AC 2009-633: USING ENTRY-LEVEL ENGINEERING COURSES AS A METHOD OF PROMOTING INDUSTRY AWARENESS

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Abstract

In today's service-based culture, certain industrial and manufacturing jobs have gained a reputation for being dirty, boring, and outdated. Even more, due to the ingrained nature of this reputation, many students have learned very little to nothing about these jobs and industries. Due to negative stereotypes, students may dismiss possible employment in these areas before they can even learn about the industries. This research describes a method aimed primarily at integrating information about industrial establishments, particularly those in iron and steel making, into first-year materials engineering curricula in order to acquaint students with a major national and international industry. A second goal is to educate students about the close relationship between steel and their engineering studies. Through these unique integration measures—which involve using aspects of industry as examples, and providing samples of manufactured products to add a tangible quality to classroom learning—not only would students have a wider array of information leading to more informed career decisions, but steel companies and others would be aided in recruiting a new foundation of employees. The effectiveness of the implementation of this approach has yet to be determined, as it has only recently been put into place, but a survey gauging students' knowledge and interest in the steel industry was given at the beginning of the course and was followed by a second survey, both aimed to help measure the success of the new teaching tools. Through accumulation of these surveys over a span of time, the success of these methods will be determined.

Introduction

First year students in modern engineering programs are constantly inundated with buzzword research topics. They come into college with notions about technology and engineering that do not measure up to reality[1]. Anything with the prefix “nano-“ or “bio-“ has a reputation for being exciting and interesting while other, more thoroughly studied subjects are looked upon as stagnant. In fact, in most studies, students in materials science seem to prefer studying so-called advanced materials as opposed to those materials that are most widely used and produced in today’s world[2]. One such industry that has been unfairly pegged as “old-fashioned” is the steel industry. Due to reports in news media of job-losses or accidents at factories, events that will always garner media attention, students are less likely to see that the industry can offer an exciting career opportunity[1]. Therefore the challenge facing the steel industry (and similar industries) in recruiting their next generation of engineers is overcoming this stereotype and presenting a true image of industry in the modern world. These representations may best be overcome with education that provides students with an accurate view of the modern industry. Were steel companies to partner with universities to present information to freshmen engineering students, many of the negative stereotypes of the industry could be dispelled. Indeed, with a fresh work force, new achievements in the industry are sure to follow[3].

Another issue, which became apparent during the course of this study, is a complete lack of knowledge about the steel industry. Many students had no prior knowledge of the processes or science occurring in the steel industry. Many knew only enough to broadly state that many items in our society were made of steel. Therefore, not only would a partnership between industry and university require attention to the industry's reputation, but also to basic education pertaining to iron and steel. One such partnership idea is for materials science and engineering programs to include basic aspects of steel in their introductory materials science classes. At most universities, engineering students take introductory classes for specific majors. Integrated into an entry-level materials science course, information on ferrous metallurgy would provide a foundation for basic materials science and steel-making concepts and would be beneficial for both the university and industry[1]. In order to achieve this goal without completely revamping their lesson plans, instructors could instead continue teaching existing fundamental content, and use examples in the area of ferrous metal technology to reinforce the information. For example, when teaching the difference between various crystal structures an instructor could use the transition of steel from one crystal structure to another as an example to illustrate this. Using examples that tie into some of the most essential concepts of materials would help introduce students to important content and dismiss any negative precepts the students had about the steel industry in general. Students would understand as well that the iron and steel field, as the largest metals-based market in the world, still has a wealth of exciting discoveries to be made[4]. Through integration with an existing curriculum, the steel industry and engineering students would be greatly aided by this new material. The specific structure of the lesson given at the University of Kentucky in 2008 is described below in detail.

Background and Structure of Plan

In their first semester at the University of Kentucky, all engineering freshmen take introductory major-related courses. These introductory courses are designed mainly as an overview to engage new students and to introduce them to not only collegiate learning, but to a variety of the subjects they will study during their university degree program. The students who enroll in these classes typically have little to no practical knowledge of the subjects contained within their new program of study, so the class also serves as their first impression of any particular degree. The specific curriculum used in the class is generally at a lower level, and one or two hypothetical examples per point are shown in order to help reinforce the explanation. By altering the presentation of these examples, they can be molded to present practical information about the science, as well as promote industrial ties. If, in these examples, the instructor were to forgo the general examples of the textbook and instead use photographs, samples, and material from industry—ideally provided by a company but alternately drawn from the internet—the students would learn about industrially relevant materials and their real world applications. Additionally, students would glean information about the industry used in the example, gaining exposure to different fields, which could aid in making informed decisions about internships, co-ops, and future careers.

The curriculum implemented in the Fall 2008 semester at the University of Kentucky was tailored for a materials science and engineering (MSE) 101 course. There were 52 PowerPoint slides in the presentation with nearly half detailing either a scientific principle or steel manufacturing process. When a slide with general MSE information was shown, it was immediately followed by a specific example slide relating to the steel industry. The initial presentation lasted about 40 minutes, almost the length of a regular class period. The purpose of this new material was to educate the MSE freshmen about the steel industry. The thought behind each section of the lesson was to present an aspect of materials science and then illustrate this with a practical example from the iron and steel making industry. Fig. 1a shows an example slide and Fig 1b shows its complement. What should become clear to the students is that the basic tenets of materials science are not only important to the further study of the degree, but are fresh, applicable, and important in industry. The goal of the approach is to make presentations in the early engineering curriculum doubly effective. In addition to learning the basics of science, students will also learn about an industry in which this science is used on a daily basis. The expectation is to be able to take the existing lectures, and give them more practical information relative to industry while maintaining their accessibility to beginning students.

Implementation of System

The newly developed lecture was first given in the Fall of 2008. Touching briefly on subjects ranging from crystal bonding and structure to metals processing to basic steel production, the presentation covered a wide variety of subjects. Each slide of the presentation, with the exception of those pertaining solely to steel production, helped give students fundamental knowledge. The presentation began with atomic bonding and crystal structure, then moved to defects, specifically dislocations and grain boundaries, briefly covered stress-strain curves and phase diagrams, and introduced the subject of mechanical testing. The slideshow then lightly touched on the steel industry, including examples of specific steel alloys and processing methods. Although samples were not obtained in time for the initial presentation, the lecture would greatly benefit from relevant product samples. For as many topics as possible, there should be steel samples that illustrate the particular microstructure or processing technique. Previous educational research has shown conclusively that hands-on learning is a very effective tool for students on any level, and one that the students prefer[5]. As a comprehensive approach, several additions to the lecture could be made. First of all, the presentation could be changed from just a presentation of information to a more interactive format, asking the students for input on quantitative and theoretical problems.[6] For example, during the presentation the students could be asked simple materials based questions such as "How do you make a material hard?" After being given time to consider the question and offer answers, the principle could be illustrated using steel. Having a piece of "soft" steel and another piece of harder steel to make the connection more physical would be ideal. The addition of samples to the presentation would help the students to remember not only the lesson, but also the industrial example used in the explanation. Also, if possible, a trip to a steel manufacturing plant would tie together the concepts of microstructure, processing, and properties that form the "materials science triangle"[7]. These changes would be invaluable to students' basic scientific understanding, i.e. the effects of microstructure or alloying elements, and how different processing steps would change those properties.

In addition, another helpful tool for relating industry to science has been discovered. The presentation can now also be enhanced by the integration of the information found on *www.steeluniversity.org*. The combination of dynamic technological teaching aids and instructor engagement has long been shown to be effective in communicating difficult information to all levels of students[8]. The site, developed jointly by the World Steel Association and MATTER at the University of Liverpool, has a large collection of interactive teaching aids covering a wide swath of ferrous metallurgy, which would be a great aid in the instruction of this course. Through the successful integration of all the above methods, this new system could provide a much broader and more encompassing basis for students.

Evaluation of System

Surveys

When implementing an innovation, it is important to be able to measure whether or not the new methods are improving the quality of the educational experience. In order to gauge effectiveness, different surveys were given to the students weeks before and also immediately after the presentation. Surveys were used due to the directness of the method and speed with which the results can be obtained and analyzed, though it is acknowledged that surveys may have a limited effect on convincing others to implement newer teaching methods.[9] As will be seen, the findings have shown that the instructor has a much larger scope for instruction than was suspected at the onset of this project and the evaluation system will change accordingly. The questions for these surveys mainly focused on students' prior knowledge of iron and steel science and industry, as well as their interest in them. Two questions given in the first survey were:

- Do you know of any steel plants in the area or in the U.S., and can you describe any of the products that they make?
- In 1-2 sentences, describe your impressions of the steel industry.

Two questions from the second survey were:

- Did the presentation pique your interest in any particular area of ferrous materials engineering, e.g. processing, property testing, or microstructural characterization?
- After hearing Monday's talk, are you more or less likely to consider an internship or co-op position in the iron/steel industry?

Results

Of the initial 14 students given the surveys, only two knew of any steel production companies in the US and neither of them could initially name any specific product they made. 7% of the students stated that they held a good impression of the steel industry, 21% of the students responded with a poor-mediocre impression, and 72% of the students had no impression at all, knowing nothing about the industry in general. The students were also asked whether or not they would consider working in the iron and steel industry. 21% responded with 'Yes', 21% 'No', and 58% stated that they did not know enough to make an informed decision but would possibly consider it. Overall, more than half of the students knew almost nothing about steel, while fewer than 25% considered it to be an undesirable industry for employment. When initially asked to describe their impressions of the steel industry, one student wrote, "Dated, with limited innovations," while another replied, "I don't know much about it. I don't think that the industry has changed much in 50 years." In the second round of surveys, 83% of students indicated a change in perception of the industry, with one student responding "I was simply unfamiliar with it prior to this semester, so I never had a clearly defined opinion on the industry. Now I view it as an open, potential opportunity…" These results are summarized in Table 1. When asked if, due to the presentation, they were more or less likely to consider an internship or co-op position in steel, 75% stated 'Yes' and 25% indicated that they were not sure. One student wrote that he/she was more likely to consider this option "because it [the presentation] cleared up a few misconceptions I had about the steel industry." In addition to information on the steel industry, the students who were surveyed also indicated that they had gained a nominal understanding of phase diagrams and different processing techniques, and that their interest in the subject had been piqued. Additionally, every student surveyed also felt that the examples for each topic helped them understand the concepts better.

Table 1: Survey results indicating student perception of the steel industry before and after the presentation given in class.

Perception	Before (% of students, 14 respondents)		After (% of students, 12 respondents)
Good	7	Better	83
Poor	21	Stayed the Same	17
None	72		-

Discussion & Future Work

The most surprising result obtained from this research was that instead of students having an inherent negative perception of the steel industry, the majority of them instead knew nothing about the industry. From the surveys it was ascertained that most of the students came into the program looking at future technologies, giving little thought to industries such as steel. This absence of knowledge on the students' part provides a different opportunity for universities and industry than previously anticipated. Instead of trying to change students' perceptions, it appears that an open foundation is available for teachers to build upon. This will afford teachers the opportunity to teach a broader array of information about any industry, giving the students a more basic understanding of the fundamental elements of subjects such as iron and steel. The lack of awareness regarding the steel industry also seemed to play the largest role in any negative perceptions of the industry, as two of the students who had at first specified a negative impression, later indicated that the presentation had made them rethink what they knew about steel and iron making industries. Given the lack of pre-existing opinions about steel, future incarnations of the presentation given to students will require little focus on dispelling negative perceptions of the industry, but can rather "start from the beginning".

After reviewing the methods used in the presentation this year, and also reviewing a number of articles on teaching methods, it has been determined that in the future, the presentation of the material will be changed in several ways. The format will change to a question and answer format, with a less dense lecture and fewer slides. Instruction related to materials and their basic science will be presented as a self-assessment tool for students, asking them to ask themselves what they inherently know about materials science from the world around them, and then answering the questions they have about the material and relating the science to their real lives via the applicable processes of industry. Together with technological aids, steel samples, and a field trip to a steel mill, this lesson would provide a firm foundation of knowledge about materials science as it relates to an important industry.

The evaluation system will also be changed to consist of a survey and a short essay. The survey will be given after the presentation and will address the lecture's perceived effectiveness as well as general thoughts about the presentation. The essay will concern the students' knowledge of materials science, steel, and the relationship between the two. The essay will not be graded on technical content, but will rather be used as a marker to gauge the students' thought processes relating science to the real world. In essence, the essay would ask the student to think about something made of steel that they use or see often and to discuss what the scientific basis (microstructure, processing) for its properties. Using the knowledge they have from high school level chemistry and physics, the presentation, and the trip to a steel mill, the students would be given a list of important scientific terms and asked to look up the definitions, and then use all of these resources to compose their essay. This style of assessment could, after a period of time, provide a wonderful resource for gauging the effectiveness of the presentation.

Conclusion

Using this year's surveys as an indicator, the data suggest that the presentation in the MSE 101 class is an effective tool for disseminating information about science, industry, and the relationship between the two. Considering the large number of engineers currently being trained in universities across the country, and those with plans to study in the field, an effort should be made to provide accurate information on industry and associated opportunities, so that students are familiar with career options. This aim, along with offering an introduction to basic engineering concepts, is the purpose of this new foundational curriculum. The lesson will help to educate students about an important national and international industry and to dispel, if they exist, negative representations of what is, in reality, a flourishing and dynamic industry. Through successful integration of this method and its future manifestations into starter classes, university students will have a better basis for career decisions and become better-informed students in general. Clearly, integration of theoretical and practical knowledge will provide positive gains for both students and industry.

Figures

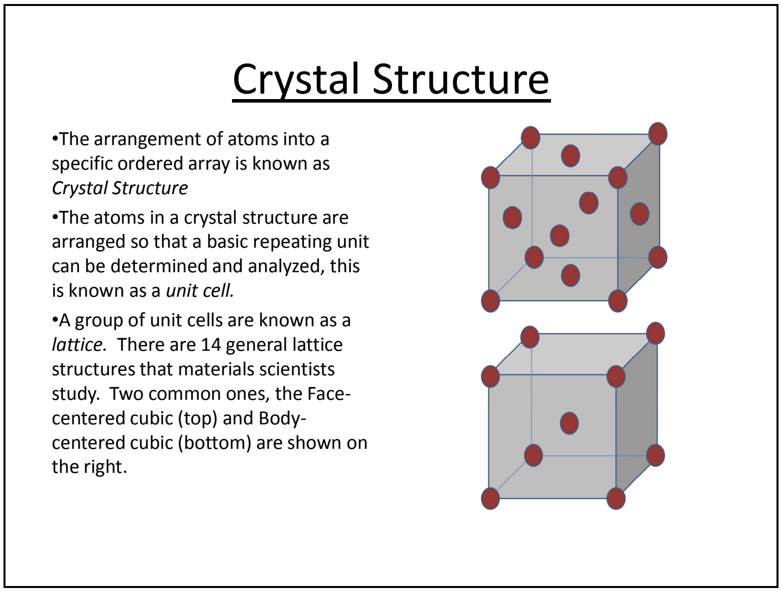

Fig. 1a: An example of a slide contained in the presentation given to materials science and engineering freshman. An understanding of the fundamental concept of crystal structure is essential for students, as it affects the properties of nearly all metals, alloys, technical ceramics and electronic materials.

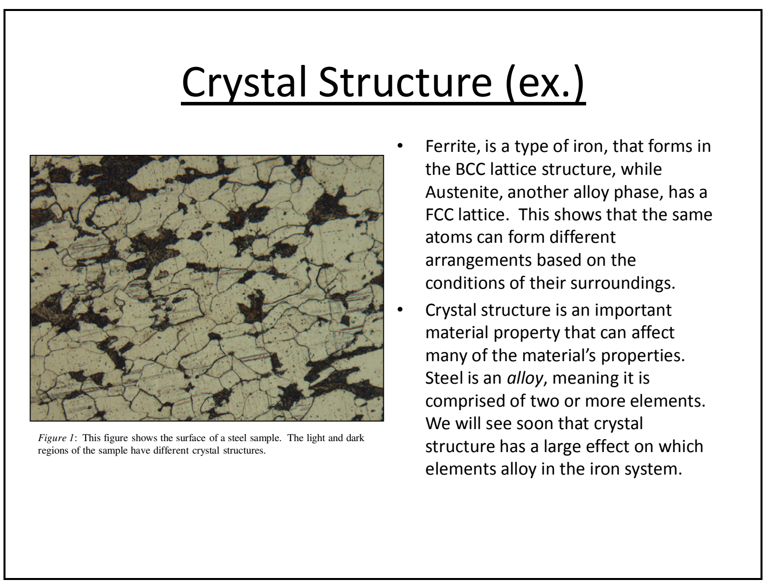

Fig. 1b: Slide with a specific and practical case of how crystal structure can affect microstructure, illustrating the basic information presented in Fig. 1A with an example involving steel.

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