

STRANGE MATTER: STUDENT IMPRESSIONS OF A MUSEUM EXHIBIT BY THE MATERIALS RESEARCH SOCIETY

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ABSTRACT

A traveling museum exhibit—called *Strange Matter*—presented by the Materials Research Society served as a relevant teaching tool for an undergraduate Materials Science and Engineering (MSE) course. A summary of the exhibit, along with impressions of the students, is reported here in order to evaluate the usefulness of the exhibit for learning about MSE. The visual stimulation of tangible models of the behavior and phenomena of materials excited the students about MSE and whetted their appetites to learn more about the underlying mechanisms. Larger-than-life representations of microstructural features improved students understanding of principles discussed in class. Finally, the exhibit offered a glimpse into emerging materials technologies, thereby encouraging students to consider the unique combinations of properties of advanced materials and to envision potential applications.

Keywords: *undergraduate MSE instruction, traveling materials exhibit, models of materials, magneto-rheological fluids, amorphous metal*

INTRODUCTION

It has been established that students learn by various methods including auditory, visual, and kinesthetic instruction. Classroom lectures generally emphasize verbal instruction with some visual aids, but Witold Brostow has noted that even teaching a basic MSE course requires more than one approach¹. With a multitude of resources about MSE available (especially via the internet) to students, the role of the teacher has shifted from primarily lecturing to coaching students: specifically, coaching students on how

to manage their time investments in different modes of learning¹. Consequently, it is important for an instructor to make accessible varied opportunities for learning the topics of MSE curricula. As discussed by McKelvy, et al., it is especially prudent to include project-based learning, where students are asked to address and solve authentic questions². Moreover, as MSE is multidisciplinary by nature and a determining factor of human progress, teachers have an advantage in capturing the attention of students of all ages, a fact noted by John Baglin³.

Thus, in teaching an introductory undergraduate course in MSE, I sought to incorporate tangible models when introducing concepts such as crystal structure, microscopy, and magnetic materials. To improve students' perspective and understanding, I wanted them to personally see and examine a wide range of the materials discussed in class.

An exhibit called *Strange Matter*, presented by the Materials Research Society (MRS) along with the National Science Foundation (NSF) of the U.S. and the Ontario Science Centre in Toronto, began touring U.S. and Canadian museums in 2004 and will continue its exhibition through 2006. The exhibit invites users to interact with practical and exotic materials through hands-on experiences. Two versions of the exhibit, one extensive and one abbreviated, exist. A website⁴ supplements the exhibit with interactive multimedia along with video highlights of statements from established materials scientists.

The smaller of the two versions of the *Strange Matter* exhibit was available at the Dallas Museum of Natural History for my class to visit. The various stations of the exhibit are described below. Several of the displays clarified and consolidated concepts previously discussed in class, as evidenced by student comments, which will be discussed later. Other displays introduced new materials and ideas.

SUMMARY OF THE EXHIBIT

At the *Strange Matter* exhibit, there were at least four major displays of interest to students of the class: (1) structures and defects; (2) zooming in on materials; (3) magnetic liquids; and (4) amorphous metals. The first of these focused on the structure and properties of metals. A large square plate with a clear covering housed a single layer of ball bearings, loosely packed into the space. The ball bearings represented individual atoms of a metallic crystal lattice. The plate could be tilted and rocked, allowing the ball bearings to freely move. As the ball bearings came to rest,

however, one could observe vacancies in the lattice, grain boundaries, edge dislocations, and presence or absence of close packing. Text displays accompanied the model of crystal structure to further describe the differences between crystalline and amorphous structures. Additionally, magnifying lenses and microscopes were available to view various metal samples. A similar version of the model described above could be constructed if one has the capability to machine grooves in facing surfaces of Plexiglas blocks; ball bearings are then added as desired.

The second exhibit was highly interactive and focused on magnification of materials. Using lenses with varying degrees of magnification, students could better develop a cohesive understanding of a material's structure from the macroscopic to the microscopic level. A wide array of materials—from polymers to ceramics to metals and including composites, textiles, sponges, and more—were available for viewing. In some cases, one could examine materials from one's own back pocket—like a dollar bill, for instance—and see the magnified items displayed on a television monitor. A large-scale model of an atomic force microscope (AFM) simulated the detection mode of the instrument. A handle connected to a giant AFM tip allowed users to feel how the sensitive tip moves across a material surface and records its topography and structure. Further illustrations, explanations, and video clips are available on the *Strange Matter* website⁴.

The third impressive exhibit introduced a magneto-rheological fluid. The liquid, containing suspended nanoscale magnetic particles, transformed into a solid under the influence of a magnetic field. Manually controlling the liquid-to-solid transition with a large magnet demystified the material and fostered ideas of applications for the unique material. The exhibit also reinforced concepts of polarization and how the strength of intermolecular attractions affects the state (solid or liquid) of a material. The *Strange Matter* website contains a description and illustration

of ferrofluids and their applications along with details of related experiments under the “Fun Stuff!” section on the site ⁴.

Fourth was an exhibition of Liquidmetal® alloy, an amorphous metal and one of the hardest materials known (www.liquidmetal.com). This exhibit highlighted a recent technological advance that could transform materials engineering for products ranging from sports equipment to aerospace coatings to medical tools. The amorphous structure of Liquidmetal® that leads to its high strength and hardness also results in the capacity to store an unusually large amount of elastic strain. These properties were evident when a steel ball that was dropped on a plate of Liquidmetal® bounced higher and longer than it did on plates of steel, titanium, and other common metals. A short video clip of steel balls dropped on different metal surfaces is available on the Liquidmetal® website (www.liquidmetal.com).

IMPRESSIONS OF STUDENTS

All students concluded that the museum exhibit *Strange Matter* was a useful learning tool in their introductory MSE course. The ball bearing representation of dislocations and defects in crystals was highly appreciated. The display, which was a surprisingly accurate model, supplemented students understanding of dislocation movement and grain boundaries in three-dimensional space.

Overall, students were most interested in the ferromagnetic liquid, using words such as “amazing” and “captivating” to describe the material. Student Edmund Duban commented that “Before I had only seen such extravagances on TV, but controlling the crystal[ine]-metal liquid was nothing less than amazing.” Piotr Blaszczyk wrote, “Just imagining the possibilities of what could be done with such a liquid was enjoyable.” Thus, the exhibit bridged a gap, enabling students to realize that they can understand—and design applications based on their understanding of—advanced

materials. This attitude may, in turn, motivate students toward continuation of laboratory research.

The students were also extraordinarily interested in the Liquidmetal® alloy. The Liquidmetal® exhibit was an excellent teaching aid as it encouraged students to think through the process of how one achieves a completely amorphous metal solid. Phase diagrams, cooling curves, and metal versus polymer processing techniques were revisited and rendered more exciting by their relevancy to an intriguing material. Moreover, the students fascination with Liquidmetal® alloy incited them to ask critical questions regarding composition, density, elasticity, strain, and more.

The strongest disappointment for the students was that the exhibits did not provide explanations and descriptions in greater detail. All of the displays would have benefited from more explication geared toward visitors with some previous knowledge of MSE. Those without such knowledge could then simply skip some of the explanations.

AN OVERVIEW

As a teaching tool, the museum exhibit improved student involvement and interaction with the course subject matter, a goal of other non-lecture tools such as online interactive educational modules. McKelvy, et al. ² discuss how online modules, for instance, are capable of encompassing multiple features that improve adult understanding: namely, that such non-lecture tools should include topics of immediate value, experiential opportunities (through multimedia, etc.), problem solving opportunities, and real world applications. Rustum Roy captures this idea, and we see that academic instruction (and MSE research) that integrates basic science with applied science and with technology is preferable to instruction that isolates one of these aspects or else relegates one or more of these facets to another academic department or to industry ⁵. As noted

by Roald Hoffmann, a strong compartmentalization of MSE still exists⁶. Comparison of processing methods for different classes of materials (of the sort students engaged in after viewing the Liquidmetal® alloy) is thus a step in the right direction toward merging so-called “disciplines” of MSE. Addressing fundamental properties of materials while also integrating technology in a hands-on method, the *Strange Matter* exhibit fostered effective and enjoyable learning.

Thus, the *Strange Matter* museum exhibit presented by the MRS enhanced the learning experiences of undergraduate students in MSE. Macroscopic models and representations of microscopic features improved students’ comprehension of important principles of materials structure and behavior. The opportunity to touch and manipulate advanced high performance materials brought to life current research in MSE—and moreover connected MSE with real life. As Baglin has noted, it is important to educate even those students who may not pursue MSE since they are still part of a community that purchases, uses, and debates the impact of new materials-related technologies³. Furthermore, the *Strange Matter* exhibit appeared to increase the students’ connection with the subject material as demonstrated by subsequent improved attention in class.

Although I did not specifically use the *Strange Matter* website⁴ in the undergraduate course, I would in future classes incorporate the website even without a visit to the accompanying exhibit. Its content relates closely to the exhibit, contains numerous animations and illustrations, and provides more descriptive explanations.

In conclusion, interactive displays and tangible models of advanced materials—and of basic principles, properties, and phenomena of

MSE—such as those provided in the *Strange Matter* exhibit, are very relevant and highly useful as teaching tools for an introductory undergraduate MSE course.

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