During lunch the attendees were split evenly among eight 10-person tables and tasked with (1) discussing and ranking the topics that should be covered in a MEMS curriculum and (2) identifying the key challenges and best practices associated with one or more of the following MEMS-education topics:

- Integrating MEMS into Engineering School Curricula (Moderator: T. Saif)
- Integrating Hands-On Laboratories into Courses (Moderator: J.W. Judy)
- Integrating Foundry Runs into Courses (Moderator: M. Sheplak)
- Integrating MEMS Design Projects into Courses (Moderator: B. Pruitt)
- Integrating CAD into Courses (Moderator: K. Turner)
- BioMEMS / Microfluidics Courses (Moderator: J. Voldman)
- Optical/RF MEMS Courses (Moderator: R. Ghodssi)
- Student-Only Table selects any topic (Moderators: R. Candler / P. Motta)

Each table was requested to consider one of the above topics in depth, but could provide feedback on the others as time and the interests of the table allowed.

In terms of prioritizing the topics covered in an ideal MEMS curriculum, each table had a different perspective. However, most felt that it was most appropriate to first cover the basic physics and chemistry involved, and then to identify and discuss scaling issues. Hands-on fabrication and testing experience was also seen to be invaluable and should be incorporated whenever and wherever possible. It was also considered very important to incorporate systems-level engineering design and to introduce various statistical design and optimization procedures commonly used in industry. The flexible addition of a variety of specialized graduate-level MEMS-related courses (e.g., microfluidics, nanoengineering, etc.) was also seen as valuable. When designing a MEMS curriculum at any institution, it was identified as important to (1) keep a balance between breadth and depth, provide some training in professional issues (e.g., patents, case studies, economics, design of experiments, failure analysis, etc.). An additional issue and barrier associated with a MEMS curriculum was the lack of appropriate textbooks.

The key challenges and best practices identified for each of the following topic were:

Integrating MEMS into Engineering School Curricula (Moderator: T. Saif)

The challenges were (1) limited curricular credits and class hours available – something added means something else must be deleted, (2) limited financial support – not all universities have a clean room, (3) academic inertial and conservatism, and (4) how to appropriately incorporate MEMS into the undergraduate curriculum.

The best practices were (1) hands-on fabrication – particularly rugged and low-cost techniques, (2) collaboration with industry and national laboratories – including internships, and most best practices were enabled by (3) federal funding

Integrating Hands-On Laboratories into Courses (Moderator: J.W. Judy)

The challenges were (1) resources (e.g., money, space, staff, time), (2) experimental setups, (3) qualified teaching assistants, (4) credit hours for students and teacher, (5) integration of lectures with labs – timing issues, (6) modules needed (e.g., actuator scaling).

The best practices were (1) simple and short labs modules (e.g., get students to measure ADI device to appreciate scale, deposit initials on a wafer, MCNC test structures, Build macro accelerometers (smaller better?), PDMS stamping, fluidics, devices, dielectrophoresis demonstration, opportunity to share), (2) hands on lab class, (3) use of a probe-station-in-a-suitcase that costs $6,000 to $10,000, (4) Caltech freshman low-tech fabrication class, and (5) strength of materials lab using hand-made paper macrostructures.

Integrating Foundry Runs into Courses (Moderator: M. Sheplak)

The challenges were (1) cost – foundry runs are not free so what is the "bang for the buck"?, (2) scheduling – foundry-run design-fab-test cycles cannot fit within a quarter or a semester, (3) logistics and contingency plans – what if…, and (4) conveying the physics behind the design rules.

The best practices were (1) constrained design optimization problem through the system, (2) design-and-implement experiments – correlating failure modes with design and physics, (3) interactive cirtual processing, and (4) interaction with foundry and guest lecturers.

Integrating MEMS Design Projects into Courses (Moderator: B. Pruitt)

The challenges were (1) creating new, real and challenging projects, (2) providing the course to larger audience, (3) critical mass in MEMS faculty (mentors, teaching rotations), (4) cost, resources (5) portability of projects/courses between institutions (6) how to get these ideas into undergraduate curriculum???

The best practices were (1) completion of a full design, build and test cycle, (2) novel, real and challenging projects, (3) application of design methodologies (DFM, DFX), (4) structured projects for quickstart on processing (shared projects and masks, maybe devices, e.g. Sandia,

Attributes with high-risk/high-payoff or double edged swords included (1) multidisciplinary students (common lingo), and (2) partnerships with industry/labs

Integrating CAD into Courses (Moderator: K. Turner)

The challenges were (1) price of CAD package, (2) teaching integrated design and system level concepts using CAD, (2) getting students trained on the CAD package so they can effectively use it during the term, and (3) addressing widely varying student background and expertise,

The best practices were (1) train students to use the CAD packages they are most likely to use in industry, (2) use tutorials and assistance from the CAD company to develop examples for students to follow, (3) CAD user workshops for academia and industry – combine user groups, (4) having students use experimental data to verify simulation results, (4) back-of-the-envelope estimation techniques for checking simulations and gaining insight, and (5) teaching how to do numerical convergence study.

BioMEMS / Microfluidics Courses (Moderator: J. Voldman)

Since microfluidics and BioMEMS only partially overlap the will be considered separately. The challenges for microfluidics courses were (1) the multiple length scales when dealing with many microfluidic domains and (2) the lack of a compromise between a microfluidics survey course and a microfluidics science course. The challenges for BioMEMS courses were (1) the huge pedagogical difference between biology and engineering science, (2) hypothesis-driven biology versus engineering science, (3) no governing equations for biology but systems/quantitative biology may have solution, (4) need for a BioMEMS textbook and homework problems, (5) gap between teaching engineers open biology problems and teaching biologists MEMS, (6) need for standards in a BioMEMS curriculum, (7) needs to reach beyond engineering into the school of science.

The best practices were (1) unify curriculum from biology side rather than device side – going from genome à mRNA à cell à tissue à organism, (2) team-teaching with biologists – workshops to combine both communities for teaching, (3) make engineers critically evaluate BioMEMS papers (e.g., is a given BioMEMS device an appropriate use of MEMS?), (4) stick to quantitative topics in BioMEMS (e.g., electrophoresis but perhaps provide an awareness of “other” issues, (5) view microfluidics from scaling point of view – start at continuum mechanics and then fix and eventually abandon Navier-Stokes theory.

Optical/RF MEMS Courses (Moderator: R. Ghodssi)

The challenges were (1) getting enough students interested to fill out the class, (2) lowering the barriers – perhaps embed RF MEMS as part of electrophysics, and (3) lack of successful products – need a market.

The best practices were (1) having students with the right background in RF and optics, (2) providing an introductory-level course for all students and faculty, (3) incorporating a testing and instrumentation component, and (3) a discussing the historical evolution of the field.

Student-Only Table selects any topic (Moderators: R. Candler / P. Motta)