Advances in Engineering Education

SUMMER 2013

Product Dissection and Beyond

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BACKGROUND AND CONTEXT

Over the past twenty years product dissection has become a common pedagogical approach to help engineering students build physical intuition about components and systems, and to enable students to make connections between abstract concepts and analyses of the physical systems they represent. Many product dissection activities that are in use today have their roots in Sheppard's (1992) *Mechanical Dissection* course at Stanford; however, numerous engineering product dissection-based educational activities, course modules, or entire courses have been developed since then at multiple institutions. Initially, these developments targeted both intellectual and physical activities (such as dissection) to anchor the knowledge and practice of engineering in the minds of students. However, many product dissection activities that resulted from these initial efforts tended to focus solely on the technological aspects of a product (i.e., how it functions and how it is made).

Recent efforts have sought to extend product dissection activities using cyberinfrastructure tools to study the global, social, environmental, and economic (GSEE) factors that influence the design of products and systems. One such approach is product archaeology, a framework that extends product dissection activities by prompting students to consider products as designed artifacts with a history rooted in their development. The term *product archaeology*, initially coined by Ulrich and Pearson (1998), is the process of dissecting and analyzing a physical product to assess the design attributes that drive its cost. More recently, the term has been formally defined as *the process of reconstructing the lifecycle of a product—the customer requirements, design specifications, and* *manufacturing processes used to produce it—to understand the decisions that led to its development* (e.g., Lewis et al., 2011; Simpson et al., 2011; McKenna et al., 2011). With an "archaeological mindset," students approach product dissection with the task of evaluating and understanding a product's (and its designers') global, societal, economic and environmental context and impact. These hands-on, inductive learning activities require students to move beyond rote knowledge to hone their engineering judgment, extend and refine their knowledge, and apply their knowledge in meaningful ways to realistic challenges. This pedagogical framework thus provides students with formal activities to think more broadly about their professional roles as engineers.

Exploring new educational frameworks is also relevant as it relates to educating future engineers to succeed in an increasingly global and multidisciplinary setting. As ABET Outcome h explains, engineering programs should provide "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" (ABET, 2012, p. 3).

For this special issue, we invited submissions related to product dissection or relevant pedagogies, including product archaeology. The goal was to prepare a special issue that has roots in dissection as a pedagogical tool but shows how this approach has been extended to new topic areas, and within various educational settings. After an extensive review process, this special issue presents eight papers that focus on: product dissection, product redesign, problem-based learning, design fixation and product archaeology.

BRIEF OVERVIEW OF PAPERS IN THIS ISSUE

In the first paper of this issue Wittig reports on using a problem-based learning approach that moves beyond traditional classroom walls with the Engineers Without Borders (EWB) program. She reports on the rewards and offers evidence of the educational potential of EWB projects while also providing candid information regarding the challenges often involved in facilitating EWB projects.

To consider design fixation, Toh, Miller and Kremer share results of an exploratory study conducted in a first-year engineering design class that involved the dissection and re-design of electric toothbrushes. The paper describes the metric they used to measure the design fixation, and how it was derived from the work of others. The authors conclude from their findings that fixation effects are affected by the participant's involvement in the particular categories of dissection activity and that individuals with certain personality traits (e.g., extraversion, conscientiousness) were found to participate more in the team-based dissection activity.

Hansen and Lenau report on their experiences using product analysis and redesign with first year students over a span of eight years. They provide details and examples of what they have identified as three dimensions of analysis, which include: use-process, mode of action, and manufacturing. Providing lessons they have learned over the years, the authors make informed suggestions for finding suitable products for more productive student analysis and redesign.

Dalrymple, Sears and Evangelou build on the original idea of product dissection and present the methodology, analysis, and findings from a quasi-experimental study. In this study the authors used various items (e.g., measures of motivation, component identification questions, variant design questions) to compare two groups of students. The treatment group experienced DAA (Disassemble/Analyze/Assemble) activities involving a disposable camera; the control group experienced a lecture that was accompanied by a multimedia presentation. The authors report on evidence of advantages of the DAA activities.

Grantham, Kremer, Simpson and Ashour explore how product dissection fits in situated cognition theory. The authors focus their investigation on functionality and creativity related to the redesign of a coffee maker with two groups of students, those with and those without previous related experience dissecting the product. The students in the study who had previously performed product dissection were able to focus on both form and function of the product, while those who had not engaged in dissection focused primarily on the product's form.

The article by Moore-Russo, Cormier, Lewis and Devendorf addresses the challenge of meeting ABET Outcome h in an innovative way using product archaeology as the core curriculum paradigm. The authors outline how the promotion of engineering design across the curriculum can provide educators more opportunities to address global, societal, economic, and environmental factors in designing engineering solutions. The paper outlines how product archaeology has been implemented in two mechanical engineering courses - one a lower-level introductory course, the other an upper-level design course. The authors report that the incorporation of product archaeology in each course has had a positive impact on students.

While Moore-Russo and colleagues report on more extensive alterations to infuse product archaeology in courses, Kremer, Simpson and Ashour investigate the effectiveness of embedding just five hours of product archeology experiences in a first-year course and in a senior elective course. Based on their findings, the authors report that for both levels students' perceptions suggest that product archaeology inspired curricula seem to be not only effective, but an efficient, means of increasing engineering students' awareness of global, societal, economic, and environmental concepts.

In the Neumeyer, Chen and McKenna paper, the authors present their framework for implementing a product archaeology approach in two instantiations of a senior level engineering design course. The paper reports students' interpretation of contextual factors, particularly as they relate to a product's design specifications. The paper reports students' responses that characterize aspects of ABET Outcome h including global, social, environmental, and economic factors. The authors also report that students extract factors related to GSEE aspects from a diverse set of resources such as websites, clients and users.

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