

# DESIGN OF E-LEARNING ENVIRONMENTS FOR ENGINEERING DESIGN STUDENTS

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## ABSTRACT

This paper analyses two online resources for engineering students, an information portal (“Design Surfer”) and a collaborative tool set for supporting engineering student projects (“Project Web”). The paper discusses the use of existing heuristics as a measure of website usability and success. These heuristics focus mainly on the development of sites that transmit information in one direction. The need for further heuristics and principles that guide the specific development of active and engaging online resources for engineering students has been identified.

*Keywords: Internet, Heuristics, Web Development, Engineering Design Projects, Active Learning, Online Learning*

## INTRODUCTION

One of the eternal challenges for engineering design educators, particularly in mechanical engineering, is providing students with authentic design experiences equivalent to industry. Time and budgetary restraints have made it nearly impossible for students to be part of a design and build team. Many educators have turned to multimedia and internet technologies to create such things as virtual design projects and simulations in an attempt to expose students to more “real” situations.

This paper critically analyses two different online resources for student designers, the “Design Surfer” and “Project Web”, against a set of usability metrics and heuristics[1-4], usage data and user feedback. This analysis points towards some design principles for the future development of e-learning environments aimed at developing design abilities in engineering courses.

## “DESIGN SURFER”

The “Design Surfer”, created in 1995, is an information portal for design students focusing on the processes, methods and methodologies in engineering design. It has been developed over several years and has undergone many content and structural changes. The present version of the “Design Surfer”, created in 2002, has two levels of themed directory navigation. The site contains 51 flat html pages and 15 printable documents (in pdf format).

The site has a hierarchical structure with converging branches and secondary links [1] as illustrated in Figure 1b. Figure 1a shows a traditional hierarchical structure. This is an intentional design feature to maximize the chance of the user navigating to a piece of information. However this chosen information structure is not always obvious to the user. Farkas et al point out that the underlying structure “should help users build a mental map of the node-link structure of the site (p348)”[1].

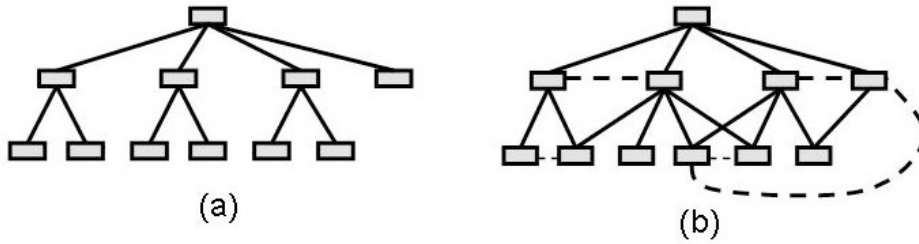


Figure 1: (a) Traditional hierarchy information structure. (b) Hierarchy structure with converging branches and secondary links as used in the “Design Surfer”.

The top level browsing themes for the “Design Surfer” include; Design Engineering Basics, Working in Teams, Generating Ideas, Requirements, Concepts, Decisions, Embodiment and Communication. These themes are intentionally based on the general design process, such as those illustrated in Cross[5] and Pahl and Beitz[6]. Figure 2 shows a screen shot of the “Design Surfer” home page.

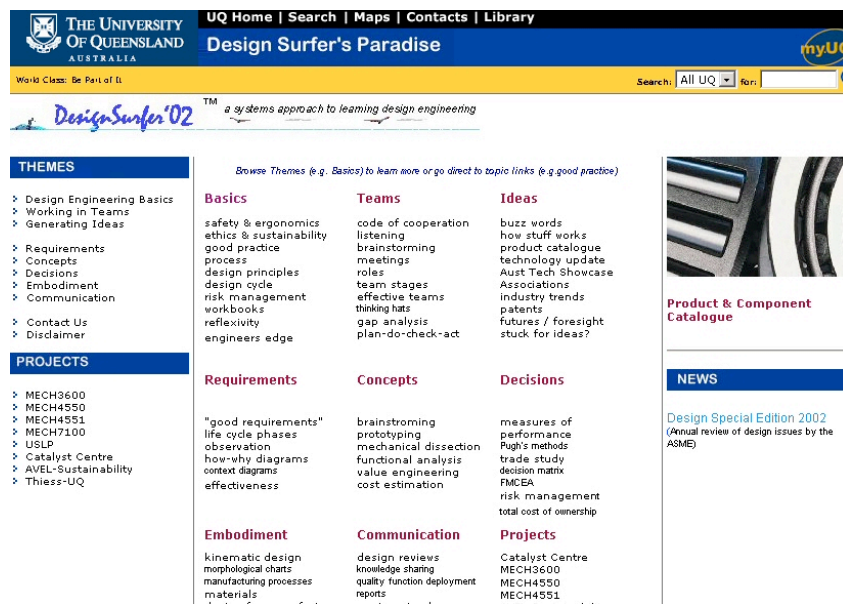


Figure 2: “Design Surfer” home page. The user has the choice of navigating step by step through the hierarchy by clicking on the major headings or the left menu, or accessing resources directly by clicking in the minor links in the centre of the page.

## “PROJECT WEB”

While the “Design Surfer” offers students access to many useful resources, it does not offer them the opportunity to apply the information and concepts. “Project Web” is a prototype collaborative tool for supporting student engineering project teams and providing them with an active environment to engage with the concepts required to successfully “run” an engineering design team. It draws on the core ideas of commercial

project management software but aims to deliver a much simpler, more accessible product that allows students to focus on and be actively guided through the fundamental concepts behind managing engineering projects. The prototype version of “Project Web” contains the following tools:

- A multi level access area for describing the project
- Client briefing (uploaded by course coordinator)
- A multi level access area for maintaining and developing the project scope
- A multi level access area for maintaining and developing the project requirements
- Contact details of project members
- A discussion area
- A facility for setting meeting agendas and posting meeting minutes
- A file sharing library
- A project scheduling facility that monitors actual and projected time.
- An individual task allocation and monitoring facility.

The “Project Web” prototype was initially used in a project based engineering management and communication course on a voluntary basis. There were nineteen student groups in the class. Groups actively engaged in the use of the available tools at various levels. Figure 3 shows the number of groups that actively used the various tools.

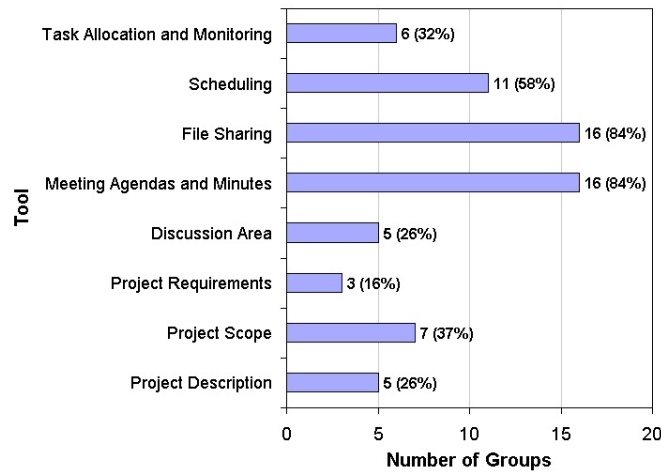


Figure 3: Usage of “Project Web” tools.

While use of the system was voluntary and not assessed, students were asked to reflect on their management practices and methods including their use (or otherwise) of project management as part of the course assessment. Analysis of this data has concluded that the major obstacle to the use of “Project Web” was the “barrier to aliveness”, motivating students to log in and add and maintain information. In many cases students found it easier to email information because it did not require them to continuously check “Project Web” for new updates and postings. Students also viewed the systems as a communication tool for completed work rather than a place to “do” work.

The following is a more detailed description of the functions included in “Project Web” and a performance analysis based on usage statistics and feedback from students.

### **Project Description Function**

The project description function contains three levels of open text fields for the project members to describe their project. The three levels correspond to, public access, class access and group access. Group members can create project descriptions specific to these groups, tailoring the information for the appropriate audience. The initial concept for the three levels of access was to provide students with the opportunity to share ideas and progress with their cohort and the external community, while still having an area to place information only accessible to their group.

The public access field was initially populated by the course coordinator. Six groups actually removed these descriptions from the public view and only two groups placed further information about their projects on the system for the rest of their cohort to view. Three groups placed further information on the system to be viewed by their group only. This area was intended to provide a workspace, not just a finalized description. Analysis of the information shows little development and updating after the initial stages of the project.

### **Project Scope Function**

A similar multi-level area was provided for defining the scope of the project. In addition to the public, cohort and group levels a field was set aside for the course coordinator and/or project client to place the initial brief for the project. The students could not edit this field. Seven groups used the public field, three groups used the cohort field and seven the group only field. Analysis of the information entered by groups who used two or three of the access levels shows little differentiation in the type of information entered for each access level.

### **Project Requirements Function**

The project requirements tool was again set up using a similar three level approach. Only three groups used this tool, one placed the information on the projects requirements in the public area, while the other two groups placed the information in the group only area. Feed back from in class presentations and group reports suggested that the requirements tool could be vastly improved by providing a more powerful tool for categorising and tracking requirements throughout the duration of the project.

### **Discussion Board**

Each group has a discussion area only accessible to them. This function was actively used a various levels by five groups. Fifty two discussion threads were started with a total of 78 additional postings under these threads. The discussion board was only really embraced by one group. Threads started by individual groups ranged from two to thirty five. Most threads only contained one or two additional postings. The nature of the discussion almost exclusively referred to the progress of the project, arranging meetings and notifying group members of an individual's progress on a particular task. There was little intellectual discussion on critical issues to do with the project content. This is not surprising since students had the opportunity to meet in person to discuss such issues, a much more appropriate medium for discussing difficult issues.

### **Meeting Agendas and Minutes Function**

There is an area in which groups could construct meeting agendas and then append actions to these agenda items during or after the meeting. Individual group members can

add agenda items to be addressed at a meeting at any time before or during a meeting. An initial inspection of the use of the meeting agendas and minutes tools seems to reveal a high adoption and usage rate, 16 of the 19 groups. The 16 groups created a record of 155 meetings through out the semester. However, closer inspection reveals that this function was not used as intended. Most groups used the system as a repository for meeting notes. Groups did not create agenda items before the meetings. Preferring instead to store the notes from meetings in one agenda field, even though an inspection of the content revealed such items contained several distinct agenda items. The primary cause of this is student's lack of preparation before meetings. A much simpler mechanism for recording meetings would be appropriate given students motivations.

#### **File Sharing Function**

"Project Web" allows students' to upload and share files in a common library for each group. Files could be checked out by a group member reloaded after changes had been made. Other group members could download the document while it was checked out but could not reload it. Students' comments and usage of this tool indicate this facility was particularly useful. Sixteen groups actively used this facility for sharing files, although the check in - check out facility was not frequently used.

#### **Scheduling Function**

The scheduling function was in the form of a basic Gantt chart with a time increment of one week. The facility allowed students to compare predicted time for scheduled activities and actual time. The tool was used by just over half the groups (eleven of nineteen). Students found this function easy to use and the concepts contained within it familiar. The large time increment and the inability to group activities did create some resistance to the use of the tool.

#### **Task Allocation and Monitoring Function**

This function allowed the groups to monitor tasks within the project team. Each task is allocated to one or more of the group members. These members describe their input into the task and then enter the time that they spend on each activity. This facility was seen by most students to be in competition with the scheduling function. Feedback indicated that the integrating of scheduling, task allocation and monitoring would greatly enhance the functionality of "Project Web".

#### **USEABILITY HEURISTICS – “DESIGN SURFER” AND “PROJECT WEB”**

The previous sections analysed the type of content contained within the "Design Surfer" portal and the functionality of "Project Web". We must also consider their usability as learning environments, or more particularly identify any factors that could limit their use by students. Turns et al[4] drew on the work of Williams[3], Farkas and Farkas[1] and Spyridakis[2] to develop a set of heuristics and a rating scheme to evaluate the usability of websites, with particular application in engineering education.

Table 1 shows the results of the analysis of the "Design Surfer" and "Project Web" using these heuristics. Clearly, both of these learning support environments have strengths and weaknesses. Both could be improved according to this heuristic analysis. These heuristics, however tend to focus on sites used for transmitting information in one direction and some are not as applicable to environment such as "Project Web".

Heuristic	Design Surfer	Project Web
1. Indicate link destination	3	3
2. Create hierarchical breadth of information structure	2	3
3. Reveal the information structure	3	3
4. Provide orientation information on the home page	3	4
5. Provide orientation information on lower level pages	2	4
6. Provide search engine or index	3	4
7. Provide link to home page from every webpage	1	1
8. Minimise information	2	2
9. Orient readers	2	4
10. Create hierarchical frameworks	2	3
11. Create order in content	3	4
12. Include organisational cues	2	3
13. Use understandable words	2	2
14. Demonstrate credibility	2	4
15. Utilise appropriate size of visual elements	2	2
16. Avoid distracting background	1	1
17. Employ appropriate visual design to reveal information structure	2	3
18. Group related elements	2	3
19. Graphically reveal relative importance among elements of display	2	3
20. Contain consistent and predictable graphical elements	1	1
21. Reveal sequence of information	2	4
22. Ensure text is readable	2	2
23. Include supplementary text	4	4
24. Employ visuals to depict perceptual qualities	3	3
25. Label and use conventional icons	4	4

- 1- Excellent – Consistent with principle; No useability problem will result
- 2 - Good – Minor deviation from principle; Slight confusion, impaired productivity, and reduced satisfaction
- 3 - Fair – Major deviation from principle; Significant detriment to usability
- 4 - Poor- Principle overlooked; User is expected to experience significant difficulty

*Table 1: Usability heuristic evaluation of “Design Surfer” and “Project Web”*

Improving both the useability according to the heuristics and the performance as measured through usage patterns are necessary but not sufficient conditions to assure success. There seems to be more holistic considerations that go beyond the individual functions and features.

### **DESIGN PRINCIPLES FOR E-LEARNING DESIGN ENVIRONMENTS**

The results of this analysis are informing the design of a new e-learning environment, called the Collaborative Engineering Learning Environment (CELE)”. It incorporates elements of both the “Design Surfer” and “Project Web”. The Collaborative Engineering Learning Environment recognises the blurring of the boundaries between engineering design, project management, systems engineering and the development of professional engineers.

### **Communities of Practice and Student Motivations**

Many of the functions supported in “Project Web” were developed based on emerging online tools used for cultivating and operating communities of practice. The distinct and fundamental difference between student groups and communities of practice is that

communities of practice are voluntary[7]. Despite that enrolment and attendance at university is voluntary most students would not identify as being volunteer members of their groups. Students' motivations differ significantly from those of practitioners who join communities of practice. Accordingly the incentives and barriers for keeping student project sites "alive" have to be approached differently. Accordingly we need additional heuristics that take into account the "barriers of aliveness" based on the different motivations that drive students compared to those of practitioners. This is the subject of ongoing research.

### **Inherent Motivation**

Schein[8] observes that learning, and more generally change, occurs when the "survival anxiety" of an individual or group exceeds their "learning anxiety". "Learning anxiety" refers to discomfort we feel when "disconfirming data" challenges what we do or what we know or understand. "Survival anxiety" is the feeling that if we do not change we will "fail to meet our needs or fail to achieve some goals or ideals that we have set for ourselves".

In simple terms, a learning environment can increase the propensity for learning by either raising the "survival anxiety" by putting more pressure on the learner in some way or by reducing the "learning anxiety". A balance needs to be struck. For many engineering students, major sources of "disconfirming data" in relation to authentic design experiences include the need to adopt an explicit approach or methodology and where necessary adapt it to the circumstances, the need to acquire information from diverse sources, the need to make judgements based on evidence, the subtle demands of communication of all types and the need to document and to monitor.

### **Aliveness**

To make a learning environment like CELE "more alive" we can increase the "survival anxiety", for example by making its use mandatory or assessable for credit. Alternatively, and preferably, we can bring the environment alive by lowering the "learning anxiety" through increasing the student's desire to engage with it. This could be achieved by delivering some inherent value to the student, like making their work easier to accomplish through a more disciplined approach to their design work and the management of it.

### **CONCLUSIONS**

If engineering educators are to fully utilize the information technologies as genuine learning tools they must not only design them within the framework of accepted usability metrics but also understand the motivations of the students and the information seeking patterns of engineers. Analysing two internet based tools used within our program from these perspectives has allowed us to begin to develop heuristics and principles to guide the development of much more effective, integrated online tool sets for engineering design students.

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