

Engineering Design, A Shift From a Process to a Model-based View

William A. Kline
Professor of Engineering Management
Rose-Hulman Institute of Technology
Terre Haute, IN

William D. Schindel
President
ICTT System Sciences, Inc.
Terre Haute, IN

Abstract— A design education approach is presented using a model-based framework emphasizing information collection and construction of model views. This approach is based upon a “meta-model” from the field of systems engineering and includes a keen focus on creating value as a primary outcome. With a model-based approach, the emphasis shifts to information collection and synthesis and away from the traditional representation of design as a following a sequence of tasks and steps. Two recent developments applying this model-based approach are presented and illustrated with examples. Early classroom results indicate that these new approaches may help to improve student outcomes.

Keywords— design, design process, design models, canvas, creating value, systems engineering

I. INTRODUCTION

The representation of the design process as a series of steps or activities has been a standard in engineering design courses for many years. In spite of this widely held view, both student and more informed designers struggle to achieve consistently successful results with this approach. To address several of the shortcomings of inexperienced designers, an approach to design education is presented using a model-based framework emphasizing information collection and construction of model views. This approach is based upon a systems “meta-model” from the field of systems engineering and includes a keen focus on creating value as a primary outcome. Two recent developments applying this model-based approach are presented and illustrated with examples. This new approach has been applied in several design courses, and “canvas” frameworks have appeared that create a visual tool for analyzing the design problem at hand.

II. DESIGN IS DIFFICULT

In a classic work reviewing the design teaching and learning landscape, it is noted that “design is hard to learn and harder still to teach” [1]. In addition, the distinction is made among the design process followed, the information collected, and the final design outcome. Supporting this assertion of the challenges in teaching/learning design, unsuccessful design results in the classroom and in practice are common. Despite the availability of software based design tools and access to consumer preference data, some 40 percent of new products developed by expert designers still fail to find success in the marketplace [2].

A study of designers has compared the traits of student designers compared to more successful and informed designers [3]. Nine design strategies are identified and the traits displayed by beginning and more informed designers are compared relative to these strategies. Several shortcomings of inexperienced (student) designers are noted including they 1. don’t collect enough or the right information before they start designing, 2. focus on just one or a few ideas, 3. fail to consider a range of options, and 4. follow a simple linear path or other unsuccessful process when conducting the design.

III. DESIGN AS A PROCESS

Engineering educators have represented the design process as a series of steps for some 50 years [4,5]. This process representation documents the main components of successful design, but it is noted that students may fail to grasp the significance of the steps. It is also noted that this design process view makes more sense in a retrospective view of a successful design, but it breaks down when a novice attempts to apply the process to a real, more complex design project. Finally, it is suggested that educators must develop a design education approach that encourages synthesis as well as analysis [4].

A collection of over 120 “design models” has been presented and all representations cited view design as a process and describe sequences of design activities, steps, or iteration [6]. The representations do not clearly describe the information that needs to be collected or synthesized to complete a design. An example of a representation of design as a process is shown in Fig. 1 [7].

IV. DESIGN AS AN INFORMATION AND MODEL-BASED ACTIVITY

Building on findings presented in previous sections that design is represented as a process, unsuccessful design outcomes are common, and inexperienced designers often don’t collect enough or the right information before starting a

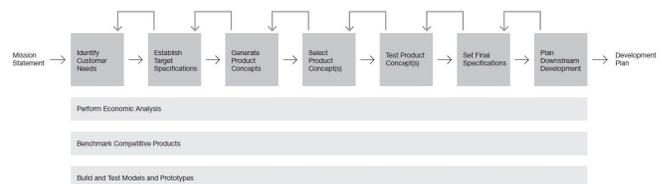


Fig. 1 – The Design Process from Ulrich and Eppinger [7]