WEB-BASED MODULES TO INCREASE RELEVANCE IN AN INTRODUCTORY MATERIALS ENGINEERING COURSE

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1. INTRODUCTION

The engineering enrollment at Purdue University is among the largest in the country, with nearly 6,000 undergraduate students enrolled in twelve departments. One challenge the Materials Engineering Department (MSE) faces is how to increase the relevance of materials science for those ~400 non-majors who either must take or elect to take the introductory materials engineering course (designated as MSE 230). Mechanical and biomedical engineers must take this course; typically, several aeronautical and electrical engineers volunteer to participate in MSE 230. It is this department's opinion that it is essential for almost all engineering students to understand the relevance of materials science to their major. To increase the relevance of materials engineering to the non-materials majors, we have develop web-based modules that demonstrate the applicability of materials engineering to students whose major is not materials engineering. In this paper we will discuss the development of the four modules, how they are implemented into the introductory materials engineering class, and provide some initial student feedback.

2. MODULE EXAMPLE

To date, we have developed 4 different stand-alone modules, choosing to put these in an overhead format like that found in Microsoft Powerpoint™. The titles of the modules developed include:

1. Why Don't You Go Out and Play!: Piezoelectric Materials in Sports Equipment,
2. Why Don't You Go Out and Play!: Materials Used in Golf Equipment,
3. Materials Used in Space: Very High-Temperature Resistant Materials, and
4. The Hydrogen Economy: Materials Issues Used in Fuel Cells.

Each module is approximately 16 pages long, with a 4-5 problem set at the end. Problem sets were designed such that each has design component question that typically involves graphing a set of data, followed by interpretation and selection of a best material.

To illustrate module design the piezoelectric module will be discussed in more depth in this section. Figure 1a shows the purpose of this module, describing the emphasis on understanding the "science and engineering that goes into designing with new materials," and "understanding how processing influences microstructure and final properties." Each of the four modules includes a purpose statement to clarify what they are expected to learn. Figure 1b describes the problem the new material, in this case piezoelectric materials, is intended to solve. For this particular module, the problem is "chatter" that occurs when a skier is "zooming down a hill." A need statement sets up the rest of the module; in this case the need is for "tiny shock absorbers."

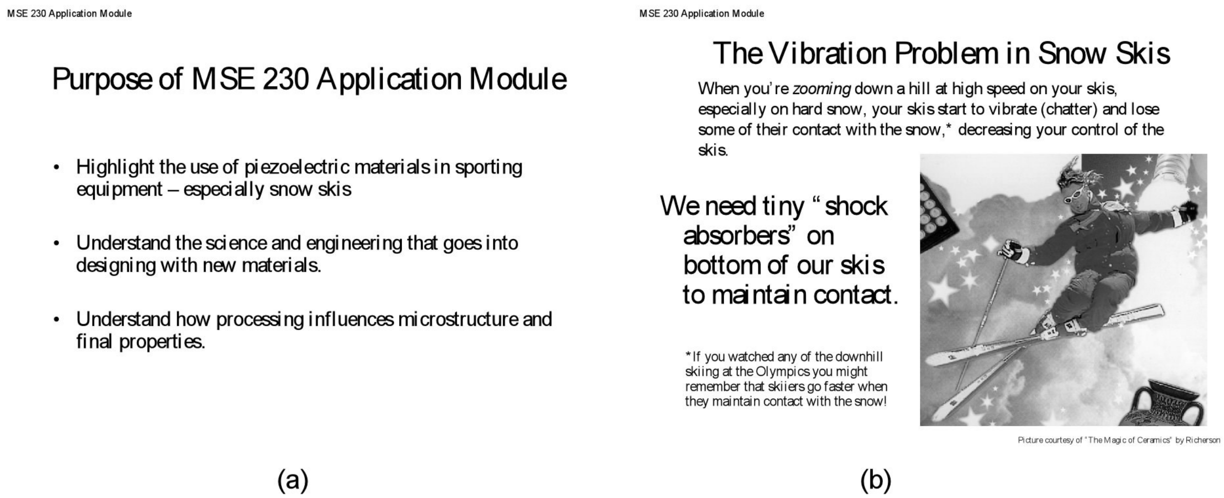


Figure 1: Highlights from the "Why Don't You Go Out and Play!: Piezoelectric Materials in Sports Equipment," module developed for MSE 230. (a) shows the purpose statement, and (b) develops the problem statement solved by piezoelectric materials.

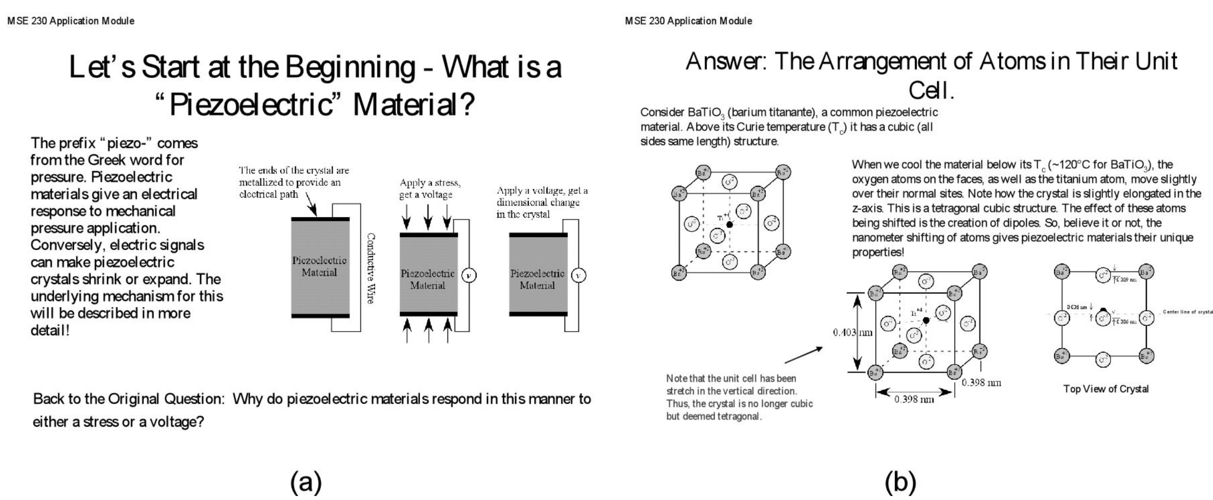
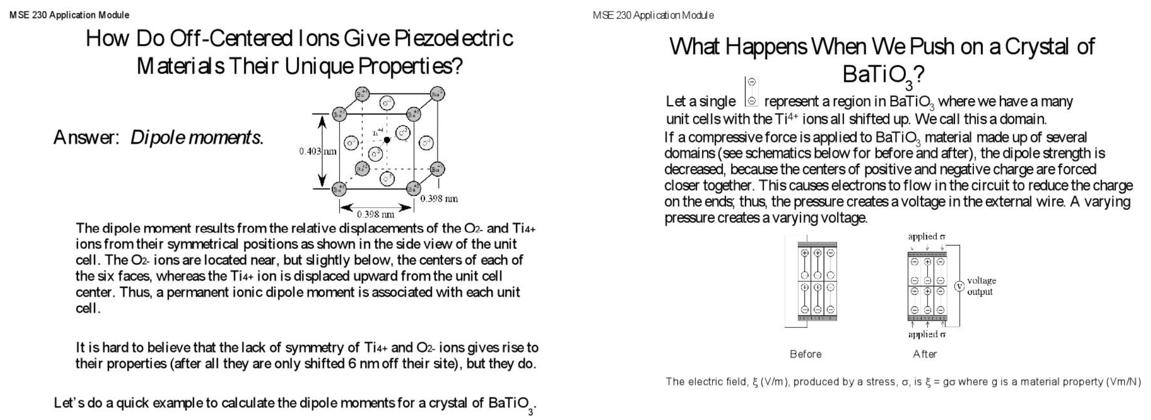


Figure 2: Slides from the "Why Don't You Go Out and Play!: Piezoelectric Materials in Sports Equipment" module that are intended to (a) describe the basic properties and (b) develop an understanding at the atomic level of how a piezoelectric material works.

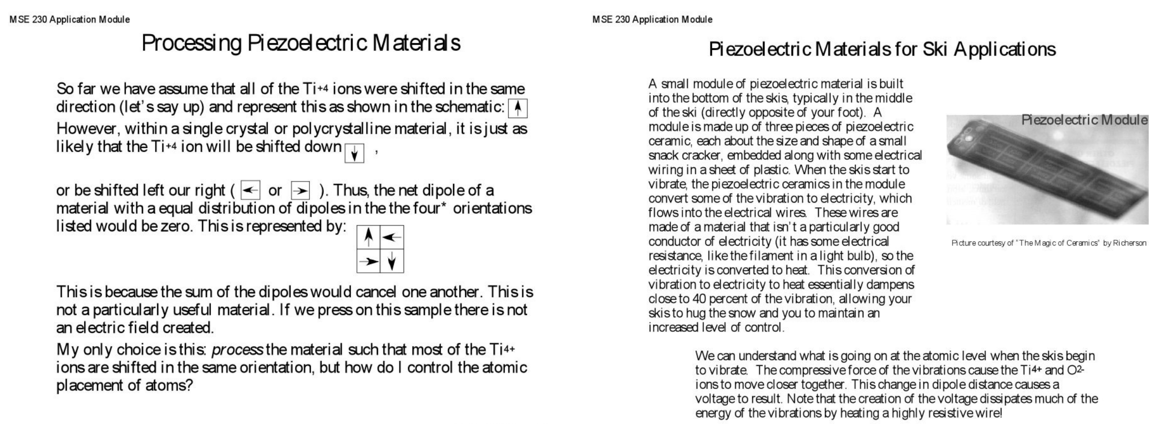
The answer to this need statement, which in this module is piezoelectric materials, is given in the next slide (not shown). From this point in the module the goal is to describe the basic properties of a piezoelectric material (see Figure 2a), and then develop an understanding at the atomic level of why it has these properties (see Figure 2b).

The next 5-6 slides were used to develop more understanding of the basic underlying phenomenon that cause piezoelectric materials to have their unique properties; specifically this is due to the "dipole moments" created by atoms being shifted slightly off center (see Figure 3a). Figure b shows what happens when a stress is applied to a piezoelectric crystal.



(a) (b)

Figure 3: Slides from the "Why Don't You Go Out and Play!: Piezoelectric Materials in Sports Equipment" module that are intended to (a) show that dipole moments are responsible for the unique properties of piezoelectric materials and (b) what happens when you push on crystals of a common piezoelectric material ($BaTiO_3$).



(a) (b)

Figure 4: Slides from the "Why Don't You Go Out and Play!: Piezoelectric Materials in Sports Equipment" module that are intended to (a) show some simple processing concepts for preparing piezoelectric crystals and (b) finishes by connecting the original problem (skis chatter or vibrate) with the piezoelectric material that can solves this problem.

The module ends with several slides that discuss the processing of piezoelectric material (see Figure 4a) and finishes by connecting the original problem of ski vibrations with specifically how the piezoelectric material can alleviate the problem. The last slide in the module (not shown) is the homework problems.

3. IMPLEMENTATION OF MODULES IN MSE 230

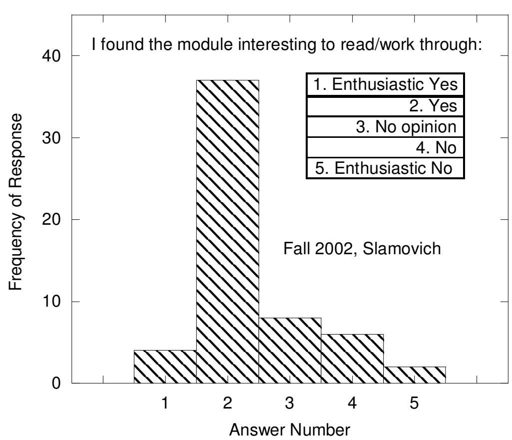
The four modules are posted on WebCT after the second exam. Students in MSE 230 are given the choice to select one of the four modules with the idea that they will download the file off of WebCT, read and work through it individually, and then complete the homework assignment associated with it. The homework for these modules is due the final week of class. As with any other homework, students can approach the teaching assistants or the primary instructor for help or clarification. On the final exam, students are to check the module they completed, then answer the module specific question. Because it is difficult to write questions with the same level of difficulty, student grades are normalized between modules.

4. STUDENT FEEDBACK

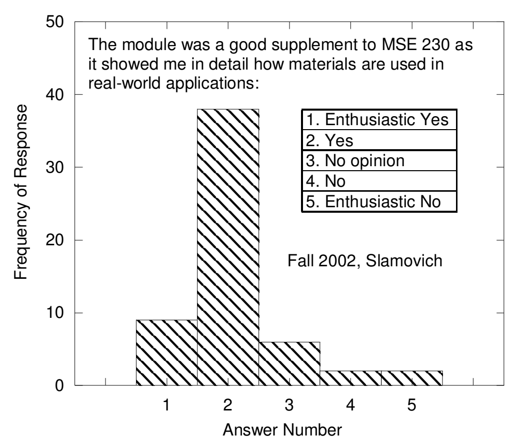
To date, the modules have been used twice during the teaching of MSE 230; thus, the discussion will be divided into these two years.

Fall 2002 Module Feedback: Only one module was available for use in Fall of 2002; it was essentially a combination of the modules dealing with piezoelectric and golf club topics. Thus, its length was ~32 pages. Approximately 160 students were in this class. The students were asked to respond to the following questions during the end of the semester evaluations:

1. “I found the module interesting to read/work through,” and
2. “The module was a good supplement to MSE 230 as it showed me in detail how materials are used in real-world applications.”



(a)



(b)

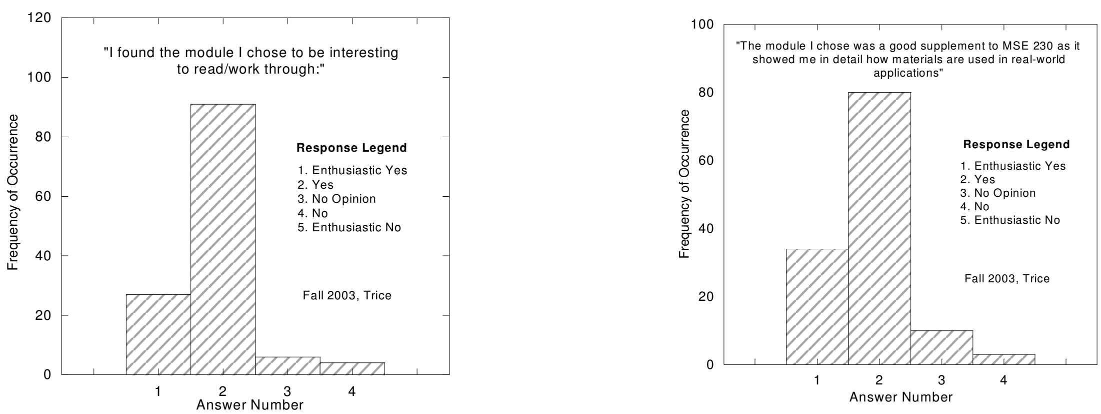
Figure 5: Histogram of student responses to question, (a) “I found the module interesting to read/work through” and (b) “the module was a good supplement in MSE 230 as it showed me in detail how materials are used in real-world applications.” This data was collected fall 2002.

Students could respond by circling one of five options that best represented their thoughts including “enthusiastic yes”, “yes”, “no opinion”, “no”, or “enthusiastic no”. The frequency of their response to these two questions are shown in Figure 5a and b. Please note that the responses are from section 1 of this class only, but that equivalent responses were obtained from section 2.

For question 1, students in MSE 230 answered either “enthusiastic yes” or “yes” 75% of the time; the percentage of negative responses (no or enthusiastic no) was approximately 8%. The student response to question 2 was either an “enthusiastic yes” or “yes” 77% of the time; the percentage of negative responses was approximately 8%.

The students provided written comments as well. The most reoccurring comment was that the module was too long. In response to that, this module was divided up into individual modules dealing with piezoelectric and golf club materials. Thus, I divided up the “Why Don’t You Go Out and Play!: Materials Used in Sporting Equipment” module into two separate modules, one focusing on piezoelectric applications and the other focusing on titanium alloy applications. Future modules developed all have ~15 slides.

Fall 2003 Module Feedback: During the summer of 2003, two new modules were developed including “Materials Used in Space: Very High Temperature Resistant Materials,” and “The Hydrogen Economy: Materials Issues in Fuel Cells”. All four modules were incorporated into the MSE 230 class during Fall 2003. Student perceptions of the module were assessed using a modified course evaluation sheet that allow differentiation between module completed and engineering major.



(a) (b)

Figure 6: Histogram of student responses to question, (a) “I found the module interesting to read/work through” and (b) “the module was a good supplement in MSE 230 as it showed me in detail how materials are used in real-world applications.” This data was collected fall 2003.

The total number of responses was 130, with 93 mechanical engineers, 18 materials engineers, and 19 “other” engineering majors responding. The overall student response to the question, “I found the module interesting to read/work through” was overall very positive, with 92% of the class responding with either an “enthusiastic yes” or “yes” (see Figure 6a). All the materials engineering majors answered with either an “enthusiastic yes” or “yes” to this same question. The mechanical engineering majors answered “enthusiastic yes” or “yes” 91% of the time; the response indicated by the other engineering majors was similar.

As shown in Figure 6b, the overall student response to the question, "The module I chose was a good supplement to MSE 230 as it showed me in detail how materials are used in real-world applications" was also positive, with a full 90% of the class responding with either an "enthusiastic yes" or "yes". The responses for materials engineers, mechanical engineers, and other engineering majors were all similarly positive. It should be noted that the prior time these modules were used that only 70-75% of the student's answers were "enthusiastic yes" or "yes" to the same two questions. It is believed the improvement in student response is due to two factors: more choices for modules (4 modules in Fall 2003 vs. 1 module in Fall 2002) and a reduction in the length of the modules (from 32 pages/module to16 pages/module).

Based on the design of the survey, I was also able to separate out the student responses to the same questions described above with regard to the particular module they chose to complete. The students seemed to think that the module dealing with piezoelectric applications did a particularly good job showing how materials are used in real-world applications.

5. CONCLUSIONS

Four web-based modules have been developed that teach students in a sophomore level introductory materials science and engineering course about real-world applications of materials. These modules have been implemented twice, Fall 2002 and Fall 2003, into the sophomore level course with overall positive results as tabulated using end-of-the-semester evaluation forms. In particular, 92% of mechanical engineering students agreed with the statement that "this module was a good supplement to MSE 230 as it showed me in detail how materials are used in real-world applications." Module lengths of ~32 pages were found to be too long; modules of about half this length were more accessible to the student's interests.

6. ACKNOWLEDGMENTS

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