operate at UNM until August, 2009. A proposal for a renewal of the SCME at UNM will be submitted in October, 2008, and if successful, the new grant will provide funding for three additional years, beginning in 2009.

Faculty Enhancement Activities

During the past year, faculty enhancement activities continued to be a vital component in meeting Goal # 1. Without trained faculty in MEMS technology and applications, increases in educational capacity to produce technologists skilled in assisting microsystems research, design, and commercialization activities will not happen. Hence, the SCME has devoted much time and resources to faculty enhancement. The SCME strategy has been to use short, one-day workshops to introduce faculty to MEMS technology and applications. From this cadre of instructors, those instructors who demonstrate the desire to integrate MEMS instruction into the classes that they teach were supported in continued professional development activities, e.g. the two-day, pre-conference MEMS workshop at the SAME-TEC conference. Finally, for those faculty

who taught MEMS technology and applications to their students, the one-week, pressure-sensor, cleanroom workshop was offered to them as a capstone experience. In this manner, increasing professional development resources were allocated to those faculty who actually integrated MEMS workshop material into their classes and hence, will produce the broadest impact on student learning by SCME professional development opportunities.

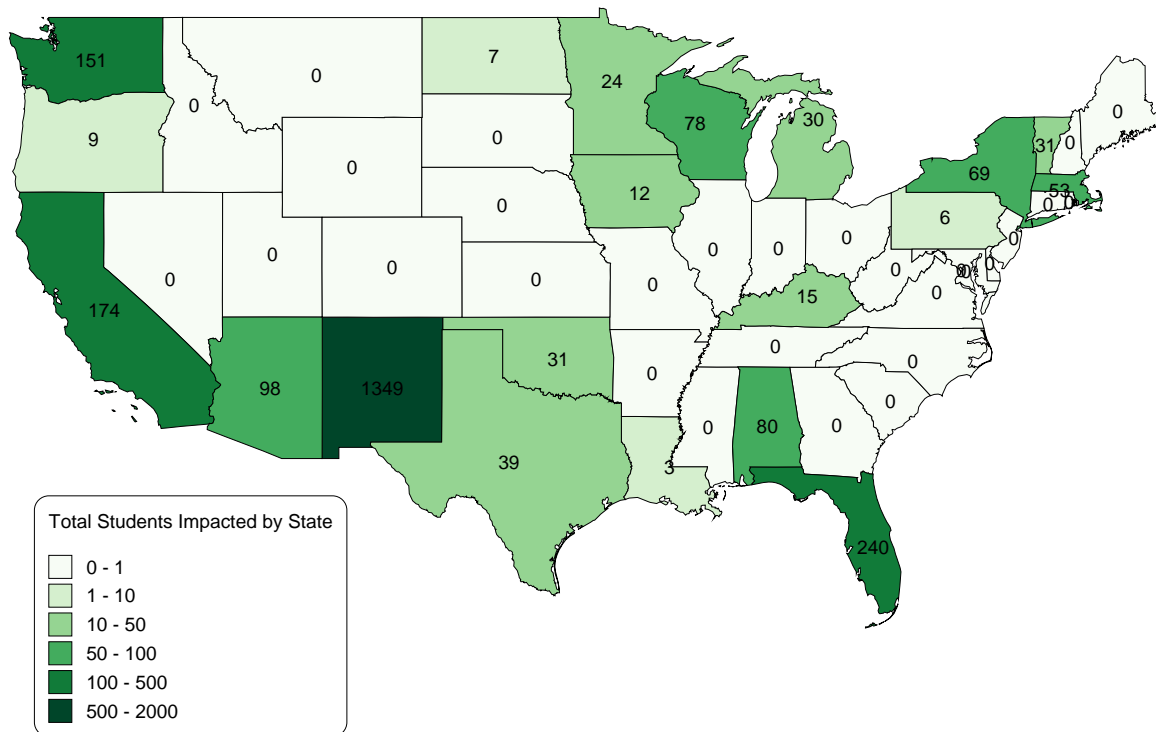
Since September, 2007, twelve faculty have participated in the one-week, Pressure Sensor Workshop and forty participated in the “Demonstrating MEMS in the Classroom” series of parallel-running, one-to-two hour workshops at the 2008 SAME-TEC Conference. This brought the total number of workshop participants impacted by all SCME sponsored workshops to 224 individuals. Of the 224 individuals, 213 were from the United States, 9 from Mexico, and 2 from Canada. Map 1 shows the distribution of workshop participants by state.



Map 1. Workshop participants by State, 2005 – 2008.

Being an A.T.E. regional center, SCME serves the southwestern portion of the United States, namely California, Arizona, New Mexico, and Texas. However, Map 1 shows that SCME also mimics a national A.T.E. center in that it has trained faculty from STEM programs from coast-to-coast and in a total of 31 states.

A total of 58 faculty responding to our surveys have indicated that they have integrated SCME workshop material into the classes that they have taught over the past three academic years. Map 2 shows the number of students per state that have received this instruction.

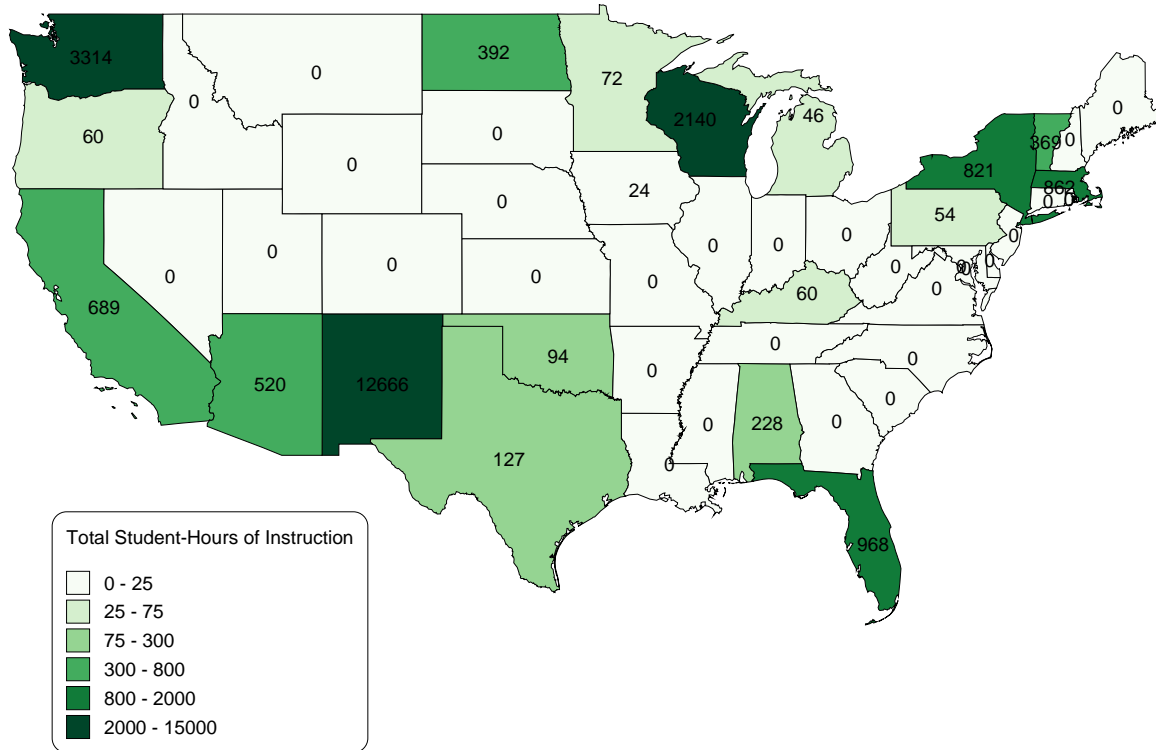


Map 2. Number of students impacted by MEMS instruction by State, 2005 – 2008

Map 2 shows a concentration of students receiving MEMS instruction in the Southwestern portion of the United States as well as a national impact from Washington State to Florida and California to Massachusetts. The totals did not include the number of students in the Manufacturing Technology MEMS (Microsystems) Program at CNM.

The number of instructional hours varied by instructor and class. As a metric of instruction, SCME used “student x instructional hours”, or “student-hours” for short. A

single student receiving one hour of MEMS instruction equals one “student-hour” of instruction. Map 3 shows the total number of student-hours per State.



Map 3. Total number of Student-Hours of instruction by State, 2005-2008.

Map 3 shows a concentration of student-hours delivered in the Southwestern portion of the United States, but also the national impact that SCME had from 2005 to 2008. Again, the total number of student-hours delivered in CNM’s Microsystems Program were not included in these totals. As expected, the greatest number of student-hours of MEMS instruction was delivered in New Mexico, but significant student-hour totals also occurred in Washington State, Wisconsin, Florida, New York, Massachusetts, California, Arizona, North Dakota, and Vermont.

Figure 1 shows a graph of Student-Hours by semester and year. Comparing Fall semester student-hour totals, the number of student hours increased from 1,545 student-hours in Fall of 2005 to 4,934 student-hours in Fall of 2006 to 8,833 student-hours in Fall of 2007. Student-hours for Spring semester were not as great, but also showed an increasing trend from 1,526 student-hours in Spring 2005 to 4,474 student-hours in Spring 2008. This was expected since with each SCME-sponsored workshop, the size of the MEMS

learning community increased. In addition, most community colleges have a significantly higher enrollment in the Fall semester compared to the Spring semester.

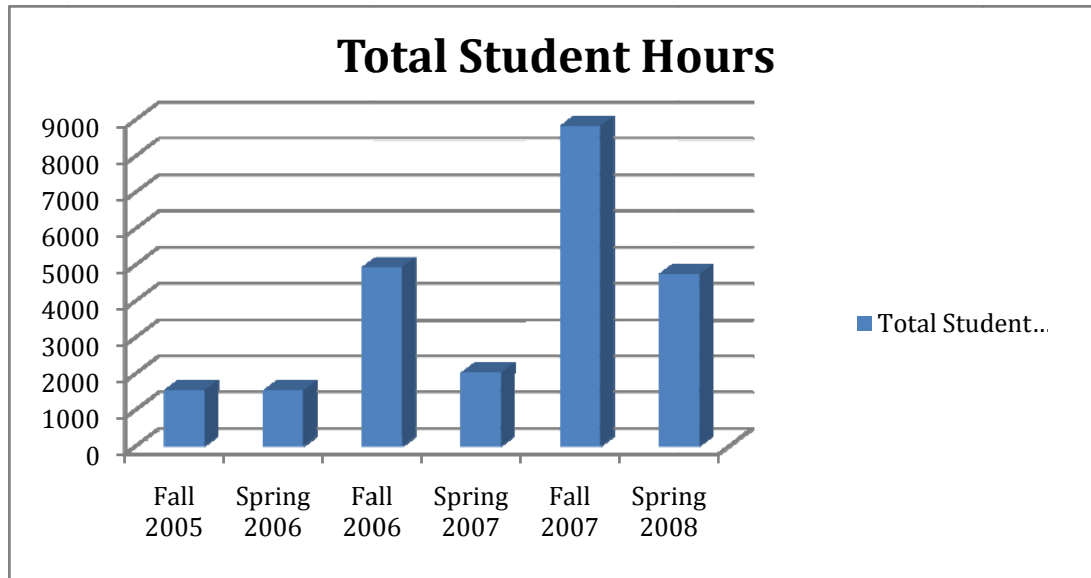


Figure 1. Total Student-Hours by Semester and Year.

Another significant finding occurred in the analysis of the student demographic data. The location of the Center in the Southwestern region of the U.S. provides a unique opportunity to impact underrepresented groups in STEM education. In the non-New Mexico student population, 19% were female and underrepresented groups comprised 22% of the total student population (13% Hispanics, 5% African Americans, and 4% Native Americans). In the New Mexico student population, 35% were female and underrepresented groups accounted for 81% of the student population (54% Hispanic, 5% African American and 22% Native American).

Educational Materials Development

Much of the impact on student learning that has occurred has been accomplished by faculty attending SCME sponsored workshops and receiving printed copy and electronic copy of the PowerPoint presentations. A recurring request from workshop participants has been for additional materials that they can use in their classes. In response to this request and need, SCME has developed instructional materials in the form of Shareable Content Objects, or SCOs. Each SCO focuses on one topic and has a limited set of objectives and outcomes. SCOs can be combined with other SCOs to form SCO suites that provide a cohesive instructional package on a specific topic.

Over the past two and a half years, 90 SCO's have been developed to date yielding over 20 SCO suites. SCO topics include Safety, Introductory Topics, MEMS Applications, BioMEMS, and Fabrication. Here is a list of the SCO suites and the number of SCO's in each SCO suite:

Safety

- Hazardous Materials (5 SCOs)*
- Chemical Lab Safety Rules (3 SCOs)*
- Material Safety Data Sheets (6 SCOs)*
- Chemical Labels/NFPA (5 SCOs)*
- Personal Protective Equipment – PPE (3 SCOs)*

Introductory Topics

- Units of Weights and Measures (4 SCOs)*
- A Comparison of Scale – Macro, Micro, and Nano (3 SCOs)*
- Introduction to Transducers, Sensors, and Actuators (3 SCOs)*

Applications

- MEMS Applications (3 SCOs)*
- MEMS History (3 SCOs)*
- Microcantilever Suite (8 SCOs)*
- Micropump Suite (4 SCOs)*

BioMEMS

- What are BioMEMS? (3 SCOs)*
- BioMEMS Applications (5 SCOs)*
- Mapping Biological Concepts: DNA Overview (5 SCOs)*
- Mapping Biological Concepts: DNA to Protein (3 SCOs)*
- Mapping Biological Concepts: Biomolecular Applications of BioMEMS (6 SCOs)*
- BioMEMS Diagnostics Overview (3 SCOs)*
- BioMEMS Therapeutic Overview (3 SCOs)*
- Regulations of BioMEMS (4 SCOs)*

Fabrication

- Manufacturing Technology Training Center (MTTC)-
Pressure Sensor Suite (5 SCOs)*
- Photolithography Overview (1 SCO)*

Total Number of SCOs: 90 SCOs

In addition to the SCO suites that have been developed, the following SCO suites are currently in development:

- Wheatstone Bridge (3 SCOs)*
- Atomic Force Microscope - AFM (3 SCOs)*

BioMEMS Therapeutics (3 SCOs)
Mapping Chemistry Overview (7 SCOs)
Environmental and Counterterrorism Applications (3 SCOs)
Clinical Laboratory Techniques (3 SCOs)
Photolithography Overview (3 SCOs)
Etch Overview (3 – 5 SCOs)
Crystallography (3 SCOs)
Deposition Overview (3)

The following are SCO suites that have been identified for completion in 2008-2009:

RF Applications (3 SCOs)
Inertial Sensors Applications (3 SCOs)
Optical Applications (3 SCOs)
Fluidic Applications (3 SCOs)
Additional Process/Fabrication SCOs (Number to be determined)

Another recurring request from workshop participants is for more hands-on activities. Sessions at SCME sponsored workshops that have focused on hands-on activities was been especially popular. For example, the session on teaching cantilever principles using a meter stick, butterfly clips, and other components received high ratings for usefulness and a number of faculty have integrated the cantilever lab into their classes. At the 2008 SAME-TEC Conference, the high school sessions that focused on hands-on laboratory activities was well attended and again received high ratings from workshop participants. Two sessions were given by high school teachers working together, one from Santa Fe Indian School and another from a high school in Vermont. This may become a model of cross-national and cross-diversity between schools.

In response, SCME has developed its first prototypical kit, Pressure Sensor Kit, and derivatives to bring elements of the cleanroom into the classroom. These kits are based on the one-week pressure sensor workshop. Actual MEMS devices fabricated at the MTTC by students and educators are used as kit components. Several additional kits, e.g. Cantilever Kit and Scale Kit, are planned. These will be promulgated through the Center for Hands-on Learning, a web based science kit distribution not-for-profit. UNM and SCME are currently developing the business process including copyright and distribution methodologies.

SCME Regional Center Continuation at UNM

The continuation of the SCME A.T.E. regional center of excellence at the University of New Mexico will build upon the foundation developed at Central New Mexico Community College. This is critical to the continued support of the MEMS learning-community that has been created. The 224 faculty and administrators that have participated in SCME-sponsored workshops need nurturing/mentoring and instructional resources to teach MEMS fundamentals and applications to their students. As is seen from the continuous increase in student-hours, a cohort of educators cutting across

secondary and post-secondary institutions is now developing and needs additional support to become a sustainable group.

UNM's continued support for the A.T.E. regional center makes it uniquely positioned to offer MEMS fabrication workshops at UNM's MTTC. In this workshop, high school and college faculty will actually manufacture and test a MEMS pressure sensor, gaining valuable hands-on experience and first-hand insight into MEMS fabrication processes. UNM also allows SIPI and CNM students to utilize the MTTC cleanroom as part of their MEMS-based Manufacturing and pre-engineering courses.

The SCME plans to continue to partner with MATEC to host the annual SAME-TEC Conference (to become ATECon in 2009). The center plans to continue to offer MEMS pre-conference workshops, sessions and sponsor paper sessions as part of the conference program. SCME will provide 25, \$400 conference fee sponsorships as well as provide travel to a few high school educators as well as provide 3-6 presenters for the workshops and planned interdisciplinary sessions.

The SCME will distribute their SCOs and kits to faculty around the country, and including Mexico and Canada. The center will collaborate with The Center for Hands-on Learning in Rio Rancho, NM. This will ensure that MEMS educational materials will be available beyond the duration of NSF funding.

Summary

SCME has made major contributions to advanced technological education, especially in the area of MEMS fundamentals, fabrication, and applications. The center has trained 224 faculty and administrators through its array of workshops and develop a vibrant MEMS learning community.

Fifty-eight of the 224 workshop participants have reported to have integrated MEMS workshop materials into their classes. Of the 58 participants, 38 are community college instructors, 16 are high school teachers, and four teach at four-year educational institutions. These educators have taught MEMS to 2,529 students in 31 states and delivered 23,605 student-hours of MEMS instruction. This is in addition to the over 30,000 student hours delivered by the PI and CNM Co-PI at CNM.

The SCME is in the process of developing educational materials to support MEMS instruction in the classroom. To date, 90 SCOs have been developed and kit development is just beginning with the introduction of SCME's Pressure Sensor Kit. SCOs and kits will be distributed by the Center for Hands-on Learning in Rio Rancho, NM.

Continuation of the regional center at the University of New Mexico is crucial to sustaining the work begun by SCME at Central New Mexico Community College over the past four years. This center will continue professional development workshops,

especially workshops in UNM's fabrication facility, creation and distribution of instructional materials and experiment kits to support a growing Microsystems learning-community, and increase the general public's awareness of MEMS technology and applications.