Work in Progress: A Student Developed Repository of Design Knowledge

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Introduction

The construction and use of a repository for design knowledge can serve several roles in an educational setting. For the instructor, the repository can act as a window into the students' design process, status in a design project, and understanding of design concepts where the construction and use of elements of design knowledge require achievement at levels of learner knowledge corresponding to basic understanding, understanding of relationships, and transfer of knowledge. For the student, the repository can be a source of solutions to specific design problems and provides the structure and easy to use digital tools for reporting on design accomplishments. This presentation reviews the implementation of a design repository used in a sophomore mechanical engineering design course.

Design Knowledge Repositories

In practice, organizations manage knowledge in order to leverage the varying expertise of employees separated by location, cultural barriers, or time. In the context of engineering design practice, this knowledge can be can be used to spark conceptual design innovation or shorten product development in various ways by enabling the reuse of proven methods and artifacts.

The operations that must be addressed in order to realize a design repository are 1) a representation for a design knowledge element, 2) a method for storing or uploading the knowledge, and 3) a method of searching and retrieving the knowledge for reuse. Several implemented repositories provided the background for the structure of the design knowledge repository. Szykman and Sriram[1] developed a design repository software system that provided insights into the use of design repositories in conceptual design. Bohm et al.[2] developed a data representation for use in design repositories that captures multiple attributes of components or assemblies including core elements of form and function. Hart et al.[3] proposed a framework and use of cyber infrastructure to guide design learning through dissection activities.

Implementation

In previous applications, design repositories have been put in place to "allow designers to store and retrieve design knowledge at various levels of abstraction — from form…to function."[2] In order for students to successfully use a design repository they must achieve at multiple levels of learner knowledge[4] to understand the core concepts that define an element of reusable knowledge (information level), understand how a design concept can be decomposed into elements of design knowledge and are related to elements of design knowledge from other students (understanding level), and be able to transfer the design knowledge to a new design problem (application level).

In this design repository, students used digital pens and a wiki to document a product level representation of their design and a component level representation of several elements of their design. The product level representation constituted a wiki page that contained a sketch of the entire product, acquired using the digital pen, and a decomposition of the product into a table of components and corresponding functions. The students also completed several component pages, each of which defined an element of design knowledge that can be reused. The component pages were linked from the product decomposition table.

The design knowledge representation (component page) consisted of three basic elements 1) the form of the component, assembly, or sub-assembly, 2) the function of the component, assembly, or sub-assembly, and 3) a math model, including all assumptions and equations used for analysis and design decision making. In order for students to construct and reuse elements of design knowledge they must first understand the concepts of function and form and the governing math and science related to the components. Their understanding of these basic elements is revealed through an evaluation of the correctness of each element alone and with respect to other elements on the page (i.e. the component was labeled with an appropriate function).

The wiki tagging structure was used to apply function tags to each of the design knowledge elements. The tagging process provides insights for the instructor into student ability to connect concepts of function in their product to abstract concepts of function that generalize across all electro-mechanical devices. The tagging also serves as the mechanism for locating design elements for reuse. The wiki structure provides a tag cloud through which future students can search the component pages (physical form and math model) for options that address their functional needs.

The use of structured forms to evaluate student design work at intermediate and final stages of design has been piloted in other forms[5] with positive results. In courses with large student to instructor ratios, a design repository provides the opportunity to evaluate and provide feedback on student work in a timely and concise manner while still providing insights into their depth of knowledge in design in general and in the context of their projects.

Bibliography

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