Active Learning in Materials Science and Engineering

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The multi-faceted discipline of Materials Science and Engineering presents challenges to instructors to teach relevant topics in a meaningful way. This challenging situation, however, provides an opportunity for Materials faculty to adopt an active-learning program. Active learning is simply defined as any strategy "that involves students in doing things and thinking about the things they are doing". [1] These strategies include a wide range of teaching and learning activities, including: collaborative learning, practicum experiences, interactive seminars, and process drama. [2] The common theme among these methods is that students must do more than listen to faculty "pontificate" facts and then "regurgitate" them on tests. Instead, students must read, write, discuss, and be engaged in solving problems during class so that they feel a personal connection to the subject. [2]

The ultimate learning environment is an internship in industry, government laboratory, or university. In these settings, interns receive extensive individual attention from a mentor on a particular problem. They become immersed in the culture, are able to engage in two-way discussions, spend time thinking about the project, and collect and analyze pertinent data. The result of these experiences is that the intern acquires new knowledge within the context of real problems; *i.e*., they *learn by doing* [3]. In the same way, active learning in the classroom has the potential to revolutionize Materials education by converting students from spectators to active participants in the learning process.

Although it is difficult to duplicate an internship experience in the classroom, active-learning methods will enhance the learning experience. One specific example to consider is the study of "Bicycle Metallurgy" in which the three cornerstones of Materials curriculum, *Structures*, *Properties*, and *Processing*, can be readily integrated within the framework of students' existing experiences. By literally bringing the laboratory into the classroom, the faculty allows the class to solve problems not as students, but as engineers. Riding bicycles with low-carbon or 4000-series steel frames can be compared with "fat-tube" aluminum, high-strength-to-density titanium, and graphite-filament composite frames. In their role as experts, students seek to discover the answers to questions, such as: Are there differences in weight, tube dimensions, flexibility/stiffness, joining methods? What causes these differences? From a *Structures* perspective, the students can dissect the frame sections, mount metallographic specimens, and compare their microstructures. *Properties* may be measured in creative ways; students can suggest methods to compare qualitative riding "feel" to more engineering-based quantitative attributes of strength, ductility, modulus, and density. Students can correlate their observations to the *Processing* methods of ingot melting (introducing phase diagrams), and tube drawing methods for the metallic frames and polymer blending and extrusion methods for composites. The effects of joining methods, such as welding, brazing and gluing can also be discovered through visual and microstructural observations as well as hardness measurements. Finally, there is a trend in engineering education to incorporate design concepts within each course. The students extend their knowledge by selecting material combinations, tube dimensions (*e.g.*, circular or oval, diameter-to-wall thickness), thermo-mechanical processing, and microstructures to fulfill specified criteria.

1. C.C. Bonwell and J.A. Eison, "Active Learning: Creating Excitement in the Classroom" (ASHE-ERIC Higher Education Report No. 1) Washington D.C.: George Washington University, pg. 2 (1991).
2. C. Andersen, "Process Drama and Science Inquiry", submitted for publication.
3. R.M. Felder and R. Brent, "Learning by Doing", Chemical Engineering Education, 37(A), 282-283 (2003).