Chapter 6
Innovative Instructional Strategies for Teaching Materials Science in Engineering

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ABSTRACT

Advancements in materials production and materials science education accelerate innovations in many engineering fields. Therefore, strong Materials Science education is extremely important for quality part development and efficient designs. Comfort, safety, and cost requirements can be met utilizing technology and knowledge base advancements. This chapter firstly introduces the contents of a more contemporary materials science education curriculum, and advanced content-related laboratory applications. The applicability of incorporating such content in the current curriculum and number of semester hours necessary to teach such a course are discussed. Finally, it explains the role that engineering educators have in preparing students to develop designs that add to the "triple bottom line" which considers costs in economic, social, and environmental terms. Successful Materials Science education helps technological development and increases innovations. This chapter is significant for its detailed discussion on the shortcomings of current Materials Science education and its recommendations of effective teaching strategies.

INTRODUCTION

Description of Materials Science

Materials Science is a basic core course in most engineering disciplines. Materials types and their structure-property relations in macro- and micro-sizes, along with their strengthening mechanism are the main subject of Materials Science. It is usually taught as a one- or two-semester course depending upon the department's curricular constraints. The course may involve a laboratory session, or alternatively, a separate Materials Science Laboratory course is offered. The course is generally designed to introduce the fundamental properties of materials and the relationship be-

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tween the structure of materials at the atomic scale and their physical and mechanical properties identified by basic sciences.

A possible course syllabus includes topics such as: atomic structure and inter-atomic bonding; the structure of crystalline solids; imperfections in solids; diffusion mechanisms; mechanical properties of metals; dislocations and strengthening mechanisms; fracture mechanics, fatigue, and creep behavior; phase diagrams; phase transformations in metals; applications and processing of metal alloys; structure, properties, applications, and processing of ceramics; structure, properties, applications, and processing of polymers; and composites. Undergraduate and graduate materials science education provides four elements: structure, processing, properties, and performance (Flemings & Cahn, 2000). These are usually considered separately. Each element is extensive, with a huge amount of information that can be presented. As can be seen above, the topics are very broad and therefore teaching the course can be quite challenging, requiring both faculty and students to make substantial efforts and adopt various teaching and learning strategies.

Materials Science is an interdisciplinary course that is related to subjects like Physics, Chemistry, Metallurgy, and Mineralogy. A strong Physics and Chemistry background, in particular, can help students comprehend content more easily. This is because Materials Science uses basic science terms and knowledge to explain structure and properties of materials, although it is not basic science. Without this prerequisite knowledge, it would be very difficult to understand each content item in a short period of time. Traditionally, Materials Science subject content is taught in a classroom; however, initiatives to improve and teaching methods, to include laboratory experience, have also been taken.

BACKGROUND

The Importance of Materials Science

Every product we use in our daily lives is made of different types of materials. Nothing can be done without materials, may it be raw materials or a final product. Metals, plastics, ceramics, and composites are common materials types. Recently, semi-conductors and biomaterials are also considered as materials types. Some subjects are considered to be self-contained disciplines independent of external conditions. However, Materials Science is a dynamic and dependent subject; therefore, it is heavily influenced by technological developments. It will exist as long as the world exists, which offers the field a promising future (Habermeier, 1995). It is recognized to be of central importance to engineering and the manufacturing industry (Briggs, 1995). Research in materials science can easily lead to discoveries, new structures, and materials properties.

Two factors that contribute to technological development and innovations are knowledge and experience. It is important to note that we cannot expect to produce the best product without using the best available option or the best materials for a particular application. Students need to be presented with the essential knowledge and skills to be able choose the best materials for their design and manufacture.

Choosing proper materials for engineering designs requires knowledge of the direct relationship between application area, properties, structure, and processing of materials. For instance, it should be remembered that we cannot use low carbon steel for a high temperature application, no matter how good the material might be. For high temperature application, nickel alloys should be used. That is, a good product cannot be produced without proper

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