

# Using web design patterns to support students' web engineering group projects: Lessons learned

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**Abstract.** Design patterns have emerged as a means to capture design knowledge and present design solutions to designers. In this paper, we present our experience in introducing web design patterns within the context of an undergraduate web engineering course to foster poorly designed system by providing students with real and concrete examples of best practices they can utilize and emulate. The lessons learned show design patterns have a great potential for student-centered learning to support analysis and design of websites with a usability focus. Moreover, students' opinion was positive about their experience building websites based on web design patterns.

**Keywords:** Design patterns, usability, undergraduate web engineering course, lessons learned

## 1 Introduction

It is in 1996, when the Department of Computer Science of Universidad Carlos III of Madrid, decided to create a course called "Hypermedia Systems: Design and Evaluation" (HSDE) intended to teaching methods and techniques to design, implement and evaluate hypermedia systems applying basic principles of software engineering and HCI [1]. The course has been evolving over the years, mainly in the topics related to Web Engineering and Information Architecture.

HSDE is one semester elective course for undergraduate students in the Technical Engineering in Computer Science Degree, whose lasting period is about fifteen weeks, three hours per week. Students who enroll in this course have not knowledge about web development or skills in web programming. Moreover, the word "usability" is completely unknown for them.

Despite design principles and usability heuristics were explained during the lectures, students' prototypes suffered from poor usability. Students had problems to operationalize these theories and apply them to the analysis and design of specific web applications.

One way to foster these issues is the use of design patterns. Design patterns have emerged as a means to capture design knowledge and present design solutions to designers in a number of different disciplines [2][3][4] [5]. A large part of the value

of design patterns is regarded to serve as a design aid to disseminate this knowledge to novice designers.

Web design patterns integrate patterns from different design disciplines such as information architecture, navigation, interaction and interface design. Their main characteristics are: documented from a usability point of view; based on a series of design principles and independent of technology [6].

Formulating design knowledge in the form of design patterns is considered to provide more concrete design information not readily available in other forms of design knowledge representation such as guidelines, principles or heuristics [7] [8]. Moreover, design patterns have been used for teaching *human-computer interaction* (HCI) principles [9] and they appear as topic in the knowledge area “Web Systems and Technologies. Information Architecture” in the Curriculum Guidelines for Undergraduate Degree Programs in Information Technology [10].

In this paper, we present our experience in introducing web design patterns both in the theoretical and practical syllabus to enhance the usability in the analysis as well as in the design of students’ prototypes. Design patterns allowed us to bring concrete examples of web engineering best practice into the classroom that students can utilize and emulate for their projects.

The paper is divided into the following sections. In Section 2 we describe the overview of the HSDE course and the web design pattern language used in the course. In Section 3 we show the evolution of students’ projects before and after introducing web design pattern in the course. Section 4 contains few concluding remarks about lessons learned on this experience. Finally, section 5 draws some conclusions and future work.

## 2 Course overview

The intent of this *course* is to provide students with a solid introduction into design and evaluation of hypermedia applications, in particular web applications. After the successful completion of this course, the students should be able to:

- Understanding Web engineering as a multidisciplinary field and its development philosophy;
- Perform a website design project using established process models and best practices;
- Implement a prototype using web standards;
- Apply sound design principles and best practices for usability to website construction;
- Perform usability testing pointing out the web application's strengths and weaknesses.

Figure 1 shows the learning resources of the course including didactic units, tutorials and assessment project. Didactic units are explained during theoretical lectures to provide students with the fundamental issues of this discipline. They include the following topics:

- Overview of Web Engineering and hypermedia

- Development process, with special stress on functionality and usability requirements, as well as techniques for gathering requirements
- Web design patterns as mechanism for reusing design knowledge
- Web and user interface design, including information and navigation design
- Usability evaluation process, including heuristic evaluation, reports of the results of evaluations, and recommendations for solution to usability problems

Tutorials are related to technical issues of the subject fields, i.e. HTML, CSS, etc. The underlying instructional philosophy is to allow students to acquire technical skills whereas develop their class project with the aid of introductory didactic units about web programming (XHTML, CSS, Javascript, XML and XSLT) and web based resources.

The assessment is based on a team project. Project-based learning is the main pedagogical method for this course and provides students with the opportunity to tackle real world situations. The students form small groups (four members) in order to construct a wireframe, following the development process that had been taught during the lectures. There has been a variety of applications proposed by the students as subjects for their projects, such as web sites for schools, universities, conferences, etc. In the two last years, they are prototyping web sites related to e-government. The submission of intermediate deliverables and documentation is required in order to help and advice students along the project.

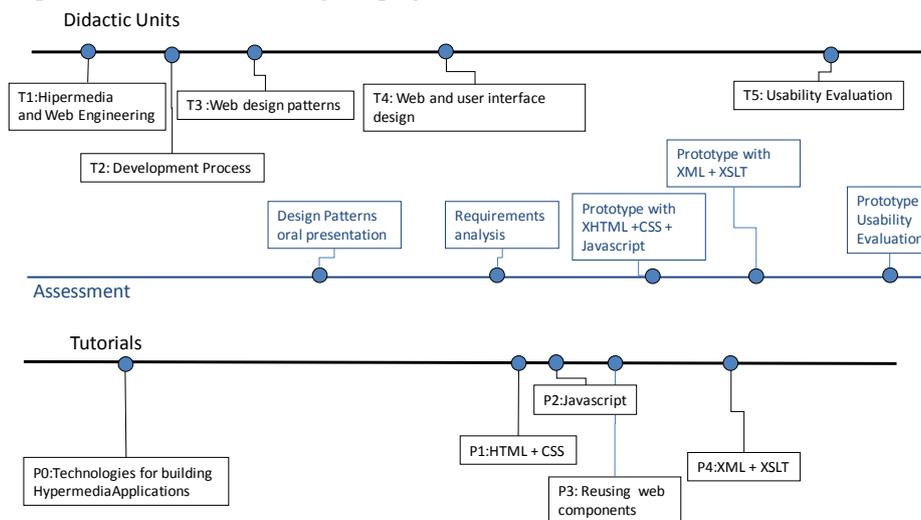


Fig. 1. Course overview

## 2.1 Web design patterns

Web design patterns are one of the topics of our course and the cornerstone learning resource during the analysis and design tasks of the team project. This assessment is based on project-based learning that assumes that students are able to produce a final product that represents knowledge integration. When immersed in project, learners

are required to access and apply related prior experiences. However novice learners, as in our case, lack them at the beginning of the project to enable them to maximize their learning. The following quote summarizes our motivation: “how can students learn by doing what they do, when they do not know how to do what they have to do to learn?” [11].

One way to foster this issue is to provide expert strategies by examples and a context for application. Design patterns have emerged as a means to capture design knowledge and present design solutions to designers. They explicitly focus on context and tell the designer when, how and why the solution can be applied, and allow us to bring concrete examples of web engineering best practice into the classroom that students can utilize and emulate for their projects.

The reference book used in the course is “The Design of sites: Patterns for Creating Winning Web Sites”, by Douglas K. van Duyne, James A. Landay, and Jason I. Hong [6]. Its patterns can be applied to practically any Web *site*, and they include visual references and examples. The macrostructure of the language is divided into a larger and more complex number of major sections: (1) Genre, (2) Navigation framework, (3) Homepage, (4) Writing and content management, (5) Trust and credibility, (6) Basic e-commerce, (7) Advanced e-commerce, (8) Help to fulfill tasks, (9) Page layout, (10) Search, (11) Facilitation of navigation, (12) Speeding up the site, (13) Mobile web. Therefore, this pattern language provides us a wide range of web design problems.

We introduced web design patterns in the course 2004-2005. They have been used in two ways: for User Interface design in a wireframe (2004-2007) and for eliciting requirements (2008-2010).

The way of studying the web design patterns has been evolving. Nowadays, the schedule for this topic is: one hour lecture for introductory concepts; three hours for working in group to prepare an oral presentation with websites examples in which patterns have been applied in a right and wrong way.

In next section, we describe how the students’ projects have changed over the years with the use of web design patterns.

### 3 The before and the after of introducing web design patterns

As mentioned in section 2 students have to develop a prototype using web standard languages and applying the theoretical issues explained during the lectures. Throughout all the didactic units, usability is a recurrent topic, such as concept, part of a user-centered design, heuristics, and evaluation.

Although, at the end of the course students were able to carry out a usability evaluation, they did not reflect in their projects the theories explained. Most of their requirements specification was complete regarding functional and non-functional issues related to the domain chosen, but not regarding usability issues. The most usability requirement included was “this website is oriented for any kind of users” but they didn’t deepen on what such a requirement implied.

Figure 2 shows a screenshot of a representative example of students’ prototype before introducing patterns in the course. Analyzing the projects done during the

course 2003-2004, their main usability problems, even though they had lectures on usability heuristics and guidelines, were:

1. Not sense of home page. They did not use particular conventions about homepage layout, such as logo, sidebars, and navigation tools.
2. Non consistent navigation elements. For example, in Figure 2 the two red rectangles mark the website index. They do not represent primary and secondary navigation. Some entries are the same but they are organized in different way and not use the same format.
3. Some navigation tools were missing, i.e. search box, breadcrumbs, or home link.
4. Pages were rather ugly because the color, image or texture choice for the background affected the website's aesthetic and readability. Moreover, they used the blue color for the text and different fonts for each page.



Fig. 2. A Screenshot of a prototype from the course 2003-2004

During the course 2004-2005 we introduced the web design patterns in the book The Design of Sites [6]. These patterns were presented in the lectures together with the topic “user interface design” to complement the usability heuristics, and thus to alleviate the aforementioned prototypes problems. During the practical sessions, students had to navigate through the pattern language starting from a pattern belonging to Pattern Group A. Site Genres, and to select those patterns that were relevant for their own projects.

Figure 3 shows a representative example of students' prototypes after introducing design patterns in the course. Although students used more web design patterns, next we relate what particular patterns helped them to deal with usability problems:

1. C1. HomePage Portal provided to the projects a strong sense of web portal. (Problem 1)
2. D1. Page Templates showed students how to get a consistent layout and to maintain consistent navigation throughout the site. (Problem 2)

3. B1. Multiples way to navigate showed the need of taking into account different navigation tools such as J1.Search Action Module, K2. Navigation Bar, and K6 Location Bread Crumbs. (Problem 3)

In [6] they don't deal with aesthetic problems issues (problem 4), but students' projects improved in this issue as well, maybe motivated by the examples included to illustrate the patterns.



**Fig. 3.** Screenshots of a prototype from the course 2004-2005 together with the solution of the pattern B1. Multiples way to navigate

In order to compare the students' projects in the courses 2003-2004 and 2004-2005 with respect to the web design patterns enumerated before we calculated their percentage of application, as shown in Table 1. We found the quality of prototypes increased considerably in the course 2004-2005, as well as they looked much more professional. The column 2004-2005 shows a high percentage in the use of these patterns and the usability issues students addressed. In contrast, the column 2003-2004 shows a high lack of these patterns and even some projects did not always maintain the navigation bar visible in all pages.

**Table 1.** Percentages of patterns application

Web design patterns		2003-2004 (8 groups)	2004-2005 (8 groups)
C1HomePage Portal		12%	100%
J1.Search Action Module		12%	50%

K2. Navigation Bar	71 %	100%
K6 Location Bread Crumbs	0%	62%
D1. Page Templates	12%	87%

However, requirements specification still lacked of usability requirements. From course 2007-2008, we asked students they used design patterns as source for eliciting requirements as well. In the requirements specification they had to record if a particular requirement was the result of a pattern or if a particular pattern contributed to resolve a requirement. Table 2 shows the variability of usability requirements in the projects for the courses 2003-2004 and 2007-2008. In the course 2003-2004 students just took into account how each type of user could move through the website and to perform its tasks (navigability) or the application shall be easy for its users to begin using (entry). In the course 2007-2008 there was more variability. Not only students incorporated more usability requirements but functional requirements were focused on usability issues as well. However, there was not a high percentage in the different types of usability requirements. Moreover, accessibility requirements were suggested by most of the requirements specification (B9 Site Accessibility).

**Table 2.** Percentages of types of usability requirements

Usability requirements	Course 2003-2004 (8 groups)	Course 2007-2008 (8 groups)
<b>Ease to Learning</b>	50%	50%
<b>Ease to Entry</b>	100%	62%
<b>Ease of Use</b>	0%	25%
<b>Navigability</b>	100%	100%
<b>Error Minimization</b>	0%	12 %
<b>Understandability</b>	0%	37%

Moreover, in this last course, we have also asked to students (45) their opinion about the use of patterns as support both for user interface design and for eliciting requirements during the elaboration of their projects. Students responded using a 5-point Likert scale from 1(none) to 5 (a lot). Figure 4 shows their responses coded and ranked. Students' opinions of patterns were overall positive (useful for web design). However, the students considered more useful the web design pattern for user interface design than for eliciting requirements. Some students seemed not to share the usefulness of patterns but no-one responded negatively.

In addition, some open questions were asked. All students would return to use the patterns to tackle a new web project. Some of their comments related to why they would do it were "websites are more attractive and usable", "they help to organize site navigation in an intuitive way", "they are a good information source to start a new project", and "they deal with user's needs".

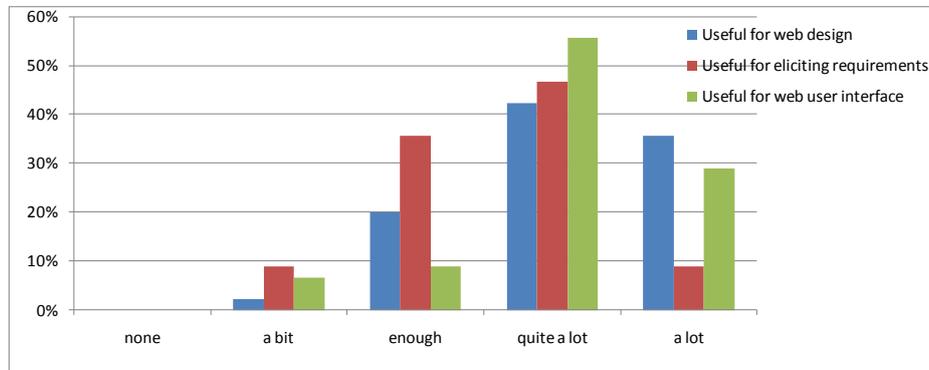


Fig. 4. Student responses about the usefulness of patterns

## 4 Lessons learned

### 4.1 Web design patterns are a valuable learning resource

Our aim with the web design patterns is not to teach HCI principles or web design, but students count on an extra information source to support the lack of experience in web design.

Web design patterns have provided to students the best practices within web design by lots of examples and explanations from an end-user perspective. This has led to:

- Move from teacher-centered to learner-centered learning since students have been proficient with the study, analysis and application of design patterns by themselves.
- Critical thinking to analyze, evaluate and report usability problems caused by lack of design patterns in a particular website.

### 4.2 Web design patterns are beneficial for analysis and design activities

Although our students are not very enthusiastic about the use of patterns for eliciting requirements we have found a considerable improvement in the writing of the requirement specification due to design patterns provide students with a more professional vocabulary for describing designs and solutions. The main benefits found were:

- Requirements are meaningful justified from the user's point of view, e.g. forum messages organized chronologically help user to distinguish between past and present messages (B6 Chronological Organization)
- Usability requirements are more tangible since students might record the pattern or patterns that solve the requirement and so they are able to verify them and trace them during the development.

With respect to the design of the prototype, students are aware of web design patterns provide general solutions that can be applied to different site genres.

- The result of the prototype is more professional. Before introducing design patterns students' projects were a set of HTML pages in which usability issues were not addressed.
- Web design patterns are standard solutions that appear in most web sites. If some of them are missing students understand the website is less usable.

#### 4.3 Patterns by themselves are not a requirement

When students started using web design patterns for eliciting requirements some problems arise.

- Pattern solutions are turned into functional requirements without no mention of the specific project, e.g. Tab rows will be located on the top of the web page (K3 Tab Rows)
- Typical usability requirements are turned into functional requirements just because there is a pattern that deals with them, e.g. The homepage will be simple and explain briefly the web site motivation (C2 Up-Front Value Proposition)

In order to avoid these misinterpretations during the eliciting requirement, face-to-face tutorials become very important. Moreover, it could be considered the inclusion of domain-specific design patterns for such as emergency [12] or learning [13] management systems, to elicit more functional requirements.

## 5 Conclusions

Current studies indicate an absence of the consideration of usability requirements in early phases of the development lifecycle, as well as other studies have pointed out a wide range of benefits stemming from usability [14].

This means that we are preparing our graduates to be aware of usability issues at the early stages of the software development above the current understanding of most of the jobs they will be entering.

Web design patterns are reusable usability design knowledge that students can apply in their future professional, independently if they have to operate with ad hoc or mature development methods.

We have showed how web design patterns are used as support instructional material during the elaboration of the students' project. The most clear use for them is during the web design stage to solve design problems such as make content navigable or provide a consistent layout, but we have showed how students have used web design pattern as well to capture functional usability requirements.

We are working on a deeper study over the result of students' projects to find out if there is any kind of correlation between the number of patterns used properly in the requirement stage, in the prototype implementation and in the usability evaluation and the overall usability of the prototype.

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