Toward the creation of effective virtual learning environments for online education

A dissertation submitted by David García Solórzano at the Universitat Oberta de Catalunya (UOC) to fulfill the degree of Doctor of Philosophy.

Barcelona, March 18, 2013

Director	**Dr Eugènia Santamaría Pérez** IT, Multimedia and Telecommunication Department Universitat Oberta de Catalunya (UOC)
Co-director	**Dr Jose Antonio Morán Moreno** IT, Multimedia and Telecommunication Department Universitat Oberta de Catalunya (UOC)
Adviser	**Dr Joan Claudi Socoró Carrié** The Media Technologies Department La Salle - Universitat Ramon Llull (URL)

This document was typeset by the author using LaTeX.

The research described in this book was carried out at the Universitat Oberta de Catalunya (UOC), Barcelona. The author confirms that the work submitted is his own and that the appropriate credit has been given where references have been made to the work of others.

A Elena,

Ahora que por fin se ha acabado este larguísimo espejismo,
donde encerrado entre las cuatro paredes del presente he vivido,
empieza la realidad de un extenso futuro que estaba escondido,
¡cargado de tantas cosas por hacer! ¡Y todas contigo!

Acknowledgments

Echo la vista atrás y hago balance de lo andado. Ha sido un camino largo, pero más lo hubiera sido sin ti:

Elena, gracias por haber sido en cada instante el agua que me faltaba para ver el vaso lleno. ¡Gracias por tantas cosas! Creo que, por mucho que viva, no seré capaz de devolvértelo.

Papá y *mamá*, ¿qué puedo deciros a estas alturas? Solamente se me ocurre una palabra: gracias. Espero que a partir de ahora pueda llevar una vida normal y recuperar así todas las horas que mis estudios nos han robado durante tantos años.

Abuelos y *tíos*, gracias por estar ahí siempre. Teneros es una gran suerte.

Jose, *Javi* y *Carlos*. Gracias por preocuparos por mí y sacarme a que me diera el aire.

Eugènia Santamaría y *Jose Antonio Morán*, directores de esta tesis y mucho más. Gracias por vuestra orientación y paciencia. Perdonadme los momentos en los que no entraba en razón.

Germán Cobo, compañero de fatigas. Gracias por hacer de nuestra cueva un lugar más habitable.

Carlos Monzo y *Javier Melenchón*, directores a la sombra de esta tesis. Gracias por vuestras indicaciones, sugerencias y, sobre todo, vuestro apoyo.

Montserrat Junyent, *Pepi Pedrero* y *Montse Ricart* o, lo que es lo mismo, mis ángeles. Gracias por las conversaciones, las risas, etc. En definitiva, gracias por hacer el trabajo en la UOC más fácil.

A las chicas de psicología y pedagogía: *Beatriz Sora*, *Teresa Guasch*, *Anna Espasa* y *Mercè Boixadós*. Sin vosotras esta tesis no hubiera sido posible. Gracias por todo lo que me habéis enseñado. Ha sido una suerte que nuestros departamentos estuvieran en la misma planta.

A todos aquellos que, en algún momento de esta tesis, han mostrado su interés: *Julià Minguillón*, *Joan Manel Marqués*, *Jordi Conesa*, *Cristina Ureña*, *Carlos Casado*, *César Córcoles*, *Marta Borràs*, *Adriana Ornellas*, *Laura Porta*, *Laia Blasco*, *Iolanda García*, *Marcelo Maina*, etc.

A todas las personas que me dejo por citar, pero que no por ello han sido menos importantes.

Abstract

In recent years, due to the widespread use of the Internet, online enrollments have been growing year after year. As a result, online education has become a real alternative to traditional face-to-face (F2F) instruction. One of its main advantages is the possibility of learning at any time and any place. To allow this flexibility, the whole teaching-learning process is carried out by means of a virtual learning environment (VLEs) which replaces the physical classroom. Due to the absence of F2F interaction between students and teachers, VLEs provide tools and resources to deliver, track and manage teaching and learning processes. Consequently, these systems inevitably play a significant role in online education. Thus, developing effective VLEs has become a great challenge.

Although VLEs are well-established tools, some researchers argue that most of these platforms are designed from an IT rather than educational approach. In consequence, the teaching-learning process that is conducted through these systems may not be as effective as it is expected. For this reason, this thesis focuses on identifying those elements which may improve the effectiveness of VLEs when they are used in fully online courses. To achieve this objective, this dissertation has employed the design and creation research strategy which is characterized by including a systems development methodology. More specifically, this research work has used three data generation methods (documents, questionnaires and interviews) and prototyping.

First of all, a document-based research allowed to know the implications of online delivery for education as well as the main features, needs and barriers of online students and teachers. Next, eight of the most popular VLEs were analyzed by focusing on their pedagogical approach, information structure and interface. This analysis revealed the lack of a sound pedagogical approach in the core of their designs which affects the functionalities, information structure and interface.

Based on the main conclusions drawn from the document-based research, a set of recommendations/heuristics is proposed so that designers and developers have a simple instrument which allows them to create effective VLEs for online teaching-learning. To evaluate the suitability of each recommendation, these were put into practice by means of three prototypes of an ad hoc VLE called AdVisor, which also included a monitoring tool called FACRO. In this regard, a sample of students tested AdVisor in a real scenario and, afterward, assessed the suitability of the heuristics through a questionnaire. Furthermore, eight teachers were interviewed to know their opinions.

In general, the results have shown that the recommendations are suitable, especially those related to self-regulation (to guide learners through the course and to help them to be aware of their learning process), providing multiple views and giving a student monitoring tool to teachers.

Contents

List of Tables

List of Figures

Acronyms glossary

ACT American College Testing

ADSL Asymmetric Digital Subscriber Line

AJAX Asynchronous JavaScript And XML

ATTLS Attitudes to Thinking and Learning Survey

CA continuous assessment

CAA continuous assessment assignment

CD-ROM Compact Disc - Read Only Memory

CI confidence interval

CLE Collaboration and Learning Environment

CMC computer-mediated communication

CMS Course Management System

COLLES Constructivist OnLine Learning Environment Survey

CSS Cascade Style-Sheet

D2L Desire2Learn

DBMS database management system

DE Distance Education

DM data mining

DVD Digital Versatile Disc

EHEA European Higher Education Area

eLC eLearn Center

EML Educational Modeling Language

F2F face-to-face

FACRO FAceted Class ROster

FAQ Frequently Asked Questions

GNU/GPL General Public License

HCI Human Computer Interface

HTML HyperText Markup Language

ICT Information and Communication Technologies

IMS Instructional Management Systems

IMS LD IMS Learning Design

IQR interquartile range

IT Information Technology

ITOL Interactive Tools for Online Learning

IS Information Systems

InfoVis Information Visualization

LCD Learner-Centered Design

LCMS Learning Content Management System

LMS Learning Management System

LTI Learning Tools Interoperability

MIT Massachusetts Institute of Technology

MW Mann-Whitney U test

NKS NKS Distance Education

OKI Open Knowledge Initiative

OS Operative System

OUNL Open Universiteit Nederland

PDA Personal Digital Assistant

PHP Hypertext Preprocessor, originally Personal Home Page

PLE Personal Learning Environment

QTI Question and Test Interoperability

SCORM Sharable Content Object Reference Model

SUE Systematic Usability Evaluation

TELE Technology-Enhanced Learning Environment

TOC table of contents

UAB Universitat Autònoma de Barcelona

UB Universitat de Barcelona

UCD User-Centered Design

UCL Université Catholique de Louvain

UI user interface

UK United Kingdom

UNED Universidad Nacional de Educación a Distancia

UOC Universitat Oberta de Catalunya

URL Uniform Resource Locator

USA United States of America

VLE Virtual Learning Environment

W3C World Wide Web Consortium

WCAG Web Content Accessibility Guidelines

WOLF Wolverhampton Online Learning Framework

WWW World Wide Web

WYSIWYG What You See Is What You Get

XML eXtensible Markup Language

Explanatory notes

In this section, some explanatory notes to make the reading of this document easier are presented.

Format

Acronyms

A list of all acronyms used in this dissertation can be found in page xxix. Nevertheless, most of the acronyms are expanded when first used in the text.

Bold and italic type

Important concepts, sentences and results are emphasized in bold and italic type.

Italic format

Italics are used for emphasis. Thereby the term or sentence in italics is clear.

Decimal numbers

Decimal numbers whose whole-number part is zero, e.g. 0.589, can be found in any part of this dissertation as *.589*, i.e. without writing the digit zero.

Quotations

Text in quotation marks and italics shows literal sentences that were said by a person or extracted from a questionnaire or interview.

Relevant facts of the thesis

This type of box contains information that is relevant to the thesis, e.g. assumptions, research questions, objectives, clarifications, important conclusions, etc.

Definitions

Definitions are highlighted with this kind of box.

This box enumerates a set of items that will be addressed below.

Terms

Continuous assessment assignment (CAA)

The term *continuous assessment assignment* (CAA) will be used to describe that learning activity which students must do obligatorily during the semester, not in exams. The grade of each CAA is included in the students' final grade.

Lastly, it is worth stressing that the assessment model of the UOC is based on CAAs.

Difference between the terms *teacher* and *teaching collaborator* at the Universitat Oberta de Catalunya (UOC)

Teachers are in charge of the design of the course and are the people responsible for the course, whereas *teaching collaborators* are facilitators that guide students during their learning process. As a result, *teachers* do management tasks and stay in the background, while *collaborators* perform teaching tasks (e.g. grading, clearing up doubts, etc.) and communicate with learners. Therefore, *teachers* coordinate a network of *teaching collaborators* that play the role of the typical teacher to which educational community is used.

Learning outcomes and course objectives

The terms *learning outcomes* and *course objectives* are used interchangeably in this work.

Online

Unless said otherwise, the term *online* is used as a replacement of the phrase *fully online*.

S/he

The term *s/he* can be read as *she* or *he*. Likewise, the pronouns *she* and *her* are usually used to refer to a person, regardless of her gender.

Terms to refer to teachers and students

The words *teacher*, *instructor*, *lecturer* and *facilitator* will be used interchangeably. The same is applicable to the words *student* and *learner*.

Virtual Learning Environment (VLE) and other similar terms

Although the term *Virtual Learning Environment (VLE)* is widely employed, other names such as learning management system (LMS), course management system (CMS), learning content management system (LCMS) and technology-enhanced learning environment (TELE), are used interchangeably in the literature. The term *VLE* will henceforth be used in this thesis.

Statistics

Frequency tables, bar charts, pie charts and box plots

In Appendices D, E and F, frequency tables, bar and pie charts contain *no response* answers, whereas box plots do not.

1 Introduction

This first chapter is devoted to giving the reader an overview of the present thesis. To this end, the following sections will be covered:

- The motivation and problem statement of this research work (see section 1.1).
- The main research objective along with the principal research questions and sub-goals (see section 1.2).
- A brief summary of the context in which this thesis was conducted (see section 1.3).
- The research strategy that was performed (see section 1.4).
- An outline of how this dissertation is structured (see section 1.5).

1.1 Motivation and problem statement

In recent years, society has undergone a radical change because of the use of Information and Communication Technologies (ICT), especially the Internet. This has implied a shift in the way in which people do daily tasks, i.e. to purchase things, search for information, interact with friends, etc. Likewise, education, due to its close relationship with society, has been affected by technology too. In this regard, the use of new technologies has allowed teachers to move beyond the blackboard by creating new learning activities supported by computers, e.g. webquests and wikis. Moreover, ICT have enabled to devise new teaching-learning modalities such as online education (also known as *e-learning*), which can be defined as follows:

Online Education

Educational modality that integrates the use of ICT into the teaching-learning process, providing high quality educational offerings at the same time that it allows for convenient and flexible learning environments, without space, distance or time restrictions.

(Seufert et al., 2002)

Nowadays, online education is emerging as a very popular teaching-learning approach, as evidenced by the fact that ***the number of online students increases every year***. In this regard, Figure 1.1 shows that the percentage of online enrollments (i.e. learners who take at least one online course) in relation to the total enrollments in the USA post-secondary institutions tripled in eight years, this went from 9.6% in 2002 to 31.3% in 2010. Likewise, European online universities have also increased the enrollments in recent academic years (see Figure 1.2). For example, in 2011, the number of students at the Universitat Oberta de Catalunya (UOC), a Spanish fully online university (where this thesis was carried out), was 3.75 times more than that in 2000.

As seen, there is clear evidence to venture to say that there may be a high demand for online courses in the future and, in consequence, ***online education may even become as important***

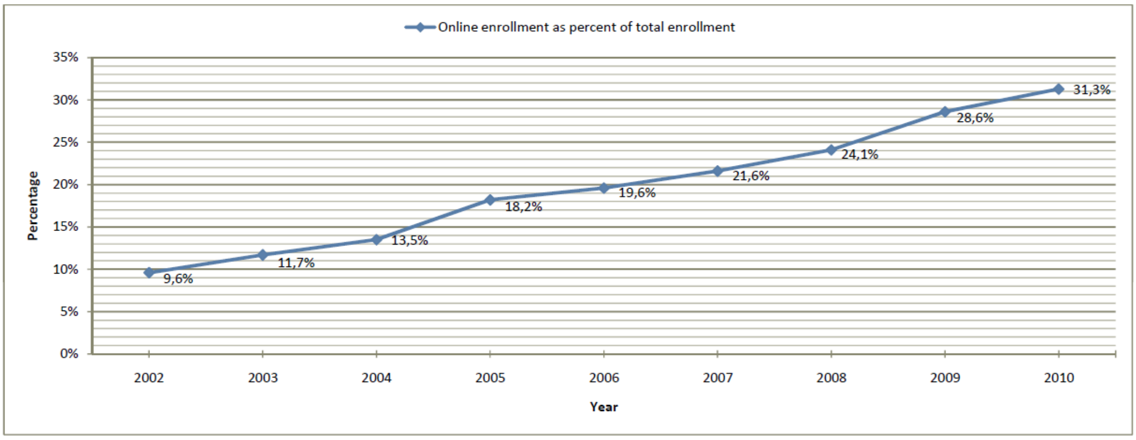


Figure 1.1: Evolution of online enrollment, as a percentage of total enrollment, in post-secondary institutions from fall 2002 to fall 2010 in the United States of America (USA). ***Source***: (Allen and Seaman, 2011).

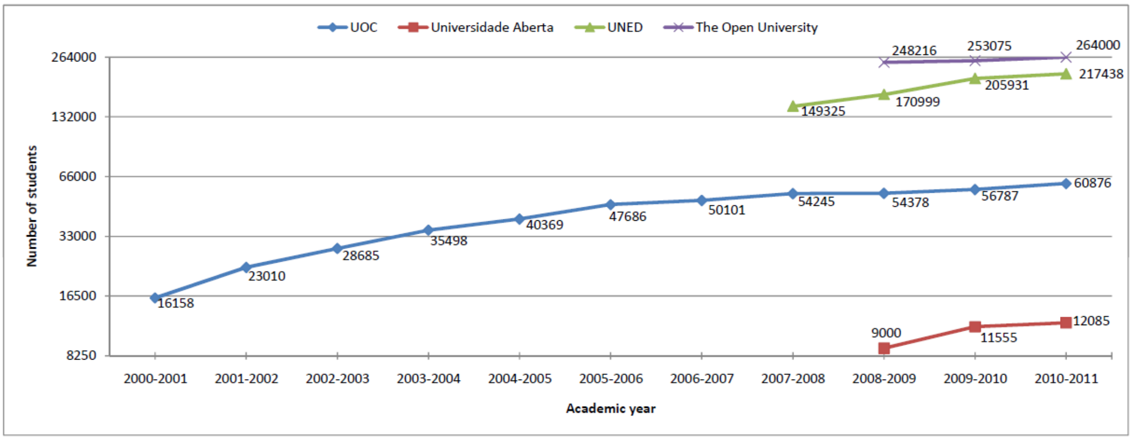


Figure 1.2: Evolution of the number of students in different European online distance universities from 2000 to 2011. ***Sources***: (OU, 2011; UAb, 2011; UNED, 2011; UOC, 2011).

as face-to-face (F2F) instruction. For this reason, more and more universities and schools have taken a firm step toward their virtuality in recent years. Some of them have even achieved robustness, sustainability and critical mass to such an extent that it can confidently be asserted that they are lasting providers that will not likely go away. In order to refer to these well-established online institutions, Paulsen (2007) coined the term *megaprovider of e-learning*, for which he established two requirements: (1) to have more than 5000 online enrollments per year or more than 100 online courses on offer at any time, and (2) at least 51% of a program was fully online. Moreover, Paulsen identified 26 European megaproviders in 2007. Some of them were: The Open University (United Kingdom), Universidade Aberta (Portugal), Universidad Nacional de Educación a Distancia (UNED) (Spain), Universitat Oberta de Catalunya (UOC) (Spain), etc.

Despite its fast growth, online education, unlike traditional F2F instruction, is still in its infancy. Actually, many teachers and institutions have not yet realized either the potential or the particularities that the online environment has. For example, a lot of instructors continue to preserve and translate the learning materials used in F2F lectures to the online classes (Sheely, 2006).

One of the most notable differences between online and F2F education is the replacement of the physical classrooms with virtual learning environments (VLEs). These systems provide, due to the separation between students and teachers that exists in online education, tools, services and resources to deliver, track and manage the whole teaching-learning process. For this reason, ***VLEs inevitably play an important role***.

Nevertheless, the design of most of these platforms is based only on IT guidelines, being detached from any pedagogical approach (Govindasamy, 2002; Laanpere et al., 2004, 2012). In consequence, their effectiveness decreases, since technology itself cannot improve learning process. In other words, a VLE which does not take educational aspects into account is a mere vehicle that cannot satisfy online students' and teachers' requirements effectively.

Because online enrollments continue increasing and VLEs are a key element during the online teaching-learning process, ***there exists the need to develop VLEs whose designs go beyond the IT standards. To this end, it is required taking account of facts, findings and proofs that are the result of a systematic research on online education***.

1.2 Research objectives and questions

The principal aim of this thesis is:

Main research objective

To provide designers and developers with a set of recommendations (or heuristics) that helps them to create VLEs which are effective for fully online education.

In order to achieve the previous research objective, investigations regarding the following research questions were conducted:

Q1. ***What implications does online delivery have in the teaching-learning process?***

The fact that online education revolves around the use of the Internet and new technologies implies a set of advantages and potential problems. For this reason, it is essential that teachers, VLE developers, teaching practitioners and institutions know the strong and weak points of the online environment. In this thesis, a literature review was performed so as to: (1) identify the implications of online delivery for teaching and learning, and (2) compare online and F2F education in terms of students' performance and satisfaction.

Q2. ***What characteristics, needs, preferences and barriers do online students have?***

The main goal of education is to ensure that students learn new knowledge and skills. As a result, in order to guarantee successful outcomes, any learning resource (e.g. lecture notes, tools, etc.) must always be designed by taking students into account. As this thesis focuses on designing effective VLEs for online teaching-learning, it is essential to know online learners' characteristics to meet their needs and preferences as well as reducing potential problems that they may have. In this regard, an in-depth analysis on online students was carried out.

Q3. ***What role do online teachers play and what problems may they find?***

In addition to the student, another important agent in any learning process is the teacher. Once again, the difference in the delivery mode implies that teaching is different when this is carried out online or F2F. Nowadays, many lecturers are used to teaching students who attend classes in physical classrooms at a certain time. Due to new technologies, this has changed and, hence, teachers should adapt their strategies to the online environment. Because online teaching has its own particularities, it is important to identify which is the role of the teacher, what requirements they may have and what problems they may have during the teaching process. These three aspects were studied by means of a literature review.

Having answered the previous three questions (i.e. Q1–3), it was identified a comprehensive set of aspects that should be taken into consideration when teaching online. Subsequently, the following research question was addressed:

Q4. ***To what extent are the current VLEs effective tools for fully online teaching and learning?***

The goal of answering this question was twofold:

- To identify the gap between the functionalities that current VLEs offer and online students' and teachers' needs and preferences.
- To detect if current VLEs take advantage of the potential of ICT and the online environment.

The response of this question was very important, because it focused on the main research topic of this thesis: virtual learning environments (VLEs). Actually, it was a barometer of the significance of this research. To answer the aforesaid question, eight of the most popular VLEs were analyzed.

Given that the aim of this research is to help designers and developers to create effective VLEs for online teaching-learning, two objectives were established:

O1. ***To propose a set of recommendations which helps to create effective VLEs for fully online education***

Based on the results from the research questions Q1–3 and other research works, it has been created a set of recommendations (or heuristics) that synthesizes the most important aspects that should be taken into consideration when designing a VLE for fully online education. This set has been organized into three categories that corresponded with the three cornerstones of any VLE: (1) pedagogy (or educational functionalities), (2) information structure (or course organization), and (3) usability (or interface).

O2. ***To evaluate the suitability of the proposed recommendations in a real fully online scenario***

In addition to proposing a series of recommendations based on a comprehensive literature review, these heuristics were evaluated by real learners and teachers, more specifically, members of the UOC community. To this end, an ad hoc small VLE, called AdVisor, and a student monitoring tool, called FACRO, were developed based on the recommendations suggested in this thesis (see objective O1).

As seen, ***this thesis makes a contribution to online education and, more specifically, to the design of virtual learning environments (VLEs).***

1.3 Context

This thesis was written as a part of my work in Interactive Tools for Online Learning (ITOL), a research group which belongs to the Universitat Oberta de Catalunya (UOC). Moreover, all the experiments were conducted at this university. Next, the UOC and ITOL are described briefly.

1.3.1 Universitat Oberta de Catalunya (UOC)

The Universitat Oberta de Catalunya (UOC) is a Spanish fully online university which was founded by the Catalan government in 1994. Its aim was to meet the educational needs that society began to have at that moment, e.g. retraining, lifelong learning, etc. To this end, the UOC has been using ICT so as to offer flexible courses that allow students to perform a fully online learning process, regardless of their residence, age, availability for studying and so on. In this regard, the UOC has had its own virtual campus since the beginning. This virtual campus allows learners to do non-educational tasks (e.g. enrollment, payment, etc.) as well as accessing to virtual classrooms. In other words, this replaces the traditional campus where student life happens.

As it has been shown in Figure 1.2, the UOC has undergone a remarkable growth in the number of enrollments since its inception: this has gone from 16.000 students in 2000 to over 60000 during the 2010-2011 academic year (UOC, 2011). This growth has been due in part to the fact that the UOC has settled in other areas beyond the Catalonia. In 2000, it expanded to Spain and Latin America countries and, more recently, it has begun to offer its courses in other markets, such as English and French-speaking countries.

Apart from being present in many countries and its more than 17-year existence, the UOC has a large catalog of more than 850 qualifications. Thanks to these figures, ***the UOC is***, together with the UNED, ***one of the two main online universities in Spain and a European megaprovider of e-learning*** (see page 3). For all of these reasons, the UOC was a suitable scenario for doing this thesis and drawing well-founded conclusions. For more information about the UOC, see Appendix A.

1.3.2 Interactive Tools for Online Learning (ITOL)

Interactive Tools for Online Learning (ITOL) is an emergent research group that was founded in the IT, Multimedia and Telecommunication Department of the UOC in 2007. Its research mainly focuses on designing and developing effective educational tools and resources for online teaching and learning. Hence, ITOL's research areas are totally aligned with the interest of the UOC and any outcome from its research can directly be used to improve the UOC's teaching-learning process.

ITOL is a multidisciplinary group that consists of 9 members who belong to different areas of knowledge: computer science, pedagogy, multimedia, etc. At present, Carlos Monzo, PhD is the principal investigator.

Finally, regarding this dissertation, it is worth saying that two ITOL members, Eugènia Santamaría, PhD (former principal investigator) and Jose Antonio Morán, PhD are the thesis directors.

1.4 Research strategy

This section first justifies and describes the research strategy that was employed in this thesis. Secondly, it is explained how that research strategy was put into practice during the research period. To do it, this section is made up of the following two subsections:

- Design and creation
- Research strategy outline

1.4.1 Design and creation

As said already, the main research objective (and contribution) of this thesis is to provide a set of recommendations for creating VLEs that are effective for online education (see section 1.2). To achieve this goal, two stages should be done. Firstly, to propose a set of recommendations (i.e. research objective O1) and, secondly, to evaluate its suitability (i.e. research objective O2). As it can be observed, the second stage requires putting the recommendations into practice. To do it, a VLE should be developed to be used as a vehicle for evaluating the suitability of the recommendations.

Due to the necessity of creating a VLE, this dissertation needed to use a research strategy that included the development of IT applications. In this regard, ***design and creation*** research strategy satisfied this requirement and, hence, it was employed in this work. This can be defined as follows:

Design and creation research strategy

Combination of a *systems development methodology* and a *research methodology* based on one or more research strategies that use one or multiple data generation methods.

(Oates, 2006, Chapter 8)

As for the ***research methodology*** of this thesis, this consisted of two research strategies. More specifically, ***design and creation*** itself was used alongside ***survey*** (see Oates, 2006, Chapter 7). Moreover, ***both quantitative and qualitative data generations methods*** were employed:

Data generation methods used in this thesis

- Document-based research (see Oates, 2006, Chapter 16)
- Questionnaires (see Oates, 2006, Chapter 15)
- Interviews (see Oates, 2006, Chapter 13)

With regard to the ***systems development methodology***, the most popular approaches for developing IT systems are: (1) waterfall, and (2) prototyping. In this thesis, ***prototyping*** was chosen. Broadly speaking, this is an iterative method that consists of the following steps:

Steps of prototyping

1. A first version of the system is analyzed, designed and implemented.
2. This is tested either conceptually (called *proof of concept*) or contextually (*proof by demonstration* if the context is restricted, otherwise *real-world evaluation*).
3. The understanding gained from the evaluation of the results is used to revisit the analysis, design and implementation stages and create an improved version of the prototype.
4. Go back to the step 2 if the prototype has not reached a satisfactory implementation or it has not proven some hypothesis.

1.4.2 Research strategy outline

Firstly, it was needed to get an overview of fully online education. This meant, on the one hand, understanding the implications of online delivery for education (question Q1) and, on the other, being aware of the features, needs and preferences of online students (Q2) and teachers (Q3). To this end, a comprehensive literature review based on a ***document-based research*** was carried out.

Next, eight virtual learning environments (VLEs) were analyzed according to their underlying pedagogy, information structure and interface. Subsequently, it was discussed to what extent current VLEs meet the requirements of online education (Q4).

From the knowledge acquired from answering questions Q1–3 and by taking other researchers' investigations into consideration, a set of recommendations for designing effective VLEs was proposed (objective O1). Based on this set, an ad-hoc small VLEs called AdVisor was created by means of ***an iterative prototyping process***. During this process, ***3 prototypes*** were developed. Each prototype was tested by UOC students in a real-world evaluation. At the end of each prototype test, a ***questionnaire*** was sent to the learners so as to evaluate the suitability of each of the suggested recommendations (O2) and, at the same time, to detect problems to be improved in the following version of the platform.

Likewise, the last version of AdVisor was introduced to 8 teachers who participated in an individual ***semi-structured interview***. The principal aim was to evaluate those recommendations that were closer to instructors. In this regard, in addition to AdVisor, it was presented the first version of a monitoring tool, called FACRO, which allowed the instructors to track the learning process of their students. Moreover, the teachers were also asked to evaluate the rest of recommendations.

1.5 Thesis outline

To report the work, this dissertation has been divided into six chapters which are aligned with the aforementioned research strategy (see Figure 1.3):

- **Chapter 2**: it mainly describes the implications of online delivery for the teaching-learning process (***research question Q1***). Moreover, it identifies the characteristics of online students and teachers as well as the potential barriers that they may find (***questions Q2 and Q3***).

- **Chapter 3**: this chapter focuses on virtual learning environments (VLEs). It first defines the basis on which a VLE should be built and then it analyzes eight of the most important VLEs that exist today. Finally, it is discussed to what extent the current VLEs are effective tools for fully online education (***question Q4***).

- **Chapter 4**: it proposes a set of recommendations whose aim is to develop VLEs that are suitable for fully online teaching-learning (***objective O1***). These heuristics are based on the conclusions drawn from the Chapters 2 and 3 as well as the results of other research works related to this topic.

- **Chapter 5**: it describes each of the three prototypes of AdVisor and analyzes the questionnaires that were filled in by the students at the end of each prototype test (***objective O2***). Moreover it explains the results of evaluating the last prototype of AdVisor and the first version of FACRO through eight semi-structured interviews with UOC teachers (***objective O2***).

- **Chapter 6**: this last chapter summarizes the main contributions of this thesis and suggests possible ideas for future research.

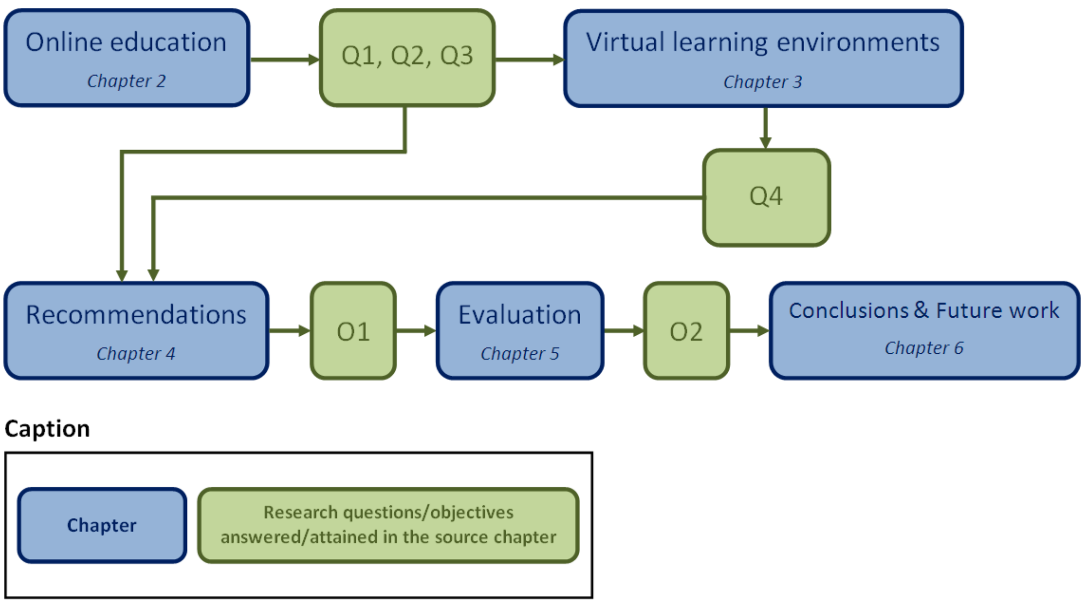


Figure 1.3: Overview of the thesis' structure.

2 Online education

This chapter aims to gain a better understanding of the issues related to online education in order that the learned knowledge is the basis on which this thesis is built. To this end, the following topics will be addressed:

- What distance education is and how it has evolved. Likewise, online education is defined based on distance education's definition (see section 2.1).

- The main implications of online delivery for the teaching-learning process (see section 2.2, this section responds to the research question Q1).

- Comparison between online and face-to-face education in terms of students' performance and satisfaction (see section 2.3, research question Q1).

- Agents that participate in online education (see section 2.4). Four of the five participants are studied in detail:

  - Online learners are profiled. Likewise, the main factors that contribute to a successful or failed experience are described (see section 2.4.1, research question Q2)

  - The role of online teachers is analyzed by taking account of the main learning theories that they can use, the tasks that they are expected to perform and the potential barriers that they may find (see section 2.4.2, research question Q3).

  - The principal implications that online education has for institutions (see section 2.4.3).

  - Virtual learning environments (VLEs) and personal learning environments (PLEs) as replacements for physical classrooms (see section 2.4.4).

2.1 Online education, a mode of distance education

Online education is a modality of learning that belongs to the category of distance education (DE). For this reason, this section defines the concept of DE and reviews its evolution in the course of time until the advent of online education.

2.1.1 What is distance education?

Different researchers have proposed a definition for *distance education* (DE), amongst which Keegan's definition stands out.

Distance education

Distance education (DE) is a generic term that is characterized by the following features:

- **The quasi-permanent separation of the instructor and the student throughout the teaching-learning process**: this characteristic distinguishes DE from conventional F2F education.
- **The influence of an educational organization**: one of the differences between DE and private study and teach-yourself programs is the presence of an educational institution that watches over learning materials and provides student support.
- **The use of technical media**: DE uses different technical resources both to deliver learning content (e.g. print, audio, images, video, etc.) and to establish a communication between students and teachers (e.g. mail, telephone, computer, etc.).
- **The provision of two-way communication** (also known as *student-instructor interaction*): this allows learners to benefit from it or even initiate dialog. Thanks to the two-way communication is easier to support the educational process, e.g. to motivate students and clarify any misunderstanding.
- **The quasi-permanent absence of the learning group**: DE does not compel students to join the learning group (i.e. the class) if they do not want. Hence learners are usually taught as individuals and not in group. However, there exists the possibility of occasional meetings for both didactic and socialization purposes.

(Keegan, 1990, p. 44)

Although this definition dates from 1990, the features that it indicates are still valid. Nevertheless, due to the evolution of distance education, some of them have undergone some changes. For instance, thanks to current ICT, not only does student-instructor interaction exist at present, but also student-student. Thereby, individual learning is combined with collaborative learning.

2.1.2 Evolution of distance education: from the mail to the computer

Although distance education (DE) has recently experienced a huge growth of enrollments thanks to its online mode (see section 1.1), this has existed for more than a century. Obviously, DE has undergone significant changes in the course of time, especially due to the evolution of ICT. In this regard, three generations of DE can be distinguished according to the main technologies employed for delivery (Garrison, 1985; Garrison and Anderson, 2003; Nipper, 1989):

- First generation – Correspondence
- Second generation – Telecommunications
- Third generation – Computer

Next, each of them is described briefly. Likewise, Table 2.1 summarizes and compares the three generations at the end of this section. Finally, in addition to describing the aforesaid generations, an overview of forthcoming DE generations is provided.

2.1.2.1 First generation – Correspondence generation

The first steps of DE date back to 1833 (Baath, 1985, cited in (Garrison, 1985)) and were possible thanks to the combination of ***printing and postal service***. This first generation of DE provided people with the opportunity to study anytime and anywhere. Nevertheless, because communication took place through correspondence only, the student-teacher interaction was slow and tiresome due to the delay of receiving letters. This implied that there was very little scope for interaction between the learner and the teacher. Moreover, the lack of more modern communication tools limited the interaction among students. In consequence, this model promoted individual learning. Nowadays, correspondence is still prevalent as a form of DE.

2.1.2.2 Second generation – Telecommunications generation

The use of devices that were able to transmit information electronically over a distance meant the beginning of a second generation of DE. These devices took advantage of radio, optical or other electromagnetic channels to transmit or receive signals for voice, video, data, etc. Some of the most notable devices were: radio and television broadcasts, audio and video cassettes, and other multimedia devices such as CD-ROMs and DVDs. These new technologies meant the emergence of new learning materials, e.g. simulations, video and audio tutorials, etc.

On the other hand, the advent of telephone made student-teacher interaction faster. However, the synchrony of telephone conversations limited the flexibility of time that distance students required. As a result, many learners could not use the telephone to interact with their teachers. In such cases, mail was used instead. Therefore, ***the interaction between faculty and learners was done via telephone calls and mails***.

2.1.2.3 Third generation – Computer generation

The advent of the Internet marked the beginning of a new DE generation. The Internet, taken in conjunction with new devices (e.g. computers, smartphones, etc.), has increased the potential of DE by allowing to create new ways of teaching and learning.

One of the main contributions of this generation to distance education is related to communication. In this regard, the Internet has allowed, in addition to student-teacher interaction, the exchange of messages among classmates, which has meant a shift from one-to-one to many-to-many communication. This is something that has been virtually impossible in distance education until now. According to Harasim (1989), this ***possibility of many-to-may communication motivated the use of a new term: online education***.

2.1.2.4 New generations

Distance education continues to evolve, so much so that some researchers today talk about new generations. In this regard, Taylor (2001) divides the *computer generation* into three:

- **Telelearning generation**: this is based on applications of telecommunication technologies to provide opportunities for synchronous communication, e.g. videoconference.

- **Flexible learning generation**: this promotes the flexibility through self-paced learning. To this end, it focuses on online delivery via the Internet (e.g. access to WWW resources) and asynchronous computer-mediated communication (CMC) tools, e.g. e-mail, forums, etc.

- **Intelligent flexible learning generation**: this expands the previous generation and tries to capitalize on the features of the Internet and the web so as to provide students with a valuable personalized pedagogical experience, e.g. to develop customizable campus portal interfaces, automated courseware production systems, automated pedagogical advice systems, etc.

Generation[1]	**Main delivery mode**	**Learning resources**	**Interaction mode**
First	Correspondence	Books and lecture notes on paper	Mail
Second	Electronic devices	Radio, TV, audio and video cassettes, CD-ROMs and DVDs	Telephone and mail
Third	Internet	Webs, remote labs, multimedia resources, ...	e-mail, forum, chat, ...

1 A generation can use delivery and interaction modes as well as types of resources that belong to the previous ones. For example, a course based on the third generation model can send books to its students via postal service.

Table 2.1: Generations of distance education.

2.1.3 Definition of online education

Based on Keegan (1990)'s definition (see section 2.1.1), Paulsen (2003) defined the term *online education* by emphasizing that ***the use of computer networks in the third and fourth characteristics is what distinguishes online education from the rest of DE modalities***.

Online education

Online education is characterized by:

- Separation between teachers and learners.
- Influence of an educational organization.
- The use of a *computer network* to present or distribute some educational content.
- The provision of two-way communication via a *computer network* so that students may benefit from communication with each other, teachers and staff.

(Paulsen, 2003)

As seen, the Keegan's *quasi-permanent absence of a learning group* has been excluded from this definition, since the use of CMC tools enables collaborative learning, which has been seen as one of the greatest advantages of online education compared to the previous generations of DE.

Two types of education can clearly be distinguished so far: face-to-face (F2F) and distance (namely, online). However, thanks to the Internet, new possibilities have emerged, positioning themselves in the boundary between F2F and distance (see Table 2.2).

Although *web facilitated* and *blended* courses have a proportion of online delivery, this thesis only focuses on *(fully) online courses* (i.e. 100% online). Henceforth, the term *online* will be used in this work as a synonym of *fully online*.

Course type	**% online**	**Description**
Traditional or face-to-face	0%	Course with no online technology used. Content is delivered in writing or orally. Likewise, students must attend class physically.
Web facilitated	1-29%	Course that uses web technology to facilitate what is essentially F2F, e.g. teachers upload resources that are used in class to a web.
Blended or hybrid	30-79%	A substantial amount of class sessions is taken online, whereas the rest of lectures are held F2F.
Online	80-100%	Most or all of the content and activities are delivered and performed online. Class attendance is almost or fully non-existent.

Table 2.2: Course classification based on the amount of online content. ***Source***: (Allen et al., 2007).

2.2 Implications of online delivery for teaching and learning

As seen in section 2.1.2, the evolution of technology has been the principal factor that has involved changes in distance education (DE). As explained in section 2.1.2, DE is in its third generation, which revolves around the Internet. At this point, it is worth asking the following question: *what implications does online delivery have in the teaching-learning process?* (i.e. ***research question Q1***, see section 1.2). Next, some of the most important implications of online delivery and new technologies for education are described. More specifically:

- Flexibility of place and time
- Self-paced learning
- Self-assessment
- Accommodate different learning styles
- Promotes student-centered approach
- Increase of participation
- Facilitate critical analysis
- Instructors are more accessible
- Plurality
- Development of computer skills
- Sharing and reuse of learning materials
- Support to teaching tasks

2.2.1 Flexibility of place and time

Online delivery removes reliance on physical attendance, since learning materials are available 24/7 and asynchronous communication tools enable students not to have to attend classes together (Cheong, 2001). This, taken in conjunction with the use of mobile devices (e.g. laptops, smartphones, etc.), allows each student to learn at her convenience, i.e. anywhere and anytime (Cheong, 2001; Dirckinck-Holmfeld et al., 2009; Vivoda, 2005). This flexibility is particularly beneficial for those learners who are unable to attend traditional classes, such as people with disabilities (Maeroff, 2003) or who live in remote areas (Bigony, 2010).

2.2.2 Self-paced learning

The flexibility of place and time involves each student regulating her own learning process. In consequence, each learner has her own pace regardless of her classmates'. For example, if a student understands a concept at the first attempt, she does not need to wait for her classmates to understand it. By contrast, if she finds a concept hard, she can spend more time on assimilating it.

2.2.3 Self-assessment

Thanks to several tools, such as Hot Potatoes[1] and JClic[2], teachers can create tests with different types of questions (e.g. multiple choice, crosswords, fill in blanks, etc.) to which the students can

[1] http://hotpot.uvic.ca
[2] http://clic.xtec.cat/en/index.htm

access at any time and from any place. Furthermore, an advantage of online tests is that they can provide immediate feedback, which may motivate and guide learners (Horgen et al., 2005). In fact, the results of the tests give the learners information about their academic achievement. These data in turn can be used by the students to regulate their learning process.

2.2.4 Accommodate different learning styles

There are web-based tools, like adaptive educational systems, which detect the student's learning style and provide her with courses that fit it. For example, as most people tend to use one of their senses more than the others when they learn, many learning style models take account of learners' perception/modality preferences, i.e. visual, auditory, kinaesthetic and tactile (Coffield et al., 2004). Due to its idiosyncrasy, an online course can explain the same concept by using a wide range of types of resources (e.g. text, image, audio, video, simulation, remote lab, etc.) and thereby its content can adapt to the modality preference of each student.

2.2.5 Promotes student-centered approach

As observed in the previous implications, the intrinsic characteristics of the online environment promote a student-centered learning approach in which the student assumes primary responsibility for her learning process and the teacher helps her to attain the expected learning outcomes. As a result, each student may have a very personalized learning experience.

2.2.6 Increase of participation

The nature of CMC tools (e.g. e-mail, forums and chat) affects students' interaction and participation. Thanks to these tools, each learner has the same opportunity to express herself by posting messages regardless of her popularity, voice volume, level of extroversion, etc. Hence, CMC tools offer students equal opportunities to communicate (Warschauer, 1997).

As a result of aforesaid equalizing effect, the participation of the students may increase, since shy learners can feel more comfortable expressing their ideas online than speaking in an F2F class. In this regard, besides CMC tools, web 2.0 applications like blogs and wikis also help to increase participation, because not only can teachers edit content, but students can also do it (Dirckinck-Holmfeld et al., 2009). This engages students in an active learning experience that is far from the typical passive attitude of traditional F2F classes.

2.2.7 Facilitate critical analysis

Asynchronous communication tools (e.g. e-mail and discussion forums) give learners extra time to analyze and reflect on content, their opinions, questions and answers before writing. Hence, asynchronous discussions facilitate critical analysis and reflection on thoughts and things learned in the course, thereby allowing to compose thoughtful responses (Althaus, 1997; Yukselturk, 2010).

2.2.8 Instructors are more accessible

Learners in F2F courses are forced to arrange an appointment with their teachers during their office hours. In consequence, F2F office hours are infrequently used by students (Bippus et al., 2003). By contrast, thanks to asynchronous tools, online students can send messages to teachers at any time and from any place. This ease of communication increases the student-teacher interaction compared to that of F2F education based on office hours (Li et al., 2011; Tu, 2000).

2.2.9 Plurality

While students in an F2F classroom usually have the same background, the use of ICT allows to put people from different countries and cultures together in the same classroom (Cheong, 2001). This undoubtedly enriches the students' learning experience.

2.2.10 Development of computer skills

As the whole teaching-learning process is carried out through computers (or similar devices) and the Internet, online learners may improve their computer literacy (Bigony, 2010). Moreover, students can use the new computer skills that they have acquired in other facets of their lives.

2.2.11 Sharing and reuse of learning materials

Thanks to the Internet and the digitalization of contents, it is easy to share learning materials with any consumer, i.e. teachers, learners and institutions. Moreover, once teachers have done the learning content, they can reuse it for the same course next time.

At present, the creation of learning objects based on standards and the existence of repositories seem to be the solution to facilitate the sharing and reusing of learning material (Ochoa, 2005).

2.2.12 Support to teaching tasks

According to a study conducted by Wang (2009), the teachers found some functions of VLEs (e.g. grade calculation, automatic tests, etc.) useful to help them to save much time and effort.

Furthermore, some of these functionalities can assist instructors in better managing student progress. For example, the outputs of synchronous and asynchronous activities as well as any action of the students (e.g. number of posted messages) are stored in logs, databases, etc. Thus, if these data are perfectly preserved and are easy to manage, then these can be used by the teachers to forecast/detect problems and take immediate actions to prevent/overcome them (Mazza and Dimitrova, 2004). This certainly differs from F2F instruction, in which the teacher is the responsible for collecting all the information that she needs.

2.3 Comparison between online and face-to-face education

Many researchers have conducted experiments to evaluate the quality of both teaching-learning modes in terms of students' performance and satisfaction, i.e. they have studied if online delivery affects some of these two aspects compared to their results in F2F delivery (***research question Q1***, see section 1.2). This section gathers the results of some of these experiments.

2.3.1 Students' performance

Several studies have been conducted to analyze students' performance in online and F2F courses. For instance, Friday et al. (2006) carried out an eight-semester study in two undergraduate management courses (678 online learners and 669 traditional students). At the end of the experiment, they concluded that there was no statistically significant difference in the students' performance.

Likewise, Ury et al. (2006) conducted a study that included 1326 students (362 online) enrolled in seven courses that belonged to a Computer Science and Information Systems curriculum. They observed that online students in three courses, which served multiple majors and minors, obtained a significantly lower average grade than that of F2F learners. However, in the other four courses, which served upper-level majors, no significant differences in performance were found.

Dolan (2008) conducted a quasi-experiment in which she taught the same course online and F2F. The students did not have differences regarding sex, grade point average and reason for taking the course. At the end of the study, she observed that there was a significant difference in scores on all components except the first exam. In each case, online students got better grades. For instance, the final course grade for the F2F and online students was, on average, 77 and 81/100, respectively.

Larson and Sung (2009) performed a study with 168 students who took the Principles of Management Information Systems course. Of the 168 students, 63 participated in an F2F class, 22 were taught online, and 83 took the course in a blended format. To determine if there was difference in the students' performance depending on the delivery mode, students' exam scores and final class grade were used. The conclusion was that there has been no significant difference.

The main conclusion from the literature reviewed here is that it is not possible to assert whether F2F is better than online delivery or vice versa due to the disparity in the results of the studies. Actually, ***it seems that the delivery mode does not have as much influence on students' performance as other factors*** (e.g. learning materials, motivation, educational background, teaching style, etc.).

Although students' performance cannot be considered better in a delivery mode or another, there is evidence that the dropout rate in online courses is significantly higher (Malikowski, 2005; Smith-Gratto, 1999). For instance, Diaz (2000) in his study observed a dropout rate for online and F2F learners of 13.5% and 7.2%, respectively. Murray (2001), in turn, reported that the Washington State Community College online program had an attrition of 30% for online students and 15% for F2F learners. In the same way, Dutton et al. (2001) studied two classes of the same course, one was taught F2F and the other was online. Their results revealed substantial differences: 20.6% of online students did not finish the course, whereas the attrition was 6.4% for F2F students. As seen, ***high dropout rate in online education is a persistent problem that must be tackled***.

2.3.2 Students' satisfaction

Students' satisfaction is difficult to measure due to its level of abstraction/subjectivity. However, there are studies that analyze it. Some of them ask learners some questions about their satisfaction, whereas others ask teachers about their perception of their students' satisfaction.

Roach and Lemasters (2006) conducted an experiment with 6 online courses from which two were also taken F2F. These authors reported that the online courses were rated highly by the students. However, the two courses that were delivered both F2F and online obtained better results in the traditional format, i.e. face-to-face instruction.

During the 2005-2006 academic year, Dolan (2008) simultaneously taught a section of a course both fully online and F2F. She saw that there were very few real differences in terms of students' satisfaction between F2F and online delivery. However, Dolan noted that several items related to communication (e.g. if the instructor's presentations were clear, if the teacher clearly communicated what was expected of students in the class, etc.) obtained lower scores in the online course.

Similarly, Negash and Vanderieft (2008) carried out an analysis with over 200 students from eight disciplines in order to compare F2F instruction with three online modalities: asynchronous, synchronous and hybrid. They did not find significant difference in students' satisfaction.

The Sloan Consortium's 2011 annual report (Allen and Seaman, 2011), in turn, indicates that 62.5% of academic staff perceived that the level of students' satisfaction was *about the same* for both online and face-to-face courses (see Figure 2.1). 22.6% found students' satisfaction in F2F instruction higher (i.e. *somewhat superior* or *superior*). By contrast, only 14.9% considered that the level of satisfaction was higher in online courses.

In conclusion, although some studies show that the learners' satisfaction in online delivery is sometimes a little bit lower than that of F2F when the courses are taken in both formats, ***it cannot be concluded that there is significant difference between both teaching-learning modes in terms of students' satisfaction***.

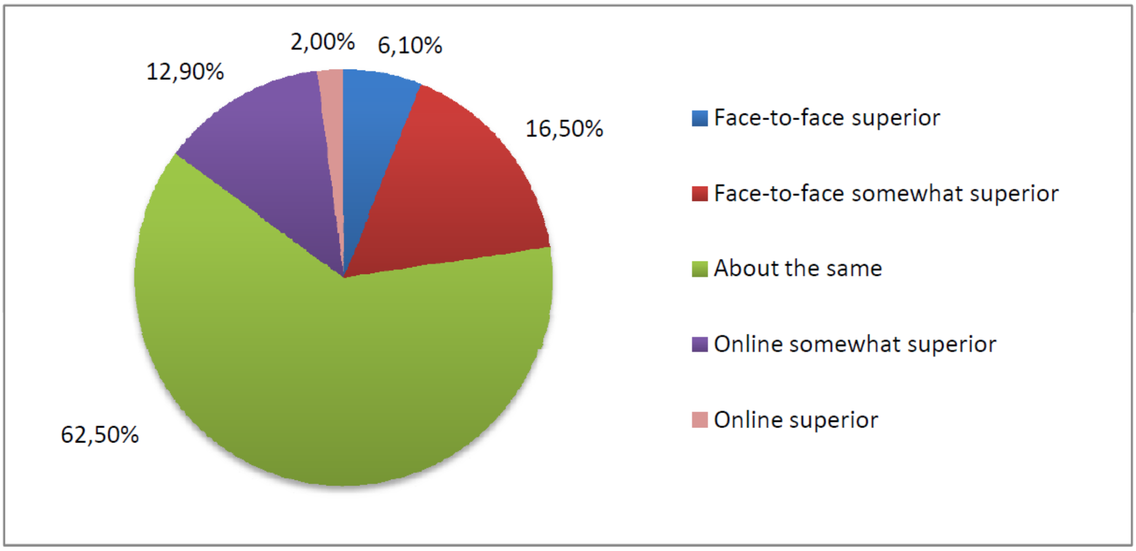


Figure 2.1: Perceived students' satisfaction in online and F2F postsecondary courses in the United States of America (USA) in 2011. ***Source***: (Allen and Seaman, 2011).

2.4 Participants in online education

In the same way that F2F instruction, online education mainly has two participants: ***the student and the teacher***. In addition, another agent can be identified: ***the content*** (i.e. learning material, resources, activities, etc.). Bearing these three participants in mind, Moore (1989) defined three types of interaction in which a distance student engages:

- **Student-instructor**: this interaction mainly focuses on stimulating and guiding students as well as clarifying any misunderstanding regarding the content.
- **Student-student**: this occurs between two or more students with or without the real-time presence of an instructor. This interaction promotes collaborative learning.
- **Student-content**: it is the process of intellectually interacting with the content, e.g. reading a text, doing an exercise, etc.

Apart from these three types of interaction, some authors such as Hillman et al. (1994) have added ***student-interface*** interaction to the list due to the increasing use of advanced technology (e.g. VLEs, CMC tools, etc.). Likewise, formal learning requires the presence of ***an institution*** (i.e. school, university, etc.) that watches over the quality of the degrees and, at the same time, supports learners and teachers. The existence of this agent is mentioned by Keegan and Paulsen in their definitions of distance (see section 2.1.1) and online (see section 2.1.3) education, respectively.

To sum up, learners interact with five agents (see Figure 2.2): classmates, teachers, content, technology (or interface) and institution. These five agents also give rise to other types of interactions such as those defined by Anderson and Garrison (1998): teacher-teacher, teacher-content and content-content.

The rest of this section will focus on four of the five aforementioned agents, since the content of the courses is out of the scope of this thesis. Moreover, regarding technology, this section only will deal with virtual classrooms.

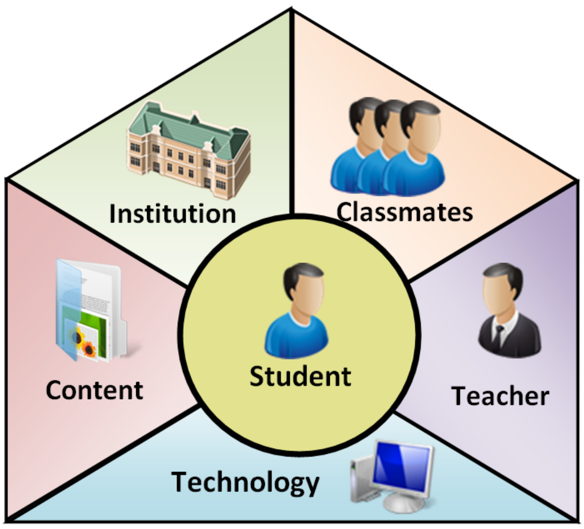


Figure 2.2: Types of interaction in which an online student engages.

2.4.1 Online learner

The first question that arises is: *do online learners have the same profile as face-to-face students?*. The answer is clearly **NO**. This question could be reformulated like this: *what characteristics, needs, preferences and barriers do online learners have?* (i.e. ***research question Q2***, see section 1.2). According to Dabbagh (2007), determining the characteristics and the educational needs of online learners may not necessarily guarantee success in a distance education course, but this can be helpful for teachers to understand:

- Who is likely to participate in online learning
- What factors or motivators contribute to a successful online learning experience
- The potential barriers deterring some students from participating in or successfully completing an online course

Next, this section analyzes the three previous issues to answer the ***research question Q2***.

2.4.1.1 Who is likely to participate in online learning?

Broadly speaking, the current online student is very different from the traditional one. This becomes apparent when the profile of a typical online learner is described:

Current online students' profile

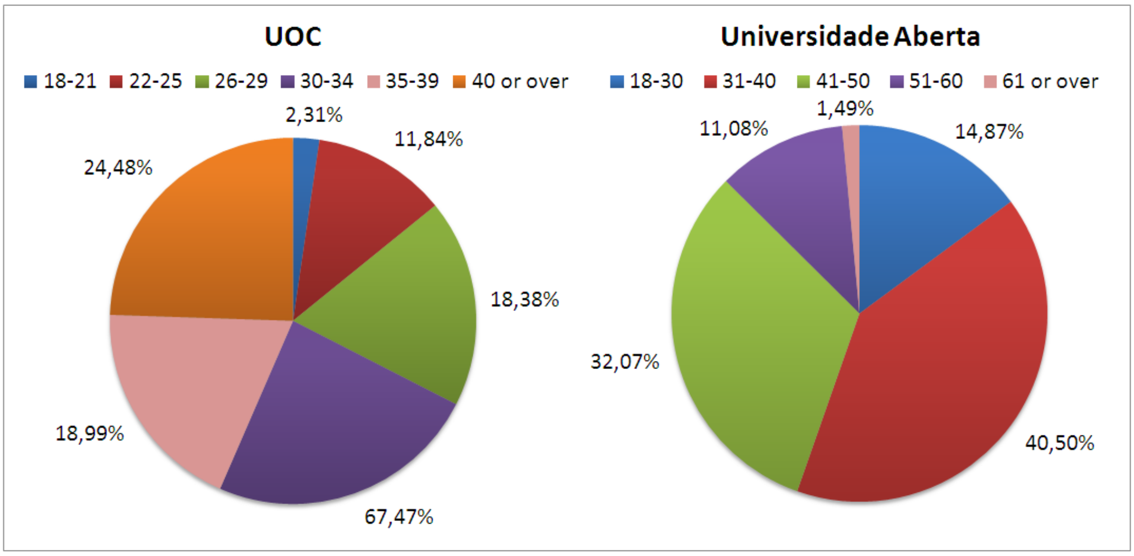
Gilbert (2000, p. 74) defines the archetype of the current online student as follows:

- Over 25 years old
- Employed
- They have some higher education experience
- They are equally probable to be male or female

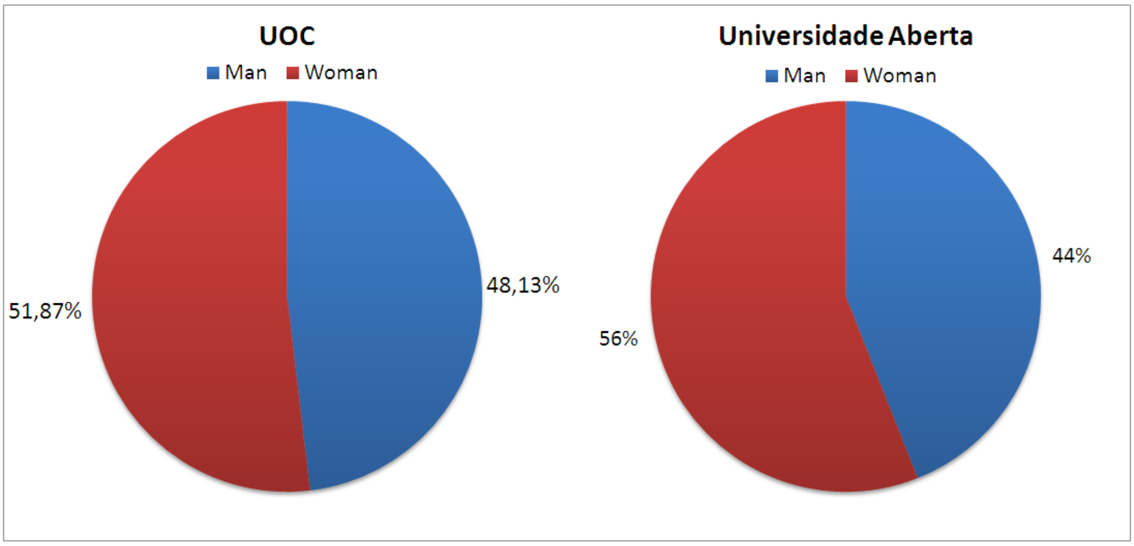
Moreover, according to Dutton et al. (2002), they are more likely to:

- Have childcare responsibilities
- Be lifelong learners
- Commute more than 10 miles to campus

Examples of this profile can be found in different online universities (Lladós, 2009; OU, 2011; UAb, 2012; UOC, 2011). For instance, in the 2010-2011 academic year, over 85% of the UOC students were older than 25 (see Figure 2.3a). This figure reached around 88% at The Open University (United Kingdom). As far as the Univerisade Aberta (Portugal) is concerned, about 15% of its students were younger than 31 years old in 2011-2012 (see Figure 2.3a). Likewise, the number of online learners who work full or part-time during their studies is high: 95% at the UOC in 2008-2009 and over 71% at The Open University in 2010-2011. Moreover, a large amount of learners have university experience before enrolling. As proof of this, in the 2008-2009 academic year, around 75% of UOC students either held a degree (44.6%) or had not finished their university studies (30.6%). Finally, the number of men and women enrolled in online courses is almost the same, but the percentage of females seems to be a little bit higher (see Figure 2.3b).



(a) Breakdown of students by age



(b) Breakdown of students by gender

Figure 2.3: Students' profile at the UOC (2010-2011) and the Universidade Aberta (2011-2012). ***Sources***: (UAb, 2012; UOC, 2011).

Nowadays, this profile depicts the majority of online learners, defining a homogeneous group. As seen, this group mainly consists of ***adult men and women with responsibilities*** (e.g. they must work, take care of children, etc.) ***who are over 25 years old***. This may be why most of these people see online learning as the approach that better adapt to their requirements, as evidenced by the fact that they rate class conflict with work, reducing commuting time, and flexibility in studying as being the most important aspects in their choice of the course format (Dutton et al., 2002).

Although the aforesaid profile continue to represent most of online learners, more and more young people have been enrolling in online courses in recent years and they will soon represent a sizable portion of the population of online students (Dabbagh, 2007). They belong to the Generation Y (i.e. born 1980-2000), which has grown up surrounded by computers, video games, mobile devices, the Internet, etc. This has meant a big discontinuity between this generation and the previous ones, especially regarding the use and the familiarity with digital technologies. As a result of this digital immersion, Gen-Y students act and think completely different. Actually, there is such a difference that Prensky (2001) coined the terms *digital natives* and *digital immigrants* to refer to the Generation Y and the previous ones, respectively.

Characteristics of digital native students

Students who belong to the Generation Y are different from the previous ones because:

- They are used to receiving information really fast
- They like parallel processes and multi-task
- They prefer graphics to text
- They prefer random access (e.g. hypertext) to sequential access (e.g. book)
- They function best when they are networked
- They thrive on instant gratification and frequent rewards
- They prefer games to “serious” work

(Prensky, 2001)

Due to their mentality, digital native students, unlike current online learners, are enrolling in online courses not because these are the only alternative, but rather because these are their preferred option (Thompson, 1998).

As observed, ***the increase of digital natives in online courses will bring new issues which may involve significant changes in the teaching-learning process***.

2.4.1.2 What factors contribute to a successful online learning experience?

Determining the factors that positively influence student achievement in online courses can be difficult. What works for one student may not work for another learner (Martens et al., 2007). Although each student is different, it seems that there are certain qualities that help to complete an online course successfully. Some of these factors are:

- Self-regulation skill
- Learner's motivation and strong academic self-concept
- Interaction
- Computer literacy

Self-regulation skill

As seen in section 2.2.1, online delivery provides flexibility in terms of time and place so that any student can adapt her learning process to her personal situation (e.g. family, work, etc.). In this regard, ***the traditional teacher-centered paradigm is not adequate for online education***, since this treats all learners as if they were the same and forces them to do the same things in the same amount of time (Watson and Watson, 2007). Instead, a student-centered approach best meets online learners' requirements. However, this approach requires students to assume primary responsibility for their learning process (Dabbagh and Kitsantas, 2004). This responsibility, in turn, implies that learners must have a lot of self-discipline and initiative in order to finish an online course successfully (Kearsley, 2002). In other words, ***online students must be self-regulated***.

Pintrich (2000, p. 453) defined self-regulated learning as *"an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment"*. Recent research studies demonstrate ***a strong relationship between online students' academic success and the use of self-regulated learning strategies*** (Barnard-Brak et al., 2010; Puzziferro, 2008; Steffens, 2006).

Learner's motivation and strong academic self-concept

The fact that students are motivated is an important factor both in F2F education and in online learning so as to avoid dropouts and attain a high performance. In this regard, Ryan and Deci (2000) distinguish between *extrinsic motivation*, which refers to the performance of an activity to attain some separable outcome (e.g. to pass the course, to obtain a diploma, etc.), and *intrinsic motivation*, which refers to doing an activity for the inherent satisfaction of the activity itself. As far as intrinsic motivation is concerned, this implies features such as curiosity, deep-level learning, exploratory behavior and self-regulation. In this regard, a study of Hayenga and Corpus (2010) shows those ***students with high intrinsic and low extrinsic motivations outperformed their peers***.

Likewise, some researchers, such as Liu (2010), have found a high positive relationship between academic self-concept and motivation. Academic self-concept refers to individuals' knowledge and perceptions about themselves in academic achievement situations (Wigfield and Karpathian, 1991). Furthermore, studies like (Muijs, 1997) have reported positive correlation between academic self-concept and performance.

Hence, there is some evidence to think that ***those students who have a high motivation and a strong academic self-concept are more likely to have a better performance***.

Interaction

Some studies, such as (Gabriel, 2004), state that students learn from the interactions with their classmates. In this regard, Swan (2002) observed that student-instructor and student-student interactions influenced learners' success positively. Moreover, Taylor (2002) found that those students who had been *workers* (i.e. who had actively engaged in the class activities) or *lurkers* (i.e. who had mainly observed the workers' interactions) obtained similar grades, whereas *shirkers* (i.e. who had not participated directly or indirectly) failed. Similarly, a study of Davies and Graff (2005) revealed that those students who failed in their courses had tended to interact less frequently.

Therefore, studies like the previous ones prove that it is important that the students participate in the online classrooms, because ***both direct and indirect interaction with classmates or instructors is an essential factor for a successful completion***.

Computer literacy

Taking an online course requires a basic understanding of computers, including applications like word processing and spreadsheets, as well as how the Internet works (Kearsley, 2002). If the students have this knowledge, they reduce the appearance of any undesirable eventuality when they use the learning tools. Moreover, they may avoid feeling frustrated and, hence, they have fewer reasons for dropping out.

2.4.1.3 Potential barriers that online students may find

Although online education provides learners with a large amount of benefits, a lot of students may, unfortunately, have to face some hurdles. These obstacles can lead learners to get low grades or even drop out. Next, this section describes some of the most relevant barriers that have been identified by the researchers:

- Feeling of isolation
- Confusion, anxiety and frustration
- Cognitive overload
- Lack of self-regulation skills
- Absence of technical skills
- Technical problems

Feeling of isolation

Despite the virtual presence of classmates and teachers in the VLEs and CMC tools, many online students may feel isolated. This may complicate the learning process, above all, for adult students (Galusha, 1997). The impersonality of the tools as well as the suppression of some communication mechanisms, like body language, may be some of the factors that contribute to this feeling.

Confusion, anxiety and frustration

According to Hara and Kling (2000), a lot of learners may feel confusion, anxiety or frustration due to the perceived unclear feedback, ambiguous instructions and lack of prompt from the teacher. Likewise, situations such as the ones where teachers are not available on demand or course materials are not delivered on time may cause anxiety.

Cognitive overload

Students can suffer from cognitive overload because of the complexity of the platforms, the course organization, the unnecessary information that is displayed, etc. (Aidi, 2009). Hence, if learners receive more data than their processing capacity, they may easily get lost and deviate from learning goals (Da, 2010).

Lack of self-regulation skills

As already said, online education gives students the control of their own learning. This requires learners to have self-discipline and self-regulation. However, lots of students need help to learn these skills, since most of them are not able to achieve these abilities on their own (McInnis et al., 1995; OECD, 2004). The lack of these abilities, taken in conjunction with demotivation, may mean a high dropout rate.

Absence of technical skills

Some students have difficulty in learning online because of their low level of computer skills, their fear of new technologies, their unfamiliarity with basic software (e.g. word processing), etc. This absence of technical skills may cause the students many problems or even lead them to be excluded from learning process inadvertently (Galusha, 1997).

Technical problems

Learners can suffer from technical obstacles which may cause frustration or anxiety, e.g. inconsistent platforms, slow or unreliable Internet connections, lack of technical assistance, etc. Although institutions make an effort to avoid these adversities, some of them inevitably arise during the teaching-learning process.

2.4.2 Online teacher

Because online students are different to F2F learners, the role of online teachers also has to be different to that of traditional lecturers. This section tries to answer ***research question Q3*** (see section 1.2): *what role do online teachers play and what problems may they find?*. To this end, it deals with the following topics:

- Learning theories
- The role of the online teacher
- Potential barriers that a lecturer may find

2.4.2.1 Learning theories: from Behaviorism to Constructivism

Learning is a complex process that has generated numerous interpretations of how it is effectively accomplished (Ertmer and Newby, 1993). In this regard, a learning theory is an attempt to give a general explanation about how people learn. The way in which learning is defined and how it is thought that learning occurs have important implications. For this reason, any teacher must understand the strengths and weaknesses of the different learning theories to optimize their use in the instructional design of a course. At present, three learning theories are widely used:

- Behaviorism
- Cognitivism
- Constructivism

Next, these three theories are briefly explained. The core of the following explanations is inspired by (Anderson et al., 2004; Ertmer and Newby, 1993; Schunk, 2011).

Behaviorism

The main goal of this theory is to ***efficiently transmit knowledge from the instructor to the students***. To this end, Behaviorism describes learning as an objectively observable change in behavior, as opposed to internal events like thinking. Therefore, according to this learning theory, students learn when there is a change in their behavior. For this reason, ***learners are characterized as being reactive to conditions in the learning environments***. Such a characterization implies that students' behavior is determined by the environment, becoming the result of a ***stimulus-response association***. This association was researched by Skinner (1938) based on Thorndike (1898)'s work. Skinner (1938) coined the term *operant conditioning* to identify this association. Broadly speaking, *operation conditioning* involves changing students' behavior by means of the use of the reinforcement which is given after the desired response. As a result of this view of learning, Behaviorism defines the learning process as follows:

1. Learners observe the information and acquire facts, concepts and skills.
2. Response: learners perform a particular behavior.
3. Stimulus: students receive reinforcement through a reward system which gives them either a prize for positive/expected behavior or a punishment for bad/unexpected behavior.

As seen, ***the role of the teacher is to provide stimulus and indicate the correct response***, while learners are forced to repeat the previous learning process until the behavioral change is permanent/inherent. Such a learning process suggests that Behaviorism tends toward a ***teacher-centered approach*** in which there are no opportunities for students to express their own ideas.

As can be seen in the article by Ertmer and Newby (1993), the stimulus-response association is mainly useful to the learning that involves discrimination (e.g. to recall facts), associations (e.g. to apply explanations), generalizations (e.g. to define and illustrate concepts) and chaining (to automatically perform a specified procedure). However, it is generally agreed that Behaviorism is wholly inadequate to predict and explain complex human phenomena like language, memory and behavior (Bargh and Ferguson, 2000). Therefore, higher-order tasks, such as problem solving and critical thinking, are difficult to teach/learn by using Behaviorism's tenets.

In conclusion, it could be said that Behaviorism is suitable for training rather than educational programs, because it stimulates surface learning, knowledge reproduction and the repetition of a behavior as reinforcement of it.

Cognitivism

Cognitivism emerged as a response to Behaviorism in order to argue that people are not like animals that merely respond to environmental stimuli, but they are rational beings that require active participation so as to learn and whose actions are a consequence of thinking. Contrary to Behaviorism which exclusively explains learning from environmental influences, ***Cognitivism stresses the thought process behind the behavior***. This means that Cognitivism sees learning as an internal process that involves memory, thinking, reflection, abstraction, motivation, and metacognition (Anderson et al., 2004). Because this process is carried out by the learner internally, ***students are regarded as very active agents in the learning process***. Consequently, the way that learners attend to, code, transform, rehearse, store and retrieve information as well as their thoughts, beliefs, attitudes and values are considered key elements of the learning process.

Cognitivists consider memory as the result of learning. For this reason, they defined the Atkinson-Shiffrin model (or also known as multi-store model) to explain how human memory is structured and how it works. Specifically, this model proposes that human memory involves a sequence of three stages (Anderson, 2000; Kalat, 2001): (1) sensory store, (2) short-term memory (i.e. a temporary storage of the recent events), and (3) long-term memory (i.e. a relatively permanent store). Broadly speaking, this model works as follows:

1. Senses receive information and save it in the sensory store for less than one second. If this is not transferred immediately to the short-term memory, then this is lost.

2. The information transferred to the short-term memory remains there for 20 seconds. Due to this limited capacity, teachers should chunk information into small meaningful units.

3. If the information is not processed efficiently, then this is not transferred to the long-term memory and is lost. Otherwise, the information is sent to the long-term memory and stored.

Because of the emphasis on the mental structures, ***the role of teachers focuses on (1) making knowledge meaningful, (2) presenting learning material in a manner that holds students' attention, and (3) helping learners to organize and relate new information to existing knowledge in memory***. To this end, teachers use props (e.g. graphics), methods (e.g. mnemonics, concept maps, analogies, metaphors, etc.) as well as different strategies (e.g. to review previous learned concepts on a topic, to connect new and learned concepts, examining, asking, summarizing, etc.).

Due to the features of Cognitivism, this is usually considered more appropriate for more complex forms of learning (e.g. reasoning, problem-solving, etc.) than Behaviorism (Schunk, 2011).

Constructivism

In recent years, Constructivism has become the most popular learning theory. Unlike Cognitivism, ***Constructivism does not focus on how knowledge is acquired, but how knowledge is constructed***. In addition, this learning theory considers knowledge as something that is subjective and does not exist independent of the learner. Actually, it argues that each student constructs her own knowledge based on her beliefs and experiences. This implies that the knowledge built by each student is true to her, but not necessarily to anyone else.

With regard to how people construct knowledge, there is a variety of epistemological positions which coexist (Kanuka and Anderson, 1999). Some of these approaches are: (1) Cognitive Constructivism (Piaget, 1971), (2) Situated Constructivism, (3) Radical Constructivism (Glasersfeld, 1996), and (4) Social Constructivism (Vygotsky, 1978). Because the objective of this section is to provide an overview of this learning theory, the differences of the aforesaid positions will not be discussed. In order to know the details of each of them, the paper (Kanuka and Anderson, 1999) is suggested. In spite of the differences of each Constructivist position, they all share some assumptions, such as (Jonassen, 1991, 1992; Kanuka and Anderson, 1999):

- ***People construct new knowledge based on what they already know***: this means that knowledge construction is not a uniform process that is identical for everyone, but this depends on each person. Therefore, it cannot be assumed that all learners in a class will understand new information in the same way.

- ***Multiple representations, perspectives and interpretations of reality/content*** should be provided, because there is no objective reality. For this reason, it is suggested using case-based instruction, which provides multiple perspectives or topics inherent in the cases.

- Knowledge construction is ***an active rather than a passive process***. This means that Constructivist learning process shifts from being teacher-centered (i.e. where the student is a container that receives information from the teacher) to being ***learner-centered*** (i.e. where ***the teacher is a facilitator***, not a transmitter of knowledge, who constantly guides each student through her learning process).

- Evaluating ***how students are progressing in the construction of knowledge is more important than the resulting product***. In other words, Constructivism supports formative rather than summative assessment (i.e. the coursework is more important than a final exam). Due to this approach, evaluation becomes a self-analysis tool.

- Instructors should present authentic tasks with real-world relevance and utility. Thus, ***activities should match the real-world tasks of professionals in practice*** instead of decontextualized or classroom-based tasks.

- Language is a key element in the learning process and, hence, ***the use of communication skills should be promoted***. Thus, activities that enhance learners' confidence and ability to express their opinions should be included.

General discussion

As seen, learning theories have shifted their explanations of how learning happens from environmental toward human factors. Likewise, "***there has been a change in the focus of instruction from teaching to learning, and from passive transfer of facts and routines to active application of ideas to problems***" (Ertmer and Newby, 1993, p. 66). Table 2.3 summarizes the main features of Behaviorism, Cognitivism and Constructivism.

Although Constructivism has become the most widely accepted learning theory at present (Ally, 2004; Hoic-Bozic et al., 2009; Morphew, 2000), neither of the other two have disappeared and they each contribute in a different way to the design of courses. Actually, different authors (Ally, 2004; Anderson and Dron, 2011; Ertmer and Newby, 1993; Hoic-Bozic et al., 2009; Johnson and Aragon, 2003) argue that all theories should be effectively used to address all learning needs and aspirations of the students. Thus, ***the use of one learning theory should not exclude the others totally***, but instructors must understand all of the theories and be able to identify in which learning situations they are best suited. For example, as proposed by Ertmer and Newby (1993) and supported by Ally (2004), Behaviorist strategies may be used to teach the facts, Cognitivist strategies may be useful to teach principles and processes, and Constructivist strategies may be suitable for dealing with real-life and ill-defined problems. In short, teachers should combine learning theories properly by taking many factors (e.g. types of students, goals of the course, content, context, etc.) into account, so that they can provide their students with a satisfactory learning experience.

Given that the context of this thesis is online education and all of the learning theories can contribute to the online teaching-learning process, the question that arises is: *which learning theory should form the basis of an online instructional design?*. ***Many researchers***, such as (Underhill, 2006; Vrasidas, 2004), ***indicate that there is a strong direction among faculty toward constructivist learning***. Some possible explanations for this may be:

	Behaviorism	**Cognitivism**	**Constructivism**
How does learning occur?	• Through guided behavioral change made evident by accurate answers/consistent performance	• Through mental processes that result in the formation of concepts and schema	• Through experience, sociocultural influence and metacognition
What factors influence learning?	• External (environment, instructor)	• Internal (cognitive processes, readiness, aptitude)	• Internal (emotional) • External (social, environmental)
What is the role of memory?	• Repetition and reinforcement facilitates memorization	• Short and long-term memory interact to facilitate schema building	• Activated and influenced by meaningful learner experiences
How does transfer occur?	• Encouraged by positive reinforcement, learners make associations in the form of "correct" answers	• Learners form mental models in order to apply concepts and ideas to new scenarios	• Through perception of personally relevant context and application of knowledge
What types of learning are best suited to this theory?	• Fact-based • Practical	• Concept-based • Procedural	• Problem-based • Collaborative
What aspects are important to instructional design?	• Provide feedback to reinforce learning • Provide opportunities for practice and exchange	• Present information with targeted efficiency in order to stimulate memory and the formation of structured knowledge	• Provide learners with opportunities to investigate content in authentic settings
What teaching strategies facilitate learning?	• Instructor-centered • Learner-instructor interaction • Information organization and repetition	• Instructor-centered • Strategic information presentation • Targeted media use • Cognitive load management • Learner scaffolding	• Learner-centered • Authentic simulation • Hands-on practice • Collaborative learning • Questioning techniques • Critical inquiry

Table 2.3: Summary of the main features of the dominant learning theories. ***Source***: (Booth, 2011, p. 51).

1. Constructivism promotes a student-centered approach in which teachers are facilitators and students engage in peer learning. As seen, each online learner needs to study at their convenience (i.e. at any place, at any time and at any pace) and, moreover, has her own background and, in consequence, personal goals.

2. New technologies along with a Social Constructivism allows to make learning interactive and collaborative (Maor, 2003). As said previously, the use of online communication tools (e.g. forums, chats, etc.), in addition to increasing the participation of the students (see section 2.2.6), helps students to complete online courses successfully (see section 2.4.1.2). Likewise, these tools improve the interaction between students and teachers (see section 2.2.8).

3. The fact that most online students are workers is totally in accordance with one of the principles of Constructivism, since they may immediately apply the knowledge that they have just acquired in class to real-world situations that occur in their jobs. This increases their motivation, because they see the relevance and utility of the things they learn. Moreover, students may understand a concept better, as they learn it from theoretical and practical perspectives.

As observed, it could be said that ***Constructivism seems to be the learning theory that, in general, meets online education's requirements better***. Nevertheless, Behaviorism and Cognitivism should also be taken into account, because they can be more suitable than Constructivism for some specific learning activities. For instance, in a Mathematics course, Behaviorist strategies may be more suitable for learning the tables of derivatives and integrals.

Lastly, it is worth mentioning that Connectivism (Siemens, 2005) has emerged as a new learning theory. This assumes that knowledge is distributed across a network of people and devices, and, hence, learning is based on the ability to construct and explore these networks. Thus students do not have to memorize or even understand everything, but they must have the capacity to find and apply knowledge when and where it is needed. Although Connectivism has had a certain impact, some authors like Kerr (2007) argue that it is not radically new at the level of a learning theory.

2.4.2.2 What is the role of teachers in online education?

As discussed in the previous section, Constructivism is the most widespread learning theory in online education. For this reason, the role of teachers should primarily accord with the principles of this theory. In addition to this, other aspects such as the implications of online delivery should also be taken into consideration so that instructors can adapt their teaching styles.

This section describes the role of the teachers in an online environment. This can be divided into four dimensions (or sub-roles):

Dimensions of the role of the online teacher

- Managerial
- Pedagogical
- Social
- Technical

(Berge, 1995)

Managerial

This sub-role involves doing tasks that are performed during the instructional design, e.g. ***to plan the course, set clear learning objectives, establish procedural rules, etc***.

Pedagogical

Because online students should regulate their own learning (see section 2.4.1.2) and they have difficulty being self-regulated (see section 2.4.1.3), ***teachers should be facilitators who guide the students through the course and arrange meaningful learner-centered experiences*** (Salomon, 1992). More specifically, the instructional process of a distance teacher ideally involves (Beaudoin, 1990):

- Diagnosing the student's readiness to learn.
- Monitoring student progress toward objectives sought.
- Recognizing and discover a student's learning difficulties.
- Stimulating and challenge students to further efforts.
- Evaluating the quality of a student's learning.
- Assigning a grade to estimate learning outcomes.

In order to perform this role of guide, instructors should be adept at communicating with students and responding to individualized learning styles and motivation (Heuer and King, 2004).

Social

As seen in section 2.4.1.2, the interaction with the classmates is a factor that helps students to have a successful learning experience. For this reason, ***online teachers should promote a friendly environment and a community that supports the students' learning process***. Moreover, they have to compensate for the reduced sensory cues and the asynchronous nature of online instruction (Heuer and King, 2004). Hence, this dimension may involve (Berge, 1995; Heuer and King, 2004):

- Promoting human relationships by fostering communities of learners.
- Developing group cohesion and maintaining the group as a unit.
- Helping students to work together in a mutual cause.
- Developing strategies to manage 24/7 communications.
- Maintaining momentum of the dialog over time (especially in asynchronous dialogs).

Technical

Online teachers should be ***familiar, competent and comfortable with the software that composes the e-learning environment*** (McPherson and Nunes, 2004). This sub-role entails, among other tasks, choosing suitable software to meet the learning goals and helping students to use it.

2.4.2.3 Potential barriers that online instructors may find

As seen, the role of the online instructor extends the responsibilities and skills required of the educator teaching face-to-face (Heuer and King, 2004). This change may cause problems in teaching which may in turn have a great impact on the learners. Some of the most significant barriers are:

- Lack of skills
- Lack of interest in teaching online
- Lack of effective tools
- Time burden

Lack of skills

Most instructors are used to teaching face-to-face. As a result, some of them lack skills and knowledge to design and teach online classes (Galusha, 1997; Vovides et al., 2007; Vrasidas, 2004; West et al., 2007). This, taken in conjunction with the low level of computer skills that some teachers have, may make difficulties for lecturers when they teach online.

Lack of interest in teaching online

Instructor's attitude, motivation, and true commitment affect the quality of instruction (Deubel, 2003). In this regard, there are mainly two reasons for refusing to teach online: (1) technophobia and lack of technological skills and, (2) fear of being replaced (Lehman, 1998; Oblinger et al., 2001).

Lack of effective tools

According to Vrasidas (2004), one barrier to teaching online is the lack of appropriate design and development tools that help faculty to easily plan and deliver online instruction.

Likewise, while in an F2F classroom teachers exercise significant control over the learning process and are able to monitor students' attention and progress closely (Besser and Bonn, 1997), they have more difficulty tracking their learners in online courses due to the nature of the environment. Although tools like VLEs are supposed to help the instructors to monitor their students, most of these display tracking data in a format that is usually poorly structured and difficult to understand (Mazza and Dimitrova, 2004).

Time burden

Researchers like (Galusha, 1997; Grosse, 2004; Lao and Gonzales, 2005; O'Quinn and Corry, 2002; Spector, 2005) argue that online courses mean a time burden on teachers. For instance, faculty spends more time on preparing an online course than an F2F one, since they have to write down lecture notes, schedule the course in advance, etc. Likewise, many teachers complain that the online instruction is more labor-intensive in the amount of time to grade papers and respond to questions (Sellani and Harrington, 2002). On the one hand, more assignments are created to track students' progress and, on the other, learners want to receive some feedback as fast as possible.

2.4.3 Institution

As read in section 1.1, there is clear evidence that a lot of people demand online courses and, consequently, many institutions are taking a firm step toward their virtuality. But, *what implications does online delivery have for the institutions?* This section collects some of them:

- Infrastructure
- Maintenance and delivery savings
- Scalability
- Staff training
- Globalization

2.4.3.1 Infrastructure

Online delivery requires institutions to invest in technological infrastructure, i.e. hardware, software and network technologies. As for software, VLEs along with personal learning environments (PLEs) are currently used as virtual classrooms that replace the physical ones (see section 2.4.4).

2.4.3.2 Maintenance and delivery savings

Although the initial cost is high due to the investment in technology, learning materials, etc., once the course is placed online, the running/maintenance cost is negligible for the institution. Moreover, online platforms, like VLEs, enable to upload and download any kind of resource. Hence, sending learning materials via postal service is not needed any more and costs can be reduced.

2.4.3.3 Scalability

Thanks to the use of virtual classrooms, there is not limited capacity. Thus, the amount of students who can be enrolled in a class only depends on the teacher's skill at managing the course. Likewise, an online scenario allows institutions to easily add/remove instructors as needed, e.g. if there are many learners in a course, two virtual classrooms with a teacher for each can be created.

2.4.3.4 Staff training

To overcome negative dispositions, it is essential that institutions choose the teachers carefully and invest in training them . In this regard, teachers must be trained not only to use technology, but also to shift the way in which they organize and deliver material (Palloff and Pratt, 2000).

2.4.3.5 Globalization

The Internet allows anyone to enroll in any institution regardless of the distance. Hence schools and universities have a good opportunity to open their frontiers and gain access to new markets.

2.4.4 Virtual classroom: VLEs and PLEs

Due to the absence of physical classrooms, teachers and students need an alternative place where the teaching-learning process can be carried out. At present, two approaches can be distinguished: (1) virtual learning environments (VLEs), and (2) personal learning environments (PLEs).

Broadly speaking, a virtual learning environment can be defined as follows:

Virtual learning environment (VLE)

A software program that provides web-based tools, services and resources to deliver, track and manage teaching and learning processes for both online and blended delivery.

(McConachie et al., 2005; van Biljon and Renaud, 2009)

As far as PLE is concerned, this is not a software application, but it is a new approach to using technologies for learning (Attwell, 2007). More specifically:

Personal learning environment (PLE)

A PLE is a mash-up environment used for learning in which students assemble their own learning environment from existing services and tools.

(Ullrich et al., 2010)

Next, six of the most significant differences between both learning systems are explained. Table 2.4 summarizes them.

2.4.4.1 Manager: institution vs student

A VLE is chosen by the institution unilaterally, without considering students' opinions. Furthermore, the VLE belongs to the institution which, in turn, manages and maintains the system.

On the contrary, a PLE is based on a web mash-up (e.g. iGoogle, Netvibes, Symbaloo, etc.) in which students are responsible for managing the whole learning tool. Consequently, a PLE is independent of any educational institution and its maintenance depends on a third party.

Virtual learning environment (VLE)	**Personal learning environment (PLE)**
Institution manages the VLE	Each student manages her own PLE
Integrated (all in one)	Customizable (one for each)
Formal learning	Informal learning
Walled garden (limited access)	Open
Well-established	Emergent

Table 2.4: Differences between VLEs and PLEs.

2.4.4.2 Integrated (all in one) vs customizable (one for each)

A VLE is an integrated system which provides all necessary tools to run and manage an online course (e.g. discussion forums, management of assignments, etc.). Each VLE has its own tools and offers all its students the same tools and features with a few customizable options. Examples of VLEs are Blackboard, Moodle, Sakai, Desire2Learn, etc.

By contrast, each PLE is different for each student, since the learners choose and customize the collection of tools and services that their PLEs (i.e. web mash-ups) have.

2.4.4.3 Formal learning vs informal learning

One of the main differences is the way in which learning is delivered. In VLEs, learning is organized in courses that are managed within the platform. Furthermore, all learning activities and materials of the courses have been created by a teacher previously. In consequence, learners must study the contents and do the tasks that the instructor suggests.

By contrast, the philosophy behind PLEs is that students are at complete liberty to decide what they want to learn, the learning goals that they want to attain, where to search information, how to organize content, etc. Hence, learners are not forced to follow a predefined course, but they find and create the content of the "course" extemporaneously. The manner in which a PLE is built implies that students do not have courses, but information about topics in which they are interested that comes from different sources.

As seen, VLEs are specially designed for formal learning that is controlled by an educational institution (e.g. a university), while PLEs are much more suitable for informal learning in which the students do not obtain a formal recognition (e.g. a diploma) at the end of the learning process. Nevertheless, some teachers are currently promoting the use of PLEs as an extension of VLEs.

2.4.4.4 Walled garden (limited access) vs open

The fact that learning in VLEs is formal involves a walled garden approach. This means that any content that students and instructors upload is all trapped within a particular course. Furthermore, the access to each course is exclusive for the learners who are enrolled in it. Hence, students can only access to the activities, materials, instructors and whatever element related to the course while they are registered in it. This also implies that students cannot access to materials when the course is over. Finally, due to the previous restrictions, the community that participates in the course is narrowed down to the registered students and teachers.

On the contrary, the information that is displayed in PLEs comes from the Internet. As a result, all content is open to everybody and can be accessed whenever the user wants. Moreover, informal interactions based on social tools (e.g. social networks, instant messengers, etc.) allow students to speak to anybody who uses the Internet, being the "classroom" much bigger than that of a VLE.

2.4.4.5 Well-established vs emergent

VLEs have been used by a large number of universities since the earlier nineties. Hence, this kind of platform is very widespread in those courses that perform activities online. As for PLEs, they are an emergent educational proposal that is possible thanks to the success of web 2.0.

2.4.4.6 Conclusion

VLEs and PLEs are two different technological approaches for online teaching and learning. A VLE is a well-established and closed system that is suitable for formal and structured learning, whereas a PLE is not a specific system, but an emergent way of informal and unsystematic learning that is based on using a customized set of open tools and services which are available on the Internet.

Despite the differences, ***using a PLE does not have to be totally incompatible with the philosophy of VLEs***. For this reason, more and more VLEs are including a limited PLE within their frameworks. For instance, Blackboard and Desire2Learn provide students with a customizable homepage that looks like iGoogle. Thanks to this page, students can have a personal and customized page that uses external services by means of widgets/plug-ins. For example, Blackboard has a plug-in that enables users to manage Youtube videos.

Regarding this thesis, its research focuses on VLEs because they are widely used by online institutions that offer courses in which formal learning takes place, like the UOC. By contrast, PLEs and informal learning are out of the scope of this work.

2.5 Summary

This chapter presented an overview of the issues surrounding online (distance) education. As seen in section 2.2, online delivery have many implications for the teaching-learning process (***research question Q1***), e.g. it provides both students and teachers with flexibility of place and time. Such implications inevitably affects the agents that participate, i.e. students, teachers, institution, technology and content. Consequently, the way of teaching and learning is affected too.

With regard to online students (***research question Q2***), their profile differs from that of F2F learners: most of them are currently over 25 years old and have responsibilities (e.g. work, family, etc.). As a result, they have specific needs such as flexibility of time and place. Likewise, in order to complete online courses successfully, students should have certain qualities. Among these characteristics, self-regulation skill is one of the most important. However, a large number of learners do not have this ability. This, taken in conjunction with other factors, may be the causes of the high dropout rates that online courses have.

Regarding online teachers (***research question Q3***), they should create courses whose instructional design is mainly based on Constructivism, since this learning theory promotes a student-centered approach which adapts better to online learners' requirements. Such an approach implies that the role of the teacher shifts from a masterful figure to a facilitator who guides students through the learning process. In addition to this significant change, online delivery adds social and technical skills to the traditional pedagogical and managerial roles of instructors. Unfortunately, many instructors do not have the necessary abilities to do all these new tasks and, therefore, they may need some help when designing and teaching online courses. In this regard, the nature of the online environment requires effective tools which especially support those tasks that are more difficult to perform online, e.g. to monitor students' attention and progress closely.

As for technology, this chapter only focused on virtual classrooms because they are the main research topic of this thesis. As said in section 2.4.4, two approaches can mainly be distinguished: virtual learning environments (VLEs) and personal learning environments (PLEs). As seen, there are noticeable differences between both systems. While VLEs are more suitable for formal learning (e.g. university degrees), PLEs are an emergent way of informal learning based on web-mashups customized by the students. Due to the context of this research, i.e. online universities, and the widespread use of VLEs in online institutions, these systems will be the focus of this thesis. The next chapter will examine VLEs in more detail.

3 Virtual learning environments (VLE)

This third chapter examines virtual learning environments (VLEs). Specifically, the following issues will be dealt with:

- What a virtual learning environment is and which is the scope of this thesis regarding these systems (see section 3.1).
- A brief history of this kind of learning system (see section 3.2).
- A discussion of the elements that should be part of the foundations of any VLE (see section 3.3).
- An in-depth analysis of the most important current VLEs (see section 3.4).
- A discussion of to what extent the current VLEs are effective tools for fully online teaching and learning (see section 3.5, research question Q4).

3.1 Introduction

As defined in section 2.4.4, ***a virtual learning environment (VLE) is a software program that provides web-based tools, services and resources so as to deliver, track and manage teaching and learning processes for both online and blended delivery*** (McConachie et al., 2005; van Biljon and Renaud, 2009). This type of system encompasses both educational and administrative issues. For this reason, the following observation about the scope of this thesis must be taken into account:

Scope of this thesis regarding the VLEs

> The scope of this chapter and the focus of this research have been limited to the educational aspects of VLEs. Therefore, both administrative tasks (e.g. to grant/revoke user permissions, to enroll students in a course, etc.) and technical aspects (e.g. system installation, setup, OS compatibility, etc.) will not be addressed.

Finally, although the term *VLE* has become widespread, other names such as *learning management system* (LMS), *course management system* (CMS), *learning content management system* (LCMS) and *technology-enhanced learning environment* (TELE) are used interchangeably. The discussion of the possible differences between these terms is out of the scope of this work and, hence, the term *VLE* will henceforth be used in this thesis.

3.2 Evolution of virtual learning environments

In the earlier nineties there was an interest in using the Internet's capabilities for education due to the web boom. This is how the first VLEs were born. In those days, there were not commercial solutions and each university had to develop its own VLE to satisfy the particular needs of the institution. An example of those VLEs is WOLF (Wolverhampton Online Learning Framework), which was created at the University of Wolverhampton in 1995.

In 1996, Murray Goldberg launched the first version of WebCT. This became the first successful worldwide VLE. This meant a turning point, since this was a first step toward the development of commercial VLEs that were suitable not only for a specific university, but they were able to adapt to the general features of any institution. From then on new companies, such as Blackboard Inc. and Desire2Learn Inc., arose with a clear objective: the creation of VLEs.

In the late nineties, there was the open source boom. This led many developers to share their VLEs with the educational community freely. Thanks to this, the code could evolve through community cooperation, since any person was able to develop new features and improvements. In 1999, the Moodle project was started. Since then, Moodle has become the most important open-source VLE and it currently competes with proprietary VLEs. In the same way, other (less popular) open-source VLEs emerged, such as Claroline, ATutor, Dokeos, etc.

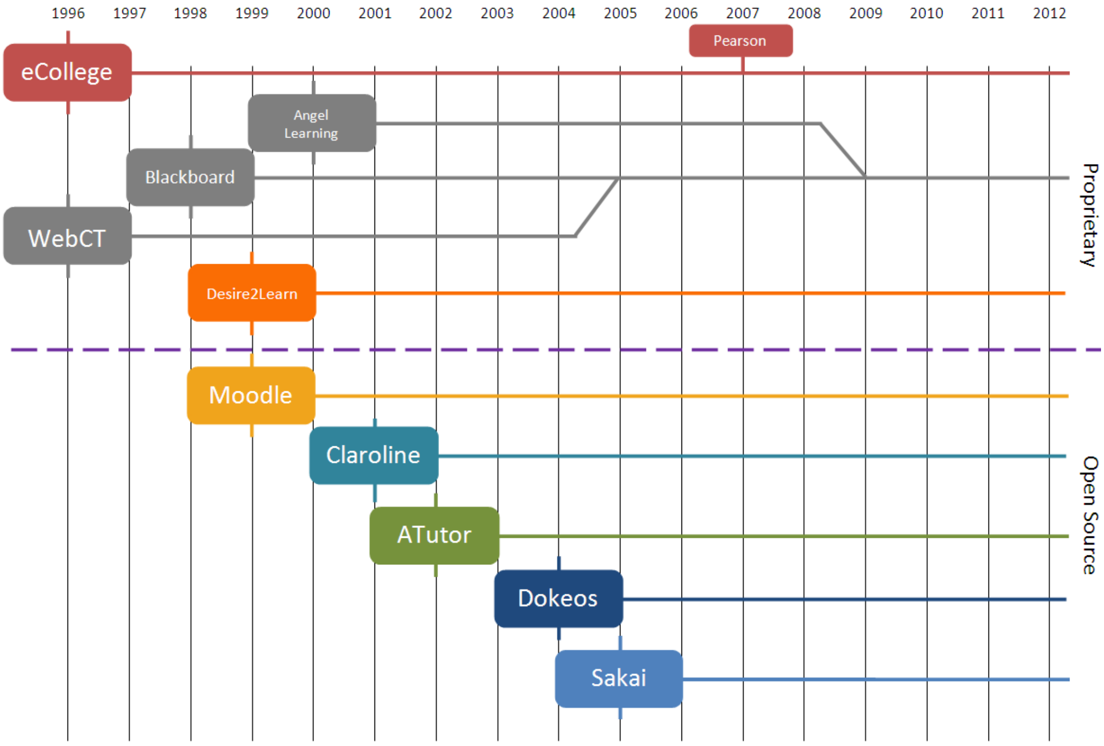


Figure 3.1: Brief summary of the history of VLEs.

Nowadays these systems have become essential in any online university or school. Moreover, there is a wide range of proprietary and open-source VLEs which offer many features and benefits (e.g. development cost savings) that ad hoc VLEs do not have. For this reason, online institutions have currently taken one of the following two decisions: (1) either to replace their ad hoc VLE with an existing proprietary or open-source VLE, or (2) to combine their own VLE with an external one. In this regard, the Universitat de Barcelona (UB) is an example of the first option, whereas the UOC and the Universitat Autònoma de Barcelona (UAB) have adopted the second one.

Finally, as a result of the increasing demand for these platforms and the rivalry that exists between these systems, VLEs continue to improve themselves by adding new characteristics, e.g. compatibility with mobile devices.

3.3 Foundations of virtual learning environments

According to Mastoras et al. (2005), designing a VLE involves a combination of three elements:

- Pedagogical approach (or design)
- Information structure (or architecture)
- Usability (or interface)

Next, the importance of each of them is discussed.

3.3.1 Pedagogical approach

Online courses, as any other kind, need to be designed according to a sound pedagogical basis so as to provide students with a successful learning experience. Nevertheless, unlike F2F courses, the success of online subjects does not only depend on the quality of the teaching style and the learning materials, but this is also determined by the learning tools that are used. For this reason, ***online learning systems, such as VLEs, should not only take technology into consideration, but also the underlying pedagogy on which they are built*** (Zardas, 2008). Although the pedagogical neutrality is taken for granted as a desired property of a system by most VLE developers (Laanpere et al., 2004, 2012), researchers like Friesen (2003) argue that the specifications and the applications that are truly pedagogically neutral cannot also be pedagogically relevant.

At this point, it is important to notice that the paradigm or approach of a VLE shapes the user experience and encourages a certain kind of usage (Rice, 2006). For example, a VLE can encourage sequential learning instead of unordered, or it can promote collaborative rather than individual learning, and so on. As observed, the approach that determines the design of a VLE is a critical factor that affects the other two cornerstones, i.e. the information structure and the usability (i.e. interface, functionalities, etc.), and consequently the whole teaching-learning process. This is why it is essential that developers take pedagogical aspects as well as online students' and instructors' features and needs into account when they design these systems.

3.3.2 Information structure

According to Snyder (2010): *"Specifying information structure is as important as specifying information content... because the value of information depends on how effectively we can use it"*.

From the perspective of the information structure, a VLE usually has a database as storage engine. This means that the developers have to turn a course into a database schema. To this end, it is important to bear in mind that an effective information architecture comes from understanding the context, the content, and the requirements of the people who will use the application (Barker, 2005). Thus, ***the database of a VLE should not only be designed according to the mainstream IT guidelines, but this should also consider the pedagogical approach that has been defined***.

Some of the decisions that may be made regarding the information structure are: what course elements are included in the database, what attributes they have, what relationships exist between them, what type of relationships they are (e.g. hierarchical, sequential, etc.), etc.

At this point, it is important to notice that if the pedagogical decisions affect the information structure and the interface, the decisions that are made for the structure have influence on the VLE's interface. This is due to the fact the structure of the information defines the primary ways in which users can navigate (Morville and Rosenfeld, 2006). For instance, if a set of items are interrelated sequentially in the database, the interface will hardly allow users to navigate through them hierarchically. Likewise, if a piece of data does not exist, the interface will not be able to show it.

In short, ***the design of the information structure should be done carefully and by taking account of the pedagogical approach that has been defined for the VLE***.

3.3.3 Usability

Aspects such as the way in which information is displayed, how user-VLE interaction is carried out, the attractiveness of the interface, and so on can determine to what extent students learn correctly. Forcing students to spend longer time understanding poorly usable interfaces than understanding learning content disturbs the accommodation of new concepts and the overall retention of what is being learned (Ardito et al., 2004b). Hence, usability has much influence on the effectiveness of the learning process, since they both are substantially intertwined (Guralnick, 2007; Tselios et al., 2001). Thus, the goal of usability in the VLEs can be summarized with the following statement: *"Interfaces ought to concentrate on learners' needs and goals, providing a clear idea of content organization and system functionalities, simple navigation, advanced personalization of paths and processes. The user should be involved in the learning process without being overwhelmed"* (Ardito et al., 2004b, p. 80).

To sum up, because modern e-learning environments are less neutral than traditional ones (Tselios et al., 2001), usability should not be overlooked. A poor and awkward interface may become a barrier to effective learning (Mastoras et al., 2005). Therefore ***the interface of VLEs should be designed by taking both usability and pedagogical principles into account*** in order to guarantee that students and teachers have a good experience.

3.4 Examples of virtual learning environment

In this section, eight of the most important VLEs are presented in alphabetical order to study their main features. For each VLE, a brief introduction is given, followed by a system description which focuses on the three aforementioned aspects: the underlying pedagogical approach, the information structure and the interface (as the result of applying usability criteria).

Table 3.1 shows the VLEs that will be described and classifies them into two groups: open-source and proprietary.

Open-source	**Proprietary**
ATutor	Blackboard
Claroline	Desire2Learn
Dokeos	eCollege
Moodle	
Sakai	

Table 3.1: Open-source and proprietary VLEs described in this chapter.

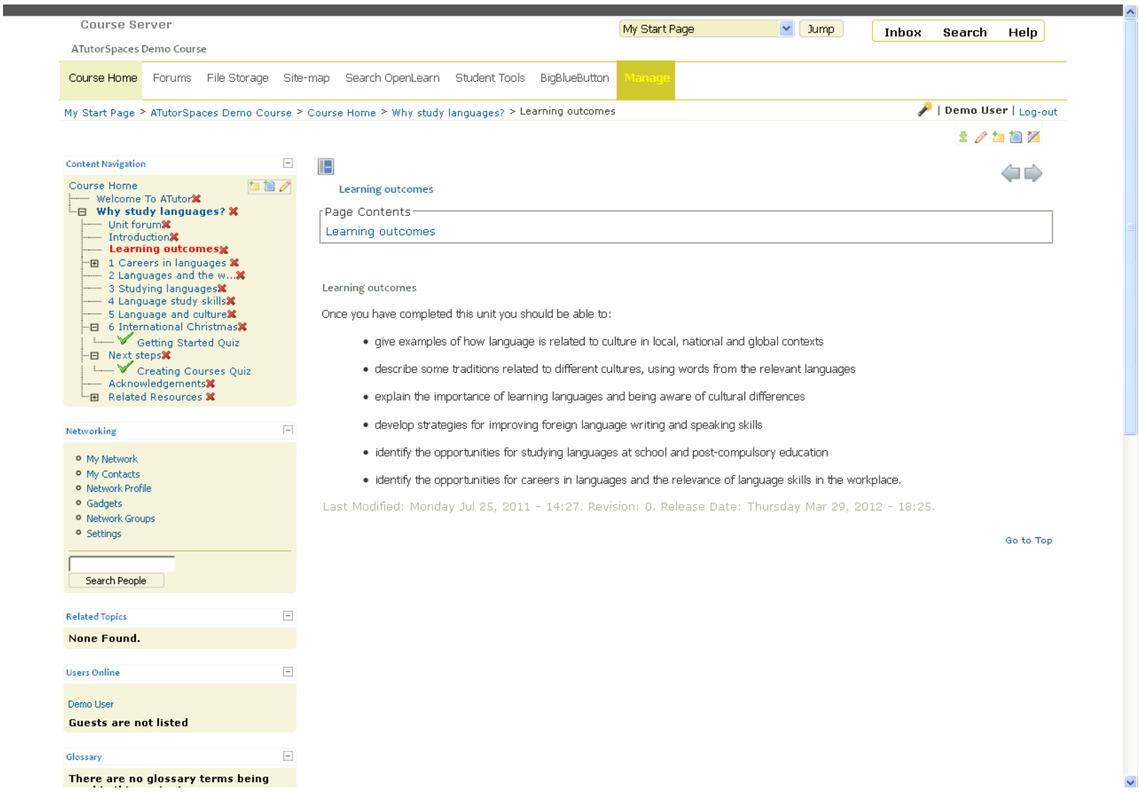


Figure 3.2: ATutor 2.1's interface from teacher's perspective. ***Source***: demo.atutorspaces.com.

3.4.1 ATutor

ATutor[1] is an open-source VLE that was developed by the OCAD University in 2002. This was created from two studies that had analyzed the accessibility of the web-based learning environments. Because both studies had concluded that none of the popular VLEs in that time allowed disabled people to fully access to online courses, ATutor focused on creating an accessible VLE that anyone could use. Thereby ATutor has become ***one of the most accessible VLEs that exist***, complying with the W3C WCAG 2.0 accessibility specifications at the AA+ level. Among the large number of accessibility features, for example, it allows users to modify text setting (i.e. font type, size, color, etc.). Likewise, ATutor can show text as an alternative for all visual elements as well as allowing users to access to all elements by using keyboard commands.

With regard to their pedagogical approach, this is poor or non-existent. This is evident in the way in which a course is organized. ***ATutor divides a subject into two parts: the table of contents (TOC) and tools***. On the one hand, teachers can create a hierarchical TOC that basically consists of HTML pages and, on the other, ATutor has a section called *students tools* that comprises tools for supporting the teaching-learning process (e.g. chat, glossary, file storage, etc.).

As far as the interface is concerned, it has a classic design (see Figure 3.2): this has a top horizontal menu, a lateral menu and a main area. The top menu contains the general options (e.g. site map, student tools, etc.), whereas the lateral one displays the TOC of the course in a hierarchical form. Moreover, the lateral menu can have extra information boxes under the TOC, e.g. a search box, online users, glossary, etc. As for the main area, it shows the content of the clicked option. The

[1] atutor.ca

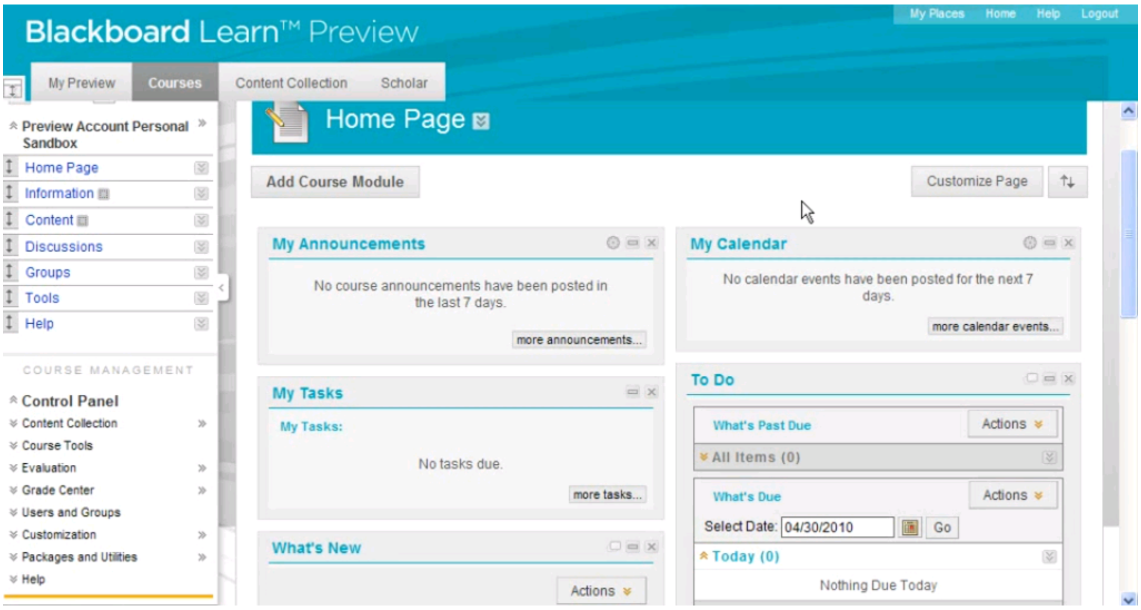


Figure 3.3: Blackboard Learn 9.1's interface from teacher's perspective. ***Source***: YouTube - mamabutton.

way how the information is displayed depends on the data. For example, when the general option *students tools* is clicked, the main area looks like an OS desktop in which the main tools (e.g. file storage, chat, forum, polls, etc.) are displayed. However, when a label from the TOC is clicked, the main area shows the HTML page that the teacher has created for that label.

Finally, ATutor enables students to navigate through the course in three different ways: (1) hierarchically, i.e. the TOC, (2) sequentially, the content is accessed in a preset order by using *next* and *previous* links, and (3) globally, a *site map* shows the course as a whole, i.e. content plus tools.

As seen, ***ATutor needs to be greatly improved. To this end, it should consider pedagogical aspects thoroughly***.

3.4.2 Blackboard

Blackboard Inc.[2] was founded in 1997 by two education advisers, Matthew Pittinsky and Michael Chasen, as a consulting firm to provide technical standards for online learning applications. The first version of its VLE was born in 1998. By the early 2000s, Blackboard became the leading VLE. In 2005, the company bought WebCT Inc., its main rival in those days. Afterward, Blackboard acquired Angel Learning, another education software developer, in 2009. The current version of its VLE, *Blackboard Learn 9.1*, integrates components from WebCT and Angel. Besides its web version, Blackboard has released a mobile version of its VLE.

The interface of Blackboard Learn 9.1 is divided into two parts (see Figure 3.3): (1) a main area, in which the content is displayed, and (2) a lateral menu. The latter contains two sub-menus:

- **Course management menu**: this menu is only visible for teachers and contains links to sections that allow to manage different parts of the course. These links are: content collection (i.e. resources used in the course), course tools (e.g. blog, chat, wiki, etc.), evaluation (e.g.

[2] blackboard.com

course reports), grade center (e.g. assignments and tests), users and groups administration, customization (e.g. properties, style), packages and utilities (e.g. export a course), and help.

- **Course menu**: this menu shows all the course elements organized in a hierarchical form. This is visible for all the users (i.e. both students and teachers), but only teachers can edit it. The course menu can include multiple instances of the following items:
  - **Blank page**: this is a single page which the teachers create by means of a text editor.
  - **Tool link**: it is a link to a specific type of course tool such as a blog, e-mail, calendar, chat, forum, wiki, test, and so on. For instance, if the instructor created a link to the forums, then when a student clicked on it, a list of all the discussion forums of the course would be shown in the main area.
  - **Course link**: this is a shortcut to an existing area, item, or tool that is within the VLE.
  - **External link**: this takes the users to learning materials that are out of the platform.
  - **Module page**: this is a customizable page that looks like iGoogle or Netvibes. It can contain any number of interactive items such as a dictionary, calculator, alert area, etc.
  - **Subheader**: it is a text that helps to structure the course menu into areas.
  - **Divider**: it is a line that is placed anywhere on the course menu. This element can be used together with the subheader to organize the course menu.
  - **Content area**: it is the main item of the course menu. This is like a folder in which the instructors can add four kinds of items:
    - **Content**: it allows to add a simple item (i.e. a small piece of text with attachments), a file (e.g. document, audio, video, etc.), a content folder (i.e. a content area), a learning module (i.e. a collection of content items focused on a specific subject and ordered sequentially), a lesson plan (i.e. a combination of information about the lesson itself with resources used to teach it), a syllabus, a course link, a module page, a blank page, a tools area and a mashup (i.e. a special link to Youtube, Flicker and Slidershare).
    - **Assessment**: it allows to add tests, surveys and assignments.
    - **Interaction tool**: it enables to add blogs, journals, forums, wikis and chat sessions.
    - **Textbook**: this item allows to provide information about textbooks used in the course.

As seen, the structure of a subject is defined in the course menu, which is a list of items that does not follow any well-known course organization, e.g. the table of contents (TOC), the course schedule, etc. Moreover, ***the items of the course menu are categorized by type rather than purpose***. According to Lane (2007), ***this organizational design forces teachers to think in terms of content types*** (e.g. is the content a file or a text?), ***breaking the natural structure of the semester***, which is based on the schedule. Likewise, Coopman (2009) argues that such a rigid structure limits how teachers can organize a course. Many teachers actually perceive Blackboard as a ***rigid VLE*** because of its lack of ability to adapt to different teaching styles (West et al., 2007).

Likewise, the course menu plays such an important role that the ease of navigation through the subject as well as the effectiveness of the learning process depend on how teachers organize it. For instance, when a new course is built in this VLE, the following items are put in the course menu by default (see Figure 3.3): homepage (i.e. a module page), information (i.e. a content area), content (i.e. a content area), discussions (i.e. a tool link), groups, tools and help. According to Lane (2008), this kind of preset organization encourages novice instructors to put the content into the most appropriate default category instead of effectively translating their teaching styles into an online environment. In fact, if the teachers who use Blackboard do not get involved in creating an effective course, they can simply put all the learning resources into the option called *content*. Obviously, such an organization affects the learning process that is carried out with the VLE.

In short, Blackboard is one of the most important VLEs at this moment. However, according to different studies and researchers, ***it is missed a sound pedagogical approach in its design***, because it focuses on managing course content effectively. Obviously, this may hinder instructors and students from having a pleasing teaching-learning process.

3.4.3 Claroline

This open-source VLE was initiated by the Université Catholique de Louvain (UCL) in 2001. This is distributed under the GNU/GPL license. Nowadays, according to its website, Claroline[3] has more than 150 downloads per day and around 2223 organizations use it, being present at 115 countries. As far as technical aspects are concerned, Claroline is written in PHP and uses MySQL and Apache.

Claroline's pedagogical approach is based on ***the dynamic model suggested by Lebrun (2007, p. 75)*** (see Figure 3.4). This model promotes a process that is made up of three stages:

- Information (e.g. goals, evaluation criteria, to illustrate the context, etc.)
- Activities (e.g. exercises, assignments, etc.)
- Productions (e.g. deliverables of assignments, texts in wikis, questions on forums, etc.)

Moreover, two elements are present in the three stages: motivation and interaction. The latter, according to their authors, implies that Claroline is biased toward ***Social Constructivism***.

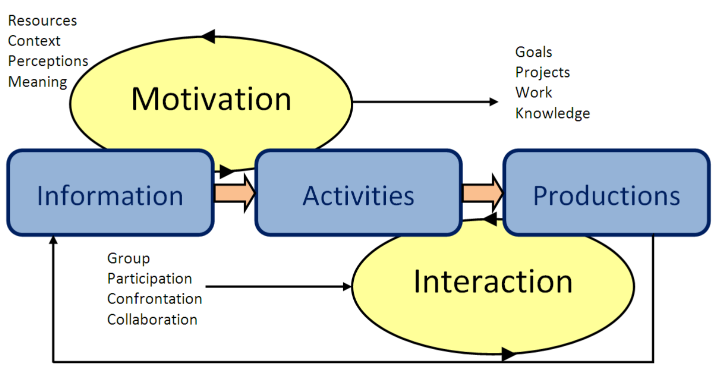


Figure 3.4: Dynamic model on which Claroline's pedagogical approach is based. ***Source***: (Lebrun, 2007).

[3] claroline.net

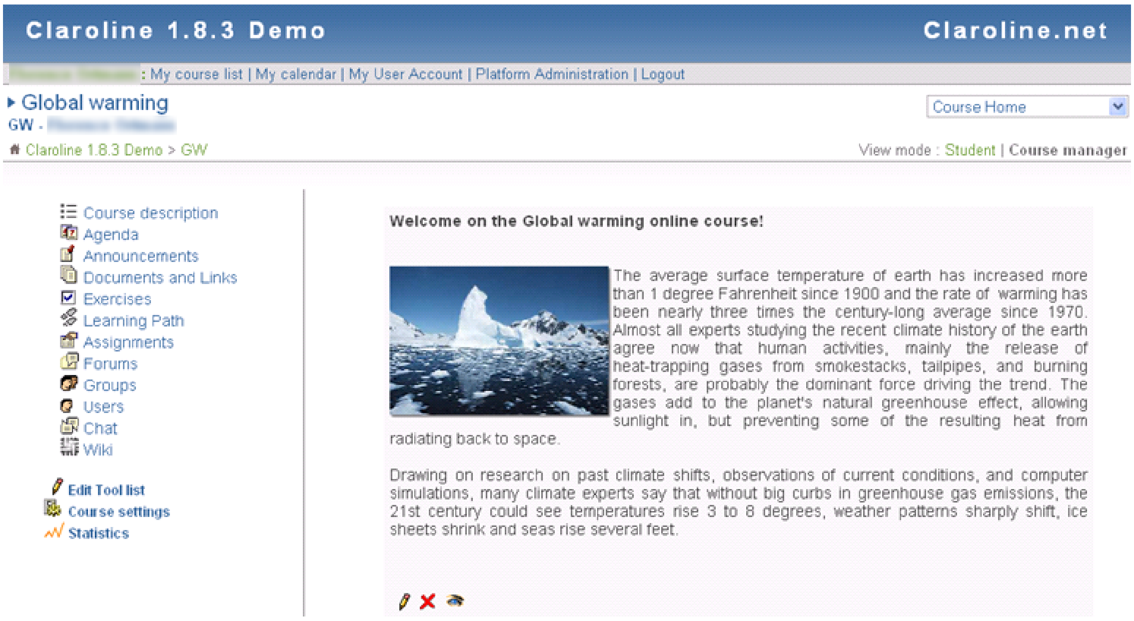


Figure 3.5: Claroline's course homepage. ***Source***: doc.claroline.net.

Each course is built on a set of tools that includes: course description, agenda, announcements, documents and links, exercises, learning path (similar to Blackboard's learning module), assignments, forums, group, users, chat and wiki. These tools are consistent with the dynamic model (see Figure 3.4). For instance, the first four tools are related to the information stage, while the chat, the wiki and the forums promote interaction. Besides the default tools, any user can develop her own tools (called modules) and share them with the community.

As seen, ***the design of the information structure is tool-oriented***. Such a design limits the creativity and freedom of the teachers, since this way of organizing the course is not natural. In consequence, the information structure may have an adverse effect on the teaching process.

As far as the interface is concerned, this consists of three parts (see Figure 3.5): on the top, there is a menu with the general options of the platform, e.g. course list, global calendar, platform administration, etc. On the left hand, there is a navigation menu that shows the tools that Claroline has. Finally, the right side holds the main area in which the contents are displayed.

As it can be observed, due to the design of the information structure, ***the navigation through any course is tool-oriented***. Such a navigation may difficult the teaching-learning process a lot.

In conclusion, the adaptation of Lebrun (2007)'s dynamic model do not seems to have been made correctly, since the final result is a VLE that is a hodgepodge of tools.

3.4.4 Desire2Learn (D2L)

Desire2Learn (D2L) Inc.[4] was founded in 1999 by John Baker and Anil Sabharwal. D2L develops online learning products for schools, universities, governments, associations and organizations. One of its leading products is *D2L learning environment*, which will be described in this section.

The ***instructional design of D2L learning environment*** (henceforth D2L) ***is based on three pil-***

[4] desire2learn.com

lars: (1) learning activities (or course content), (2) assessments, and (3) course objectives. ***The core of any course in D2L is its table of contents*** (TOC), i.e. the first of the three previous elements. The TOC (or course content) follows a hierarchical structure which is made up of modules, and each module consists of topics. The modules organize the course, whereas the topics are the content itself. There are four types of topics:

- **HTML File**: this is created from scratch by using an HTML editor.
- **Course file**: this is created from an existing file of the course.
- **Uploaded file**: this creates a new topic by using a file from the instructor's computer.
- **Quicklink**: it is a link to either a course material or a tool (i.e. discussion forums, chat, quizzes, dropboxes and grades) or a page on the Internet.

As for the second cornerstone, assessment items (e.g. dropbox, quiz, etc.) are created as a part of the course content, specifically, they are quicklinks. Each of them can also be linked to a rubric.

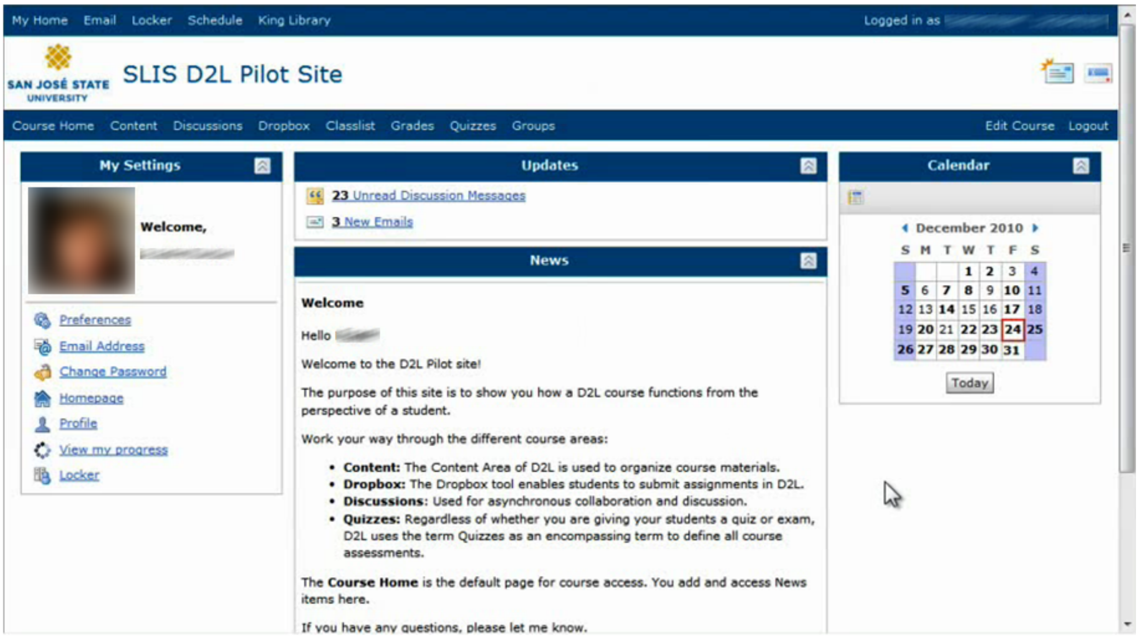
Finally, ***competences and objectives can be defined by the instructor*** too. They are defined in another hierarchical structure which is independent of the table of contents's one. However, the objectives can be linked to a topic (i.e. a content item) or any type of assignment.

As far as the interface is concerned, this is divided into two sections: (1) the homepage, and (2) the course itself. First of all, after the authentication, the homepage is shown. This is the starting point from which the student can read pieces of news and access to her courses and any content related to the institution. The homepage is made up of several customizable widgets.

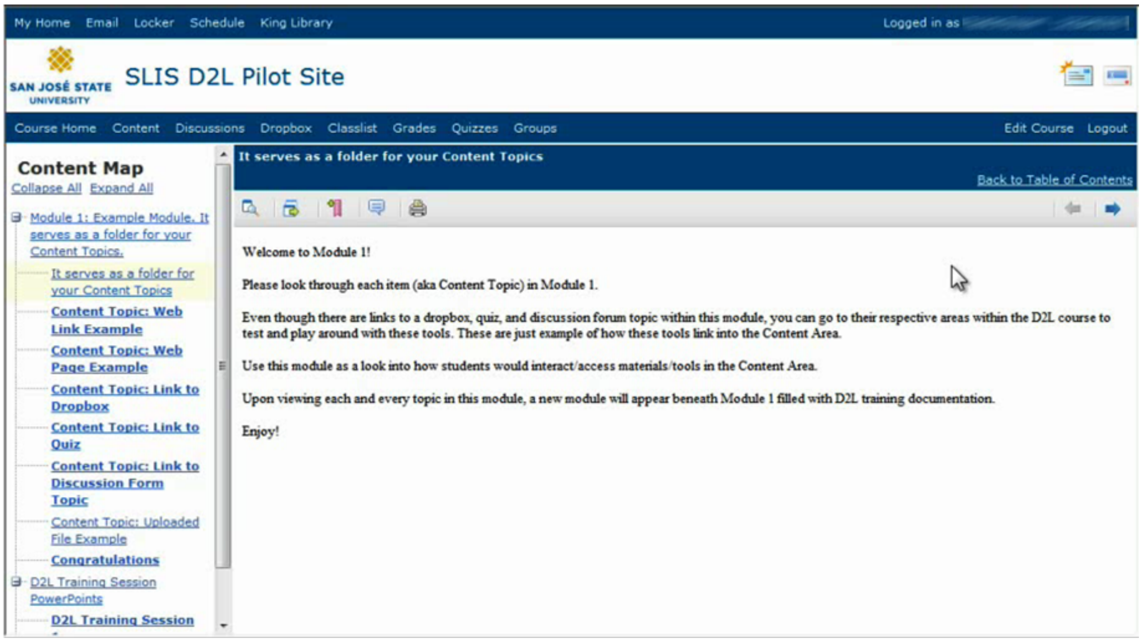
When the student accesses to a specific course, the first page that appears is the course home (see Figure 3.6a). This is like the homepage, but it only displays information and widgets related to the selected course. Moreover, there is an horizontal navigation bar that has links to several course-related tools, e.g. course home, content, discussions, dropbox, classlist, grades, competences, etc. These options vary somewhat depending on the customization determined by the administrator.

If the option *content* is chosen by the student, the main area is divided into two parts (see Figure 3.6b): (1) a hierarchical menu that includes the course's modules and topics (on the left), and (2) the content area itself. The content can be navigated by the students via several access methods: bookmarks, search box, last topic visited and scrolling. As seen, the effectiveness of a course mainly depends on how the instructor organizes the *content* section (i.e. the TOC). Although this organization is very similar to that of Blackboard, and they both are far from being based on the semester, the one of D2L is better. The reason is that the course design in D2L revolves around the TOC and the competences, which is closer to the way of thinking of teachers than designing a subject according to an undefined structure.

Finally, it is worth emphasizing that ***D2L 9.4 and later enable to directly add content*** (i.e. modules and topics) to the course calendar. As a result, ***the course content can be displayed in up to two views: the (table of) contents*** (this is required) ***and the calendar/schedule*** (optional, it requires that the *content* section has been defined previously).



(a) Desire2Learn learning environment's course home



(b) Desire2Learn learning environment's content section

Figure 3.6: Desire2Learn learning environment's course home and content section. ***Source***: https://slisapps.sjsu.edu/d2l/student/tour/d2lStudentTour.html.

3.4.5 Dokeos

Dokeos[5] is an open-source VLE whose first release was in 2004 under the impulse of Thomas De Praetere. This VLE has two versions, the free one (distributed under license GNU/GPL) and the commercial one (called Dokeos PRO). The code can be modified or adapted for specific requirements by anyone. This is written in PHP and uses MySQL as database. In the time of this thesis, the stable version was 2.2. According to the official website, there exist around 11590 implementations of Dokeos which contain 411638 courses and 4486202 users.

Dokeos is designed as ***a tool-oriented VLE***. As a result, content management is easy to do, but the teaching-learning process suffers from the absence of a sound pedagogical approach in the core of the system. The set of tools included in Dokeos is divided into three categories:

- **Content authoring**: documents, exercises, modules, course description, etc.
- **Interaction**: forums, chat, wikis, etc.
- **Administration**: reports, settings, etc.

With regard to the tools, there is one called *modules* that deserves special attention, since this allows to create a sequence of resources (e.g. documents, exercises, etc.) and tools (e.g. forums, chat, etc.). However, this type of resource requires instructors to have some computer skills and motivation. Likewise, some functionalities, such as the videoconference or Oogie[6], are only available in Dokeos PRO.

As this VLE is tool-oriented, the structure of a course is a combination of different elements that are not connected. For instance, teachers must upload the resources in the *documents* folder, create a forum in the *discussion* section, a quiz in the *quizzes* section, etc. Hence, ***Dokeos forces the teachers to upload content online without following an organization that is based on a sound pedagogical approach***. Actually, ***Dokeos is more similar to a content repository than a virtual learning environment***. In this regard, the absence of a pedagogical approach as well as its tool-based design may have an adverse effect on the teaching-learning process.

Regarding ***the interface, its design is so closely connected to the information structure that it looks like an OS desktop*** (see Figure 3.7). Thus, each course's homepage is a set of icons in which each of them takes users to a tool or section (i.e. documents, modules, discussions, calendar, etc.). One of the advantages of this desktop-like interface is that the students understand how it works because they are used to interacting with operative systems every day. By contrast, such an interface can cause confusion due to the fact that the learners only see icons. For example, students may have difficulty in knowing what they have to do in each moment.

As seen, it may be concluded that, although Dokeos has a familiar interface for all users, ***this VLE does not seem to have been developed from an educational standpoint***.

[5] dokeos.com

[6] Oogie: a converter that transforms a PowerPoint file into a SCORM learning path.

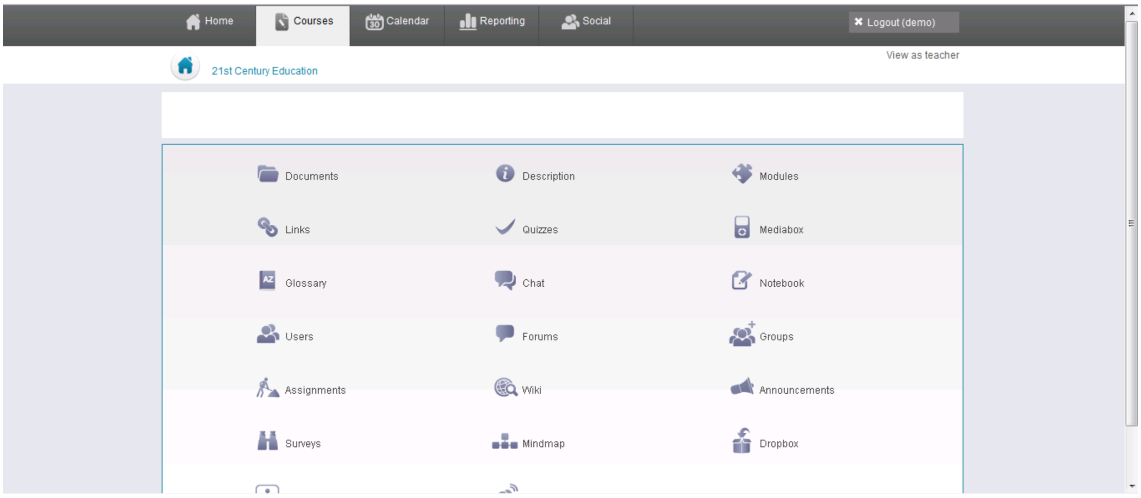


Figure 3.7: Dokeos's course homepage. ***Source***: demo.dokeos.net.

3.4.6 eCollege

eCollege[7] is a proprietary VLE that was acquired by Pearson Education Inc. in 2007. Due to the privacy of the information, it has been difficult to analyze this VLE exhaustively.

As far as the information structure is concerned, ***eCollege enables to define a course in two ways: weeks and units***. They both are natural for teachers, since the *weeks* are closely related to the semester and the *units* are part of the TOC. However, the structure of the TOC is quite rigid, because this do not allow to create a hierarchical structure inside the *units*. Hence, both the *weeks* and the *units* are sorted out sequentially and each *week/unit* is a container/list of elements (e.g. resources, tools, etc.). Likewise, ***although there are two organizational items, teachers cannot use both of them at the same time***. This makes the platform rigid.

Regarding the interface, the design of the layout is very typical. This is divided into three parts:

- **Lateral menu**: this is on the left hand and it is made up of two areas. The first one contains links to the elements that are usually present in most of the courses, e.g. the syllabus, the faculty information, etc. As for the second area, this contains a list of either *units* or *weeks*. When a student clicks on the *unit/week*, the set of items which are related to that *unit/week* appears below, e.g. a discussion board, web links, assignments, etc.

- **Main area**: this shows the content related to the link that has been clicked on the lateral menu.

- **Top menu**: this includes tools that are used in all courses or through the whole platform, e.g. dropbox, e-mail, gradebook, etc.

As it has already explained, it has not been able to analyze this VLE in depth. Nevertheless, it seems that the design of eCollege matches the way of thinking of learners and instructors, because this VLE allows to organize a course based on two familiar elements (i.e. *weeks* and *units*). This, among other things, makes the navigation through the course easier.

[7] ecollege.com

3.4.7 Moodle

Moodle[8] is an open-source VLE that was created by Martin Dougiamas in 1999 as a part of his PhD thesis. Nowadays, Moodle is the most popular open-source VLE. According to the statistics, there are 77256 registered sites from 229 countries (plus unregistered sites). This has caused that over 7125383 courses are currently active and around 66 million people are using this VLE. Likewise, its community has around 1267806 registered users. Certainly, Moodle is unquestionably the largest open-source competitor to Blackboard at present.

A large part of its success is due to its modular structure, which allows any developer to create additional modules and features easily. Actually, Moodle means *Modular Object-Oriented Dynamic Learning Environment*. Thanks to the ease of expansion, a lot of users have developed their own modules and then have shared them with the community. The existence of a powerful community of non-profit users has resulted in the creation of a vast collection of tools.

In the time of this thesis, the stable version was 2.4.1. This was developed in PHP 5.3.2 and supported MySQL 5.1.33, PostgreSQL 8.3, Microsoft SQL Server 2005 and Oracle 10.2 as DBMSs. In addition, new projects for Moodle were being developed. For instance, Moodle Mobile App[9], an interface that will allow users to access to a Moodle site and do a few tasks. For now, this application only works with iOS and servers that run Moodle 2.1 or later. However, the development of a cross-platform mobile client written in HTML5 is in progress.

According to Dougiamas (2000), he designed Moodle by following a ***pedagogical approach based on Social Constructivism***. For this reason, collaborative and communication tools (e.g. forum, chat, workshop, etc.) are key elements in this VLE. In this regard, the forums have been one of the items in which the developers have put their greatest effort since the beginning.

Regarding Moodle's information structure, all the courses belong to a category defined by the system administrator. A category may be the area where the subject is located, e.g. Humanities, Science, etc. Hence, this is a global classification that allows to organize courses for all Moodle participants. Likewise, ***teachers can choose the format of the course from four available types***[10]:

- **Topics**: the course is organized into sections or topics. Each section has a description and a list of *activities* and *resources*.
- **Weekly**: the course is structured into weeks. The first week begins at the course starting date. Like the topic format, each week has a description and a list of *activities* and *resources*.
- **Social**: the course revolves around a long discussion forum that is the key element of the course. In contrast to the previous formats, the *activities* and *resources* must be listed in the *social activities* block, instead of the main area.
- **SCORM**: this allows to upload a SCORM package to an only section. This is useful when the course focuses on a specific topic and contains a single learning object.

[8] moodle.org
[9] docs.moodle.org/24/en/Mobile_app
[10] The format can be changed at any time.

Regarding the content, ***the courses are basically made up of resources and activities***:

- **Resource**: this is an item that a teacher gives students in order to support learning. Resources appear as a single link inside a *topic* or *week*. Moodle has the following types of resources in its standard distribution:

  - **Book**: this resource allows to create an HTML book. This is a sequence of HTML pages written by the instructor.
  - **File**: this option allows to upload one or multiple files (e.g. document, image, etc.).
  - **Folder**: it helps to organize files. Likewise, one folder may contain other folders.
  - **IMS content package**: Moodle enables to upload IMS content packages.
  - **Label**: this is a simple text that is usually short and descriptive. It may be used to create headers that help to separate resources and activities in a topic/week section.
  - **Page**: this is an HTML page that is written with an embedded editor by the teacher.
  - **URL**: this is a hyperlink to any website (e.g. Youtube, Flicker, etc).

- **Activity**: this is a task in which the teachers want their students to participate actively. There are 14 different types of activities in the standard version of Moodle. However, much more activities developed by community members can be included manually.

  - **Assignments**: this kind of activity allows the teachers to collect work from the students, review it and provide feedback including grades. Moodle has four sorts of assignments:
    * **Upload a single file**: this enables the learners to upload a single file.
    * **Advanced uploading of files**: similar to the previous type of assignment, but this allows the students to upload multiple files.
    * **Online text**: this type of assignment asks the learners to write a text by using the Moodle's text editor. The students only have one opportunity to enter their answer.
    * **Offline activity**: this only shows the description of the assignment. This is useful for blended courses which may have assignments that are completely offline. In this case, the learners do not have to deliver anything via Moodle.
  - **Chat**: it allows the students to have real-time synchronous discussions.
  - **Choice**: it is a poll in which the teacher asks a question and specifies a choice of multiple responses.
  - **Database**: this activity enables the teachers and/or students to create and maintain a database of records. Each record can have the number and type (e.g. number, image, date, etc.) of fields that the participants consider appropriate.
  - **External tool**: it enables users to interact with LTI-compliant learning resources and activities on other websites.
  - **Feedback**: it is a survey, but unlike the survey tool (see below), this allows the teachers to write their own questions. Likewise, unlike the quiz tool (see below), non-graded questions can be included.

– **Forum**: it allows the learners to have asynchronous discussions. Furthermore, this can be a graded activity. There are four types of forums:
  * **A single simple discussion**: a single topic discussion developed on one page. This may be useful for short focused discussions.
  * **Each person posts one discussion**: each student can start only one new discussion, even though everyone can reply to any discussion.
  * **Question and answer**: this is a special forum that enables the students to write a question as initial post of a discussion. The rest of learners may reply with an answer, but they will not see the replies of their classmates to that question until they have replied to it too.
  * **Standard forum for general use**: a forum in which anybody can start a new topic at any time. This can be shown in a forum-like or blog-like format.
– **Glossary**: this activity is like a collaborative dictionary. The participants (the whole classroom or only the teacher) create and maintain a list of definitions.
– **Lesson**: this is a set of HTML pages in which the students are usually asked to make some type of choice at the end of each content section. The choice will take them to a specific page of the lesson. Moreover, the lessons can be graded activities.
– **Quiz**: it allows the teacher to design and build quizzes consisting of a large variety of question types (e.g. multiple choice, true/false, etc.). Quizzes have a final grade.
– **SCORM package**: this kind of package can be included as an activity.
– **Survey**: this activity allows to create surveys that gather data about the nature of the course from students. Two types of surveys are implemented: COLLES and ATTLS.
– **Wiki**: it is a collection of pages that anyone can add to or edit.
– **Workshop**: it is a peer assessment activity in which the students must submit their work and, at the same time, assess other students' work. As a result, the grade of this activity for each learner is calculated from the their own work and the quality of their assessments of the classmates' work.

The creation and edition of *resources* and *activities* are based on simple forms. Furthermore, each *resource* and *activity* has a lot of options that can be configured in order to adapt the platform to the features of the course. ***All these features, in conjunction with the four course formats which this VLE offers, help the instructors to create courses easily and quite freely***.

Apart from the resources and activities, Moodle provides other functionalities, such as gradebook, course backup, course settings, students' progress tracking and so on. One of the most interesting features from Moodle 2.0 onward is the option of *activity completion*, which allows the students to mark activities as complete. Such a feature gives learners information about their progress, which may help the students to be self-regulated, a desired skill in online education (see section 2.4.1.2).

In addition to the aforesaid functionalities, Moodle has blocks. Blocks are widgets which add additional functionalities to the course. They can be put into any page. There are 37 blocks in the

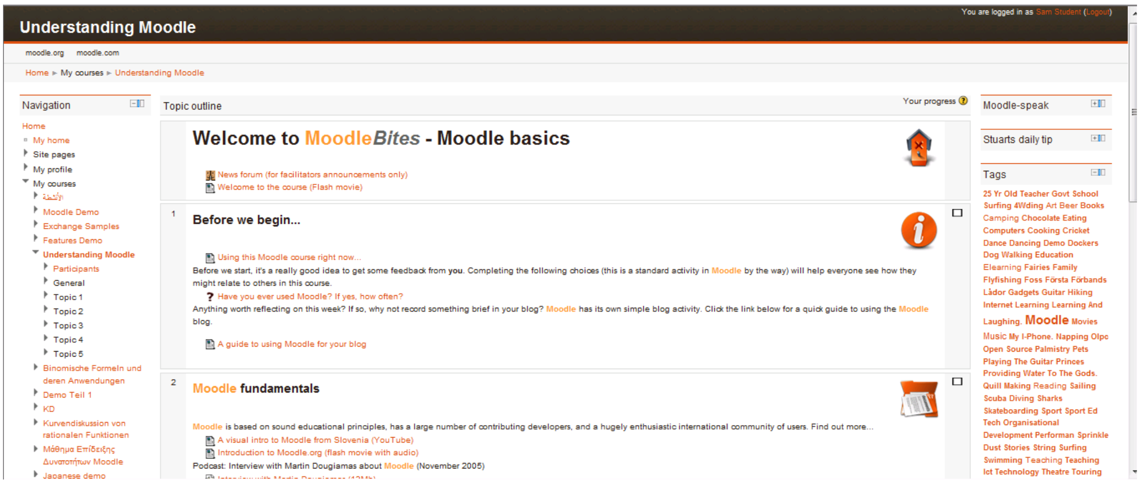


Figure 3.8: Moodle's course page with 3 columns by using the topic format (student's view). ***Source***: moodle.org

standard download of Moodle 2.4 (e.g. upcoming events, settings, online users, etc.). However, more blocks have been developed by the community and can be added to the platform.

As for the interface, Moodle has a ***classic design based on three columns*** (see Figure 3.8). The middle one is the main area, i.e. where either topics, weeks or a forum are displayed depending on the course format. In the case of the topic and weekly formats, the *resources* and *activities* are listed underneath each topic/week. The order of these two content items is defined by the teacher.

As regards the side columns, they display the blocks. The most important ones are generally put into the left side (e.g. navigation and settings), but the distribution of the blocks can be defined by the instructor. In this regard, it is important not to add too many blocks, since if an excessive number of blocks are used, then the students may feel overwhelmed by the information overload.

One of the possible drawbacks of Moodle's interface is the fact that is more textual than graphical. This may hinder users from seeing relevant information at first glance. Likewise, navigation is more difficult, because the users have to read all the time.

In summary, Moodle is the most popular open-source VLE thanks to the large catalog of tools that is daily extended by its community. As seen, its design is, moreover, based on a well-defined pedagogical approach, as evidenced by its support for Social Constructivism and the 4 course formats that are provided. Among all the VLEs seen so far, ***Moodle certainly seems to be the best one***.

3.4.8 Sakai

Sakai[11] is a project founded by the University of Michigan, the Indiana University, MIT, Stanford, the uPortal Consortium and the Open Knowledge Initiative (OKI). Its purpose was to produce an open-source collaboration and learning environment (CLE) to support teaching and learning. Nowadays, more institutions take part in this project. Moreover, over 350 institutions have reported that they are using Sakai and over 1000 individuals have contributed to improve it. The version 1.0 was released in 2005 and, in the time of this thesis, the newest version was Sakai CLE 2.9. Unlike most of the open-source VLEs, which are developed in PHP, Sakai is written in Java.

[11] sakaiproject.org

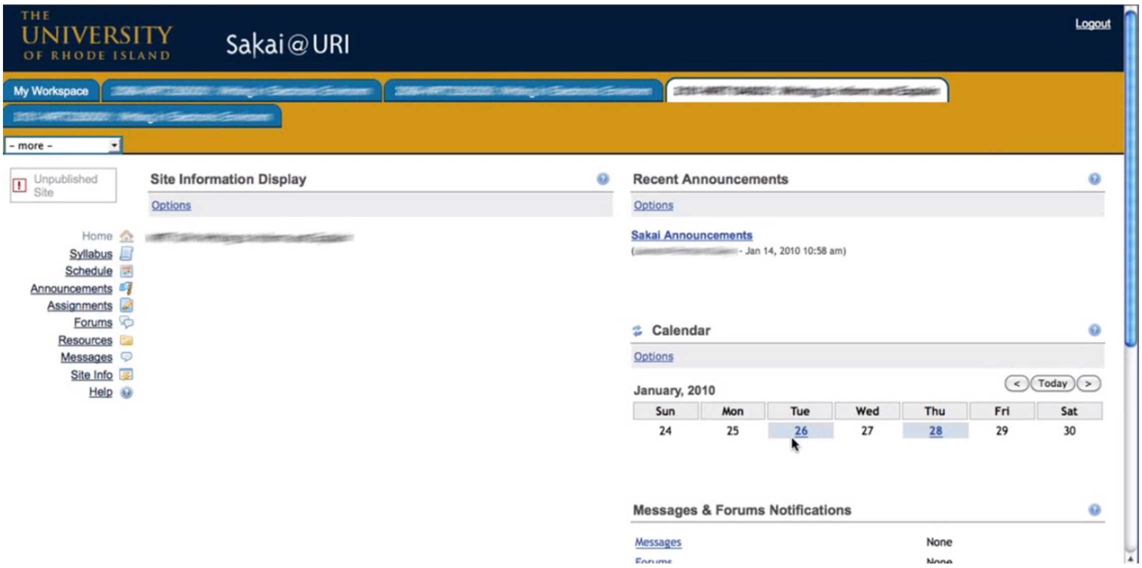


Figure 3.9: Sakai's course homepage. ***Source***: YouTube - URIWRT.

When a user logs in, a homepage called *My Workspace* is shown. Its main area has several widgets which display announcements and calendar events from all the courses in which the user is enrolled. On the left, there are links to the user's profile, preferences, etc., whereas, on the top, there is a tab menu where each tab links to a course. After clicking on one course tab, the course homepage is displayed (see Figure 3.9). It looks like *My Workspace*, but the information is only related to the selected subject. On the left, a menu contains links to different course areas: syllabus, schedule, announcements, assignments, resources, etc. This lateral menu can be customized by the teachers, who can choose from a list what items they put into it.

As it can be observed, the courses in Sakai are structured in sections that correspond with each of the available tools. Therefore, Sakai has a ***tool-based design***, very similar to the one of Claroline (see section 3.4.3), which allows to find items by type easily. For instance, all the discussion forums of a subject are in the *forums* section. However, ***this organization is not natural for teachers, most of whom are used to designing their subjects according to a calendar (i.e. time) or a table of contents***. Therefore, the lack of a sound pedagogical approach in the structure of Sakai may hinder the creation of effective online courses.

Finally, just as a matter of interest, the Universities of Oxford, Cambridge, Hull, and the UHI Millennium Institute announced the formation of the Tetra Collaboration[12] in 2006. One of its projects is to continue the work of Bodington[13] to produce a new version, called Bodington NG (Next Generation), based on Sakai. Bodington was an open-source VLE written in Java that was started in 1997 at the University of Leeds. Its last version dates from 2006 and has been utilized recently by several UK universities. For example, the Universities of Leeds and Oxford used it until August 2010 and 2011, respectively. Bodington NG will combine elements of the Sakai framework with the pedagogically strong Bodington toolset. At the same time, the Bodington toolset will be available to Sakai users.

[12] tetraproject.org
[13] bodington.org

3.5 Are the current VLEs effective tools for online education?

The principal purpose of all VLEs is the same: to provide a learning environment that makes the teaching-learning process in an online or blended scenario effective and easy. However, they each use a different pedagogical approach, information structure and interface. In this regard, Table 3.2 is presented in an attempt to compare the VLEs analyzed in this chapter at a glance.

After getting an overall idea of online education in Chapter 2 and having analyzed eight of the most important VLEs in this chapter, the following question arises: *to what extent are the current VLEs effective tools for fully online teaching and learning?* (i.e. ***research question Q4***, see section 1.2). Next, this question is answered considering the three keystones of the VLEs (see section 3.3):

- Pedagogical approach (or design)
- Information structure (or architecture)
- Usability (or interface)

3.5.1 Pedagogical approach

As said in section 3.3.1, the pedagogical decisions that are made for a VLE have a strong influence on its information structure and interface. Despite the importance that pedagogy has, according to Govindasamy (2002) and Laanpere et al. (2004, 2012), most of the current VLEs are detached from any specific pedagogical approach. Govindasamy (2002) states that most of them are mere providers of technology, including every possible feature without an overt pedagogical integration.

VLE	Pedagogical approach[1]	Information structure	Interface
ATutor	-	Table of contents	2 columns and Desktop
Blackboard	-	Hierarchical tree	2 columns
Claroline	Dynamic model	List of tools	2 columns
Desire2Learn	Activities + Assessment + Course objectives	Table of contents + Calendar	Main area + top menu
Dokeos	-	Desktop of tools	Desktop-like
eCollege	-	Units or weeks	2 columns
Moodle	Social Constructivism	Topics, weeks or forum	3 columns
Sakai	-	List of tools	2 columns

[1] A dash means that the creators of the platform do not specify any pedagogical approach explicitly.

Table 3.2: Comparison of the most popular VLEs based on the keystones defined by Mastoras et al. (2005).

In this regard, Table 3.2 shows that ***only three of the eight VLEs analyzed in this chapter declare their pedagogical approach overtly***: Claroline, D2L and Moodle. However, when they three are examined in detail, only Moodle is really based on a solid learning theory, i.e. Constructivism. Thus, the current VLEs have a ***serious mismatch between the abundance of features and the lack or total absence of explanation on the pedagogy underlying the inclusion of these characteristics*** (Firdiyiyek, 1999, cited in Govindasamy (2002)). Some researchers like Herrington et al. (2005) are even more critical and say VLEs focus on delivering information, instead of improving education.

Besides taking the learning theories into account, the pedagogical approach on which VLEs are built should meet online students' and teachers' requirements. Unfortunately, ***many VLEs do not always satisfy the actual needs of online learners and instructors***. For example, as seen in sections 2.4.1.2 and 2.4.1.3, in online education the ability to self-regulate the own learning process is a very important skill which not many students have. Hence, some functionality that helps learners to be self-regulated is something what is expected from a VLE when this is used for online learning. Despite this, Moodle 2.0 (and later) and D2L are the only VLEs that support self-regulation. In this regard, Moodle 2.x is the only platform that gives students the option of marking an activity as complete, whereas only D2L displays the course's competences and objectives clearly.

Likewise, as discussed in section 2.4.2, online teachers should be facilitators who guide the learners through the course. To perform this task correctly, the role of VLEs is crucial, because technology is needed to track each student's progress toward mastery, assess their learning, help teachers to understand what kind of guidance is needed, provide and appropriately sequence instruction and store evidence of attainments and systemically integrate each of these functions (Schlechty, 1991, cited in Watson and Watson (2007)). In this regard, although most of VLEs have a monitoring tool that give teachers tracking information about their learners and classes, some studies like (Hijón and Velázquez-Iturbide, 2006) argue that none of these systems offer much tracking ability. One of reasons is that ***the majority of VLEs provide tracking data in a tabular format, similar to a log file, which is commonly poorly structured and incomprehensible*** (see section 2.4.2.3). Obviously, this complicates the tracking of the students and, therefore, teachers have difficulty knowing what type of guidance is needed in each case is more difficult.

On the other hand, all VLEs have well-known tools that support some educational requirements. For example, these systems have forums that promote interaction within the online classroom, a factor that contributes to have a good academic achievement (see section 2.4.1.2). In this case, the question that arises is: *are the forums (or any other tool) devised from an educational perspective?*. Unfortunately, it is quite common that most of VLEs do not add educational functionalities to these tools. In general, ***the tools that are included in many VLEs only implement the same features as those of the general-purpose tools***. For instance, an option that enables teachers to grade messages may be very useful in a learning context, but not all the VLEs implement it.

As seen, ***most of the current VLEs are far from being built on an approach that is consistent with the principles of some learning theory and, at the same time, takes account of those aspects which have been proven to be suitable for online students and teachers***. The lack of design decisions based on a sound pedagogical approach is detrimental to the effectiveness of the platform and, consequently, to the whole teaching-learning process.

3.5.2 Information structure

One of the sub-roles of online teachers is to be a manager (see section 2.4.2.2). This entails scheduling the course, setting the learning objectives, etc. To perform this role, instructors depend on the information structure of the VLE, because this inevitably delimits the way in which a course can be defined in the platform. For this reason, it is essential that the information architecture of these platforms is as flexible as possible so that it can adapt to a large variety of teaching and learning styles. In this regard, the following question arises: *how flexible are the information structures of the current VLEs?*. Next, this question will be discussed.

As seen in section 3.4 and it has been summarized in Table 3.2, ***most VLEs force instructors to organize the courses in a way that it is not natural for them***. For example, Blackboard structures the courses according to the type of content (i.e. text, file, link, etc.). Likewise, Claroline, Dokeos and Sakai organize the courses as a list of tools/sections and, hence, learning materials are resources that are uploaded to a specific section called *documents and links*, *documents*, and *resources*, respectively. On the contrary, the structures of ATutor, D2L, eCollege and Moodle are more familiar to teachers and students. In this regard, the courses in ATutor and D2L revolve around the table of contents (i.e. a hierarchical structure). As far as eCollege and Moodle are concerned, they allow to define the courses as a sequential list of units/topics. Moreover, D2L, eCollege and Moodle also enable to organize course content by schedule (i.e. time). In the case of eCollege and Moodle, the smallest unit is the week. As it can be observed, the organizations based on content/topic and schedule are more natural than those based on the types of resources and tools. Actually, according to a study of the Tufts University (UWG, 2010), a lot of participants who used to use Blackboard expressed an interest in/preference for content and schedule formats after using Moodle.

Likewise, ***most of the current VLEs only have a format on which teachers can build their courses*** (Kolas and Staupe, 2007). eCollege, Moodle and D2L 9.4 (and later) are the single platforms that provide more than one kind of organization: one based on the content and another based on the schedule. Although this represents a breakthrough, these VLEs are still too rigid. For example, in eCollege and Moodle, teachers must choose one of the two formats just before they can create their courses. From this observation, one question arises: *why do not all VLEs allow to use various views/formats simultaneously?*. If VLEs showed as many views of a course as possible, teachers could design their courses from different perspectives and, consequently, the teaching-learning process would be better. Furthermore, students could navigate through the courses by using the organization/view that best met their preferences and needs in each moment. In this regard, D2L is the only VLE that enables to have two formats at the same time. However, to create the view based on the schedule it is required to have defined the other view (i.e. the TOC) previously, because the calendar extracts information from it. As a result, another question is formulated: *if multiple views/formats are possible, why are not they independent of each other?*. This would allow the teachers to create those views that are really required for the course.

Apart from the information structure, the course editor of the VLE plays an important role, since it allows the teachers to interact with the database so that they can create the course in the platform. Hence, it is on the border between pedagogy and information structure. For this reason, the features of the course editor can improve or limit the design of the subject and, consequently, its effectiveness. In this regard, despite the importance of the course design, VLEs do not give the instructors guidance on how to design their courses, instead they merely provide forms whereby teachers create course items and upload files. Such passivity of the VLEs entails the instructors designing online courses without assistance. In consequence, the design of the course may not be as effective as possible, especially if the teachers are not used to using the platform or if they lack skills and knowledge to design and teach online classes, as often occurs (see section 2.4.2.3).

As a result of the limitations and difficulties that teachers often find when they try to translate the design of their courses into an online environment, it is hardly surprising that: (1) ***a lot of instructors perceive VLEs as rigid tools***, as in the case of Blackboard (West et al., 2007), and (2) a lot of lecturers end up replicating the F2F instruction based on lectures by using VLEs as content repositories and without applying any sound pedagogical principle that is suitable for online learning (Lane, 2008; Vovides et al., 2007; Vrasidas, 2004). Hence, as observed, ***one barrier to teaching online is the lack of appropriate design tools*** (see section 2.4.2.3).

In conclusion, ***the information structures of the VLEs are not, in general, flexible enough***. Moreover, a lot of platforms provide a structure that focuses on managing content efficiently from an IT rather than an educational perspective. Likewise, the course editors are not as suitable tools as they could become due to its passive role. For all of these reasons, ***it may be concluded that the information structures of the VLEs should improve in future so that they can really meet educational needs***. Likewise, course editors should help the instructors to design their courses correctly.

3.5.3 Usability

The interface of a VLE is affected by the decisions made regarding the information structure and, above all, the underlying pedagogical approach. Hence, if a VLE is designed without taking any educational aspects into account, then the effectiveness of its interface decreases. Despite this fact, there are several pieces of evidence that prove the absence of educational foundations in the design of the VLEs' interface. Firstly, some researchers, such as Laanpere et al. (2004), indicate that ***the interfaces of the VLEs use technical instead of educational vocabulary***, e.g. *dropbox*, *file upload*, etc. Due to this out-of-domain vocabulary, both learners and teachers may get confused.

Likewise, three manners of evaluating the usability of VLEs can be found in the literature: (1) the one based on the opinion of experts who use user-centered design (UCD) heuristics and methods, (2) the one based on experiments carried out with students and teachers, e.g. (UWG, 2010), and (3) a combination of the two previous approaches. In this regard, the fact that a large number of papers only uses the first approach reinforces the perception that ***VLEs are often considered to be the same as any other software program***, i.e. without considering educational issues (a singularity of VLEs). Due to the absence of educational criteria, it could be said that these studies evaluate VLEs partially and, consequently, their results should not be considered fully reliable. However, such studies are the main source of information about the usability of VLEs. In this regard, it could be stated that ***the current VLEs in general have an acceptable usability from the point of view of the principles of UCD***, which are used to evaluate any type of IT application.

Moreover, the existence of evaluations only based on the tenets of UCD leads us to think that some VLEs may have been designed by following guidelines which are not enough (or even suitable) to create VLEs. Some researchers agree with this thought and propose learner-centered design (LCD) heuristics that have been devised to the educational context (see section 4.2 and Appendix B.2.3). In this regard, few works have evaluated VLEs by using LCD heuristics, i.e. by also taking educational aspects into account. Therefore, it is not possible to draw a reliable conclusion on the actual usability of these systems.

3.5.4 Conclusion

After analyzing the effectiveness of current VLEs from three points of view (i.e. pedagogy, information structure and interface/usability), several conclusions can be drawn:

Main conclusions from the analysis of the current VLEs

1. Although VLEs are widely used as learning platforms, most of them lack a sound pedagogical approach in the core of their designs. In fact, some of them seem to have been designed based only on IT conventions, i.e. from a technical perspective.

2. Due to the absence of a solid pedagogical approach, these systems have few functionalities and tools that have been devised to exclusively meet the actual needs of online students and teachers. Likewise, some of the functions/tools devised to satisfy educational requirements are often inadequate, e.g. student monitoring tools.

3. The way of organizing the course in many of the current VLEs is not natural for an educational context. For example, instead of calendar or content items (e.g. weeks and units/topics, respectively), it is very common to find course structures based on the type of resource or tool.

4. The information structure of these platforms is still too rigid, since most of them do not provide more than one organization/view. Regarding those that offer two or more types of views, only D2L enables to use them simultaneously.

5. Course editors play a significant role in the creation of the online subjects. However, instructors complain about the lack of suitable tools that help them during design tasks. Because many teachers need some help to design and create online subjects, course editors should be a key element of any VLE. Obviously, a large part of the effectiveness of any course editor depends on the design of the information structure.

6. Interfaces are usable from a UCD perspective, but both its design and evaluation should shift from user to learner-centered design (LCD) principles.

In short, it may be said that ***the pedagogical potential of most of VLEs is underexploited and, hence, the effectiveness of these platforms may be much better***. Although some VLEs, such as Moodle and D2L, are taking firm steps toward the design of a platform that really meets the requirements of online education, these are not enough. Consequently, ***more research and improvements are needed***.

3.6 Summary

This chapter explored the topic of virtual learning environments (VLEs). Nowadays, the use of these platforms has grown in such a way that they have become the natural replacement of the physical classrooms. In this regard, due to the absence of F2F interaction between students and teachers, VLEs have become a key element during the online teaching-learning process.

Although a VLE can be analyzed from two points of views, i.e. technological and educational, this chapter and the rest of the thesis have focused on the latter. In this regard, the pedagogical approach, the information structure and the usability of the interface were identified as the three elements that have more impact on the effectiveness of VLEs. As a result, it was concluded that any designer or developer should pay careful attention to these three aspects when creating a VLE.

In order to answer ***research question Q4*** (i.e. *to what extent are the current VLEs effective tools for fully online teaching and learning?*), eight of the most popular VLEs, both proprietary and open-source, were analyzed by focusing on: (1) the pedagogical approach on which each of them is built, (2) the information structure that they provide to create the courses, and (3) the design of their interfaces. Having analyzing the eight platforms, a discussion about their effectiveness was presented. As seen, this discussion led to the conclusion (and, consequently, the answer to ***research question Q4***) that most of the current VLEs are detached from any specific pedagogical approach and, hence, the effectiveness of these systems is not as high as it could be. In other words, the pedagogical potential of VLEs is underexploited. As discussed, this lack or total absence of a sound pedagogical approach in the core of these platforms has ill effects on the functionalities, the information structure and the interface. Consequently, the teaching-learning process that is carried out within these virtual classrooms is affected too.

In summary, the analysis conducted in this chapter certainly has proved, on the one hand, the existence of a problem in the design of the current VLEs and, on the other, the necessity of conducting a research work like this. In this regard, the following chapter proposes a set of aspects, in the form of recommendations (or heuristics), which have been identified as being suitable for the VLEs when they are used in a fully online scenario. This set was developed by taking account of a pedagogical approach based, in part, on the document-based research conducted in Chapter 2 and the analysis of the current VLEs performed in this chapter. Therefore, this set of the recommendations aims to help designers and developers to create effective VLEs for online teaching-learning based on the conclusions drawn from systematic research.

4 Recommendations for designing virtual learning environments for online education

This chapter proposes a set of recommendations/heuristics for designing VLEs that are effective tools for fully online teaching-learning. In order to explain the proposed recommendations, this chapter is structured as follows:

- A brief introduction argues the necessity for a shift from a user-centered design (UCD) to a learner-centered design (LCD) approach (see section 4.1).

- The main characteristics of learner-centered design (LCD) are described by emphasizing the differences between UCD and LCD approaches (see section 4.2).

- The proposal of a set of recommendations is detailed (see section 4.3, research objective O1):

  - First, the chapter explains the foundations (see section 4.3.2) and the consequent pedagogical approach (see section 4.3.3) on which the recommendations are based.

  - Each of the recommendations is described (see section 4.3.4). This description is organized according to the three cornerstones of VLEs:
    * Pedagogical approach (see section 4.3.4.1)

    * Information structure (see section 4.3.4.2)

    * Usability (see section 4.3.4.3)

4.1 Introduction

In the course of time, the way of designing computer applications has evolved. The first approaches were focused on creating systems that took advantage of the capabilities of technology. However, these frequently neglected the users' actual requirements. To overcome this problem, a new design approach called *user-centered design* (UCD) was proposed:

User-centered design (UCD)

> Design process in which the needs of the users dominate the design of the interface and, in turn, the needs of the interface dominate the design of the rest of the system.
>
> (Norman and Draper, 1986)

As a result of this new paradigm, the purpose of a system has gone from using a specific technology or being an elegant piece of programming to serving the user (Norman and Draper, 1986). More specifically, a computer software designed from ***a UCD approach focuses on helping users to complete familiar work tasks more easily and efficiently*** (Luchini et al., 2002a; Quintana et al., 2001). To this end, Quintana et al. (2000) indicate that the systems based on UCD try to minimize two gulfs defined by Norman and Draper (1986):

- **Gulf of execution**: the difference between the goals and intentions of the user and the permissible actions on the tool.
- **Gulf of evaluation**: the amount of time and effort that the user takes to understand the tool.

To minimize the gulf of execution, a tool should allow users to perform the maximum amount of tasks that they want to do. As for the gulf of evaluation, this is minimum if the users find task completion easy. As it can be observed, ***the actual focus of a UCD tool is on the tasks that the end-users perform frequently*** or, in other words, UCD tools are task-oriented. Actually, Quintana et al. (2001) are of the opinion that UCD designers design around the tasks, not the users themselves. Thus, to create effective UCD tools, designers must understand how people generally do things to complete a task. In this regard, the *theory of action* (Norman and Draper, 1986) gives seven steps that are involved in the mental process of a user when she performs tasks with a computer tool. In addition to theoretical approaches, more practical methods have emerged to help designers to build systems that bridge the gulfs of execution and evaluation (see Appendix B.1).

In the last two decades, UCD has meant a breakthrough in the improvement of the usability of computer programs. Consequently, ***UCD is currently the most popular approach for designing computer tools***. Nevertheless, software designers have been faced with new challenges in recent years. One of them is the use of computers to learn. In this regard, a few researchers (Ardito et al., 2004b; Quinn, 1996; Quintana et al., 2000; Reeves et al., 2002; Soloway et al., 1996; Squires and Preece, 1999) argue that UCD is not enough to deal with the teaching-learning process, since learning requires a series of specific considerations that differ from those that are taken into account in any other task. Thus, they propose a new approach called ***learner-centered design (LCD)***.

4.2 Learner-centered design (LCD)

As said in the previous section, learner-centered design (LCD) approach emerged as an answer to the specific necessities of the learning process. Next, these particularities will be explained through three dimensions defined by (Quintana et al., 2000):

- The target audience
- The main design problem to address
- The underlying theory used to address the main design problem

4.2.1 Target audience

One of the particularities of learning in comparison with other tasks is related to the audience being addressed. In this regard, ***LCD focuses on students***, who use the tools to understand and acquire new knowledge (i.e. to learn). Because of the obstacles that may arise during the learning process, students' motivation cannot be taken for granted.

On the contrary, ***UCD focuses on people*** (i.e. users) who know what activities they want to perform given a tool. Therefore, they use the tools to complete familiar tasks easily and efficiently (Quintana et al., 2000, 2001; Soloway et al., 1994). Likewise, users have intrinsic motivation.

4.2.2 The main design problem to address

Because learners are different from typical users, the goals of these two design approaches (i.e. UCD and LCD) also have to be different. To understand this better, let us see an example suggested by Wallace (1999): a program for searching information. If this were designed from a UCD perspective, this would have to retrieve the best possible results, since this is the goal of any user, i.e. to find what she is looking for. However, from an educational point of view, the same tool would have a different behavior since either the teacher could have another goal for that activity (e.g. to teach a research process) or the student could not have as goal to find anything in particular, or even she could not know what to look for exactly.

From the previous example (and others), one can notice that a typical user needs an application to do familiar tasks easily and efficiently. Thus, ***the main design challenge of UCD is "to design tools that are easy to use and understand and that allow the easy and efficient completion of work activities"*** (Quintana et al., 2001, p. 500). In contrast, students use computers as learning tools. Hence, ***LCD is faced with the challenge of designing tools that help students to learn a new field of knowledge***. This means that the designers of educational tools should address, besides the gulfs of execution and evaluation, the conceptual gap between the student and the learning domain, which is called ***gulf of expertise*** (Quintana et al., 2001). As a result, the design of tools based on an LCD approach should be such that the students can focus on the actual learning (i.e. to assimilate the learning domain) and not on learning to use the tool (Srivastava et al., 2009).

4.2.3 Underlying theory

As it has been explained previously, UCD designers use the *theory of action* so as to understand the mental process behind performing a task. As far as LCD designers are concerned, because their goal is to create tools that help students to bridge the gulf of expertise (i.e. to learn a new learning domain), they take account of the ***learning theories*** (see section 2.4.2.1), which explain how people learn. Therefore, the principles of these theories inevitably influence the decisions that are made when creating any learning tool.

In addition to the learning theories, it is important to know ***the needs and characteristics of the students and teachers*** who will use the tool. For example, the requirements of a learner in a blended course are not the same as those in a fully online subject.

4.2.4 Conclusions

As seen, there exist noticeable differences between learning and performing other tasks and, therefore, between typical users and students. This is why more and more researchers and practitioners argue that computer tools developed to support learning need design criteria that extend those for task-oriented computer systems. As a result, a new design approach called *learner-centered design* (LCD) has emerged. This can be defined as follows:

Learner-centered design (LCD)

Design approach that uses UCD guidelines but redefined and expanded by taking account of learning theories as well as students' and teachers' characteristics and needs.

In short, while UCD focuses on making usable software to support the tasks of domain experts, ***LCD focuses on developing tools that provide learners with the support that they need to understand the content, tasks and activities of an unfamiliar domain they are exploring*** (Luchini et al., 2002b). Finally, Table 4.1 summarizes the most significant differences between UCD and LCD.

	User-centered design (UCD)	**Learner-centered design (LCD)**
Target audience	Users who know the work domain in which they use the tool	Students who do not know the learning domain and whose motivation cannot be taken for granted
Main design goal	Designing computer tools that allow users to complete their work easily and efficiently	Designing tools that support students in gaining understanding of an unknown domain
Conceptual gulfs to address	Gulfs of execution and evaluation between the user and the tool	In addition to UCD's gulfs, the gulf of expertise between the learner and the learning domain
Approach to bridge the gulfs	Using theoretical (e.g. the theory of action) and practical (e.g. usability inspection) approaches that explain how people do tasks	Using UCD methods supplemented with a learning theory that explains how students learn, e.g. Constructivism

Table 4.1: Summary of the differences between UCD and LCD, based on (Quintana et al., 2003, p. 827).

4.3 Proposal of recommendations

4.3.1 Introduction

Although virtual learning environments (VLEs) are well-established educational tools, Chapter 3 has shown that there is still much room for improvement in the effectiveness of these systems.

As regards this opportunity to improve VLEs, the present chapter identifies a set of features that are highly desirable that these platforms have when they are used in a fully online environment. These characteristics have been summarized in a ***set of 13 recommendations*** (or heuristics). The reason for creating this set has been to provide designers and developers with a simple, but effective instrument that helps them when designing VLEs. The creation of this set fulfills ***research objective 01*** defined in section 1.2.

Before describing each of the recommendations, the following sections explain the foundations (see section 4.3.2) and the resultant underlying pedagogical approach (see section 4.3.3) on which they have been built.

4.3.2 Foundations

According to Friesen (2003, p. 63), *"applications that are truly pedagogically neutral cannot also be pedagogically relevant"*. This belief is closely related to the philosophy that underlies the LCD approach, which stresses the necessity of taking account of different educational aspects together with the tenets of a learning theory when a learning tool is designed. In this regard, this thesis proposes a set of LCD heuristics/recommendations that is based on a pedagogical approach which...

- takes account of ***the document-based research conducted in Chapter 2***. More specifically:
  - The main implications of online delivery for the teaching-learning process (see section 2.2).
  - The characteristics of online students (see section 2.4.1.1) and the factors that help them to have a successful learning experience (see section 2.4.1.2).
  - The role of online teachers (see section 2.4.2.2).
  - The main barriers that online students and teachers may find (see sections 2.4.1.3 and 2.4.2.3, respectively).
- is in agreement with ***Constructivism***, because this learning theory seems to be the most suitable for online education (see section 2.4.2.1).
- allows for previous ***sets of heuristics for educational software*** (i.e. LCD heuristics). These can be found in Appendix B.

The resultant pedagogical approach is described in the next section.

4.3.3 Pedagogical approach

Due to the responsibilities (e.g. work, family, etc.) and obstacles (e.g. long commute) that online students have, one of their main needs is the flexibility of time and place (see section 2.4.1.1). To guarantee it, ***asynchronous interaction*** between students and teachers is required. However, such interaction implies that, *"(...) in a web-based learning environment, students must exercise a high degree of self-regulatory competence to accomplish their learning goals, whereas in traditional face-to-face classroom settings, the instructor exercises significant control over the learning process and is able to monitor student attention and progress closely"* (Dabbagh and Kitsantas, 2004, p. 40). Thus, self-regulation skills are essential qualities that online learners should have. Actually, as said in (Beishuizen and Steffens, 2011), some research works reveal that the extent to which students are capable of regulating their own learning greatly enhances their learning outcomes (see section 2.4.1.2). Generally speaking, ***self-regulated learning*** is a process that consists of three cyclical phases (Zimmerman, 2002, see Figure 4.1):

1. **Forethought**: in general, this phase involves the student in ***setting goals***, ***planning a strategy*** to achieve such objectives, and measuring her own competence to complete tasks and reach goals (i.e. ***self-efficacy***, which is closely related to academic self-concept, see section 2.4.1.2).
2. **Performance**: this phase deploys the specific tasks that are part of the strategy defined in the forethought phase. This stage is guided by a ***self-monitoring*** process whereby the student tracks what she is learning, e.g. to self-record the time that she spends on studying a unit.
3. **Self-reflection**: this focuses on comparing self-monitored information with a standard or goal. This includes tasks such as assessing academic success and adjusting future learning strategies. Hence, in this phase, the student should be aware of her learning process (i.e. ***self-awareness***). In this regard, ***formative assessment*** based on learners' coursework may be a good way of helping students to be aware of their progress at any moment of the semester. Likewise, this kind of evaluation provides teachers with useful information that helps them to easily track and guide their learners through the course.

As seen, *"self-regulated students are metacognitively, motivationally, and behaviorally active participants in their own learning process"* (Zimmerman, 1986, 1990). Hence, self-regulated learning implies that students inevitably play a more ***active role*** compared to that of the F2F instruction. In other words, a ***student-centered learning approach*** replaces the paradigm in which learning revolves around the figure of a masterful teacher. Instead, ***teachers are facilitators*** who guide their students through the learning process and help learners to be self-regulated. The active involvement of the student in her learning process is in accordance with the principles of ***Constructivism***.

Moreover, it is important to give ***multiple views/perspectives*** of a subject so that courses adapt better to different teaching-learning preferences and situations.

Finally, in addition to individual learning, it is also essential to offer communication tools whereby students can interact with each other (see section 2.4.1.2). Such tools promote ***collaborative learning*** and, at the same time, the development of communication skills. Likewise, they reduce the feeling of isolation that a learner may experience (see section 2.4.1.3).

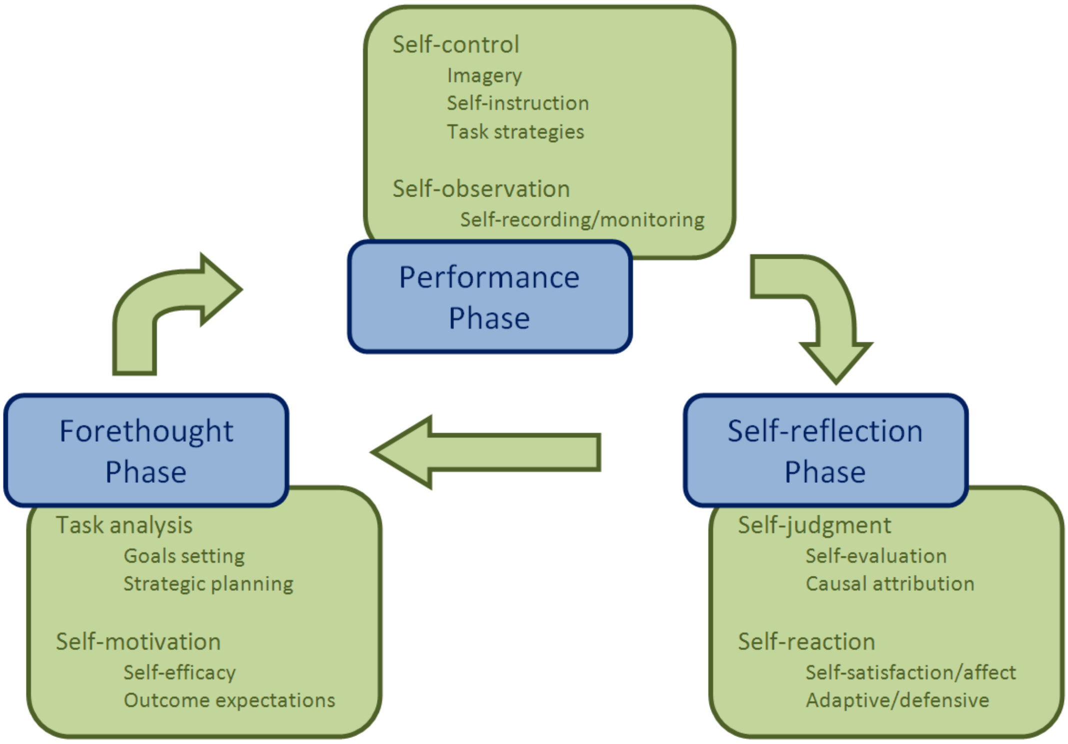


Figure 4.1: Phases and some subprocesses of self-regulated learning. ***Source***: (Zimmerman, 2002).

4.3.4 Set of recommendations

As it has already been said in section 4.3.1, the previous pedagogical approach has given rise to the ***set of 13 recommendations*** that is proposed below. This is divided into three categories that correspond to the cornerstones of VLEs (see section 3.3):

- Pedagogy (6 recommendations)
- Information structure (2 recommendations)
- Usability (5 recommendations)

Next, the recommendations of each category are explained in detail. Likewise, at the end of the present chapter, Table 4.2 lists the whole set so that the reader can get an overview at a glance.

4.3.4.1 Pedagogy

In this section, two types of recommendations can be found. On the one hand, there are four recommendations that have been specially created to provide students with a better learning experience and, on the other, there are two that have been defined to improve the teaching process. Altogether, six recommendations related to pedagogy are suggested:

Recommendations related to pedagogy

Students

A. To define competences and objectives clearly

B. To guide students through the course

C. To provide self-awareness

D. To promote social interaction

Teachers

E. To provide teachers with a student monitoring tool

F. To help teachers to design their courses

Next, each of the previous recommendations are described.

A. To define competences and objectives clearly

In the movement toward the European Higher Education Area (EHEA), there has been a shift from a course design based on content to one focused on what the students are expected to be able to do/know at the end of the learning period. In this regard, the expected outcomes of an EHEA course, which can be considered the goals of the learning process, are usually divided into *degree competences* and *course objectives* (also known as learning outcomes).

In order to make the overall learning experience more transparent, it is important that teachers share the degree competences and course objectives with their learners and, at the same time, ensure that there is an alignment between these two items, teaching methods and assessment criteria (Kennedy et al., 2006). Such transparency helps students to know what is required of them. Consequently, they may be able to regulate their own learning better, since they may set intermediate objectives for themselves (i.e. sub-goals) and plan out their learning process more easily.

In conclusion, to support self-regulated learning and the EHEA's course design approach, ***VLEs should enable teachers to clearly indicate what degree competences and course objectives the students must attain***. As observed, this recommendation completely accords with a part of the forethought phase of self-regulated learning (see section 4.3.3), in which setting goals is a key task.

B. To guide students through the course

According to the forethought phase of self-regulated learning (see section 4.3.3), after defining the goals, each learner should plan and schedule the tasks that will allow her to achieve the objectives. This involves students in managing their learning time. Such a management is not easy, because many online learners have other responsibilities (e.g. job and family) competing for their time as well. As a result, they can have difficulty in reconciling studies with personal life.

Likewise, as demonstrated in (Yukselturk and Bulut, 2007), students may underestimate the time and effort necessary to succeed in an online course.

Due to the aforesaid problems, online students can be unable to manage their time properly. Therefore, it is strongly recommended that ***VLEs guide learners through the course so that they can know what they should do at any moment***. One way to do this could be to suggest an ideal studying pace in the form of calendar.

C. To provide self-awareness

Besides setting goals and planning the learning activities in advance, students should be able to monitor their own learning process throughout the semester so that they can make, at any moment, the opportune changes to achieve the expected learning outcomes. However, distance education, including online, can make it much harder for learners to position themselves in the class and self-reflect on their work (Govaerts et al., 2010). Hence, ***VLEs should constantly provide some kind of personalized feedback that allows a student to be aware of her own learning process***.

To help students to be aware of their learning process, there exists a wide range of pieces of information that can be used. Broadly speaking, these can be summarized in two types: (1) feedback, and (2) formative assessment. According to Nicol and Macfarlane-Dick (2006), feedback and formative assessment should be used to empower students as self-regulated learners. Good examples of these two kinds of data are: the activities that have been completed by the student, the comparison between the learner's studying pace and the pace suggested by the instructor, the results that are obtained in automatic tests and mandatory assignments, and so on. Thanks to this information on the learning process, it is easier for learners to reflect on their actions, level of attainment of competences, learning progress, etc.

D. To promote social interaction

Feeling of isolation is one of the potential problems from which an online student may suffer (see section 2.4.1.3). Hence, it is essential to establish mechanisms that reduce this problem. In this regard, promoting interaction within the classroom may be a solution. Actually, not only may social interaction avoid the feeling of isolation, but it may also help to improve learners' performance (since students may learn from the interactions with their peers, see section 2.4.1.2). Thus it is hardly surprising that some learning theories, such as Social Constructivism (Vygotsky, 1978), stress the need for collaborative learning.

First of all, the use of CMC tools (e.g. e-mail, forum and chat) may enhance interaction among students and instructors (Tu, 2000). In this regard, both asynchronous and synchronous tools can be provided, but asynchrony is preferred due to the characteristics of online learners (see section 2.4.1.1). Apart from giving flexibility of time to students (see section 2.2.1), asynchrony also offers the opportunity for critical analysis and reflection before responding to a classmate's or the instructor's message (see section 2.2.7). Due to these advantages, the popularity of using asynchronous online discussion increases over time in online education (Yukselturk, 2010).

In the same way, webs 2.0 currently include functionalities which encourage social interaction by allowing users to share their opinions, e.g. *"like it"* button and star rating. In addition to promoting social participation, these features may provide students with extra information about a particular item (e.g. a message, a learning resource, etc.). For example, learners could use this information in order to focus on those items that have been rated positively by their classmates. Likewise, VLEs could have a collaborative filtering recommendation system which identified interesting items for a particular user from the opinions of other like-minded users. Some research has already initiated in this field, e.g. (Ghauth and Abdullah, 2011; Soonthornphisaj et al., 2006).

In light of the benefits of social interaction, it becomes evident that any VLE should include tools that promote the social interaction of a student with her classmates and instructors.

E. To provide teachers with a student monitoring tool

As said in section 2.4.2.2, in an educational environment where the student plays an active role, such as those based on self-regulated learning and/or the tenets of Constructivist, the role of the teacher has shifted from a transmitter of knowledge to a facilitator who guides the students through the learning process and arranges meaningful learner-centered experiences. In this regard, teachers come up against serious difficulties when they play this new role in an online course. One of the main hurdles that online teachers have to overcome is the loss of control over their students due to the lack of F2F contact. Such loss complicates the tracking of students' progress and, consequently, it is more difficult for teachers to provide just-in-time assistance and forecast potential problems (e.g. dropouts).

Having detected the previous problem, it is concluded that online instructors need appropriate means to set up a monitoring process. In this regard, although the current VLEs provide the teachers with student monitoring tools, these are not effective because they give tracking data in an awkward format (see section 3.5.2). Therefore, ***offering a user-friendly student monitoring tool is an indispensable requirement that a VLE should fulfill***.

F. To help teachers to design their courses

As said in section 2.4.2.3 and discussed in section 3.5.2, one of the barriers to teaching online is the lack of appropriate design and development tools that help faculty to easily plan and deliver online instruction. As explained, most of the current VLEs merely provide a set of forms that request information from teachers in order to create the different types of items that are part of the course.

As observed, VLEs do not give the instructors guidance on how to design their courses. Due to this, the teachers may be unable to adapt their designs to the platform in the best way. Likewise, as some lecturers may not be used to using the platform or they may even lack skills to design online courses (see section 2.4.2.3), they may not take advantage of all the features that the platform offers. Consequently, the design of the course may not be as effective as possible.

For all of these reasons, ***it is strongly recommended integrating a user-friendly tool that actively supports course design into the VLEs' framework***.

4.3.4.2 Information structure

The information structure of a VLE can influence the learning process (see section 3.3.2). This is why the database schema should not be a hodgepodge of pieces of data, but it must be consistent with the particularities of the agents that participate in online education and the tenets of the learning theories that are used. Hence, each piece of data that is added to the structure should make sense from an educational perspective.

In this thesis, two recommendations related to the information structure of VLEs are proposed. The first one focuses on how to design a course so that this can adapt to different teaching and learning styles. As for the second heuristic, this tries to make VLEs developers aware of the necessity of finding a balance between simplicity and completeness in the information structure.

Recommendations related to the information structure

G. To provide multiple views of the course

H. To provide a comprehensible and flexible schema

G. To provide multiple views of the course

As discussed in section 2.4.2.1, Constructivism seems to be the most widely accepted learning theory in online education. One of its principles is to provide multiple representations and views within the learning environment (Squires and Preece, 1999). In this regard, a VLE with multiple views/course formats (e.g. time-based, table of contents, etc.) can easily accept a more wide variety of courses than other that only has one view. Moreover, if the teachers could use, at the same time, as views/course formats as they considered, then such organization would enrich the course.

Likewise, if, for instance, a VLE provided students with multiple views of the same course, learners could choose the perspective that best met their needs and/or preferences.

In conclusion, ***the information structure of a VLE should be flexible enough to support a wide variety of representations simultaneously***.

H. To provide a comprehensible and flexible schema

The part of the database schema that is related to the course should have a logical design which can be easy to understand by any instructor or student. To this end, it is important that the course structure uses items with which the learners and teachers are familiar.

Moreover, the structure should be as flexible as possible, so that this can adapt to different situations. To achieve this, it is strongly recommended creating a modular structure in which each part is independent from the rest. The more modular this is, the easier modifying specific parts of the structure without affecting the rest will be.

In short, ***the schema of the information structure should be easy to understand and flexible***.

4.3.4.3 Usability

As said in section 3.3.3, the interface of a VLE can be a barrier to learning online. Therefore, any aspect related to usability should be studied carefully. This work, as others (Reeves et al., 2002; Ssemugabi and de Villiers, 2007, see Appendix B.2.3), proposes usability guidelines that are mainly based on the widespread and time-proven heuristics defined by Nielsen (1994a), but adapted to the educational context. The usability recommendations that are suggested in this work are:

Recommendations related to usability

I. Match between the VLE and the educational conventions

J. Minimalist design

K. Visibility of system status

L. Error prevention and easy recovery from errors

M. Documentation and help

I. Match between the VLE and the educational conventions

Some of the sets of educational heuristics that are detailed in Appendix B.2.3, such as Squires and Preece (1999), Reeves et al. (2002) or Ssemugabi and de Villiers (2007), implicitly or explicitly include the second usability heuristic defined by Nielsen (1994a, see Appendix B.2.2.3), which says that systems should speak users' language. In this regard, VLEs do not have to be an exception and ***they should use terms, symbols, concepts that are familiar for students and teachers***. This means that conventions, such as the fact that the letter A is the highest grade and F means failure, should be remained unaltered. Similarly, ***technical terms*** (e.g. chat, dropbox, upload, etc.) ***should be avoided as far as possible*** and be replaced with words that are closer to the educational vocabulary (Laanpere et al., 2004).

In summary, the coherence between the VLE and the educational conventions may help students and instructors not to get lost while using the platform.

J. Minimalist design

The interface of VLEs should be intuitive so that users (i.e. students, teachers, administrators, etc.) are able to understand and learn to use it quickly and effectively. To this end, considering that most of VLEs are web-based, some web principles defined by Scott and Neil (2009) can be used:

- **Make it direct**: this means that instead of forcing to edit content on a separate page, let do it directly in context. This idea can be summarized by using a simple rule said by Alan Cooper et al. (2007, cited in (Scott and Neil, 2009)): *"allow input wherever you have output"*. Some techniques that enable to put this principle in practice are: in-page edition, drag and drop and direct selection. As observed, this principle is closely related to WYSIWYG paradigm.

- **Stay on the page**: this idea is very close to the previous one and it involves creating a continuous visual perception that enhances flow nirvana (Scott and Neil, 2009). In practice, to allow to perform actions and display their results in a specific part of the current page without changing the surrounding context, i.e. without refreshing the whole page. Nowadays this is possible thanks to the rise of new web technologies, such as AJAX.

- **Keep it lightweight**: this tenet basically indicates that the interaction with an application should cause the least amount of physical and mental effort for the user. In other words, the effort required to interact with the VLE should be reduced to the maximum. A manner of doing this is reducing the number of steps as far as possible. For instance, if an action can be done with one click, this is better than doing it with two clicks.

  This guideline is related to Nielsen's heuristics #6 and #7 to some extent, i.e. to create an interface that is easy to learn by minimizing the user's memory load and to provide expert users with shortcuts, respectively (see Appendix B.2.2.3).

- **Provide invitations**: Nielsen's heuristic #8 says that the information which is irrelevant or rarely needed should not be displayed because every extra unit of information competes with the relevant units of information and diminishes their relative visibility. In this regard, tools and some specific actions are typical items that can be hidden while they are not needed. Thanks to this, users only focus on relevant content. In order to indicate that the hidden tools or actions exist, *invitations* are used. An example of invitation is to change the background color of an area and the shape of the cursor when the user puts the mouse over an item so that she can know that element can be edited. Such an invitation avoids putting a static button that competes with important content on the page. As seen, thanks to using invitations, the interface can achieve a balance between showing relevant and less important content.

  Nevertheless, it is also important to create a system that is easy to use by novices and experts alike (Nielsen, 1994a, see heuristic #7 in Appendix B.2.2.3). Hence, invitations and explicit static buttons sometimes have to coexist in order to provide novices and expert with different ways of doing the same action.

K. Visibility of system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time (Nielsen, 1994a, see heuristic #1 in Appendix B.2.2.3). To this end, it is essential to use progress indicators. There are other techniques that can be used too, e.g. *transitions*, *periodic refresh* and *live preview* (Scott and Neil, 2009). Similarly, elements such as *breadcrumbs* are also useful to indicate where the user is within the website.

L. Error prevention and easy recovery from errors

The VLE developers should create systems which prevent users from making serious errors. If an error occurs, then the VLE should diagnose the problem and suggest a solution. This recommendations is linked to Nielsen's heuristics #5 and #9 (see Appendix B.2.2.3).

M. Documentation and help

As any device, software, etc., ***a VLE should provide documentation that helps users to resolve their problems.*** This heuristic refers to Nielsen (1994a)'s heuristic #10 (see Appendix B.2.2.3).

4.4 Summary

The complexity and the singularities of the learning process entail a set of changes in the widely accepted principles of the user-centered design (UCD). As discussed in this chapter, these changes have given rise to the learner-centered design (LCD) approach, not only as an extension of UCD, but also as an incipient design paradigm for educational software. One of the main differences is the goal of the design process. While a UCD tool focuses on making the completion of well-known tasks easy, an LCD program must support a complex process, i.e. learning. This shift doubtless has a strong influence on the design decisions.

Regarding this thesis, it was defined a pedagogical approach that, besides being in agreement with the tenets of Constructivism, takes account of the nature of the online delivery, the requirements of online students and teachers as well as other LCD heuristics (see Appendix B.2.3).

In order to achieve the ***objective O1*** , this chapter proposed 13 recommendations (or heuristics) based on the aforesaid pedagogical approach. This set aims to help designers and developers to create VLEs that are effective for fully online education (see Table 4.2). This set was divided into 3 categories that refers to the keystones of VLEs described in section 3.3: pedagogy, information structure and usability. As noticed, the suggested heuristics only focus on those aspects that directly affect the teaching-learning process. This is due to the fact that administrative tasks are out of the scope of this research (see page 42).

Having defined a set of recommendations, the suitability of each of them has to be assessed. Thus, the next chapter will evaluate the proposed set with students and teachers.

Recommendation	Promotes	Main problem that is tackled	LCD heuristics that support it (see Appendix B)
Pedagogy			
A. To define competences and objectives clearly	Self-regulation (see sections 2.2.2, 2.4.1.2)	Lack of self-regulation skills (2.4.1.3)	Quinn (#1, #7), Ssemugabi and de Villiers (#13)
		Confusion, anxiety and frustration (2.4.1.3)	
B. To guide students through the course	Self-regulation (2.2.2, 2.4.1.2)	Confusion, anxiety and frustration (2.4.1.3)	Squires and Preece (#3), Ardito et al., Ssemugabi and de Villiers (#18)
		Lack of self-regulation skills (2.4.1.3)	
C. To provide self-awareness	Self-regulation (2.2.2, 2.4.1.2)	Lack of self-regulation skills (2.4.1.3)	Quinn (#5, #6), Squires and Preece (#6), Reeves et al. (#13, #15), Ardito et al., Ssemugabi and de Villiers (#18)
	Motivation (2.4.1.2)	Low performance and high dropouts (2.3.1)	
	Academic self-concept (2.4.1.2)		
D. To promote social interaction	Instructors are more accessible (2.2.8)	Feeling of isolation (2.4.1.3)	Ardito et al., Mehlenbacher et al., Dringus and Cohen (#8), Ssemugabi and de Villiers (#14)
	Interaction (2.2.6, 2.4.1.2)		
	Plurality (2.2.9)		
E. To provide teachers with a student monitoring tool	Gaining an insight into students' progress (2.2.12)	Lack of an effective monitoring tool (2.4.2.3)	Dringus and Cohen (#8)
		Time burden (2.4.2.3)	
F. To help teachers to design their courses	Effective course design	Lack of skills to teach online (2.4.2.3)	Ardito et al., Dringus and Cohen (#7)
		Time burden (2.4.2.3)	
		Lack of an effective tool for designing courses (2.4.2.3)	
Information structure			
G. To provide multiple views of the course	Learner-centered approach (2.2.5)	Bias toward a specific perspective of the course	Quinn (#3), Squires and Preece (#6), Dringus and Cohen (#9, #13), Ssemugabi and de Villiers (#16)
H. To provide a comprehensible and flexible schema	Effective course design	Time burden (2.4.2.3)	-
Usability			
I. Match between the VLE and the educational conventions	The design of a user-friendly web interface	Confusion (section 2.4.1.3)	Nielsen's heuristics (see appendix B.2.2.3)
J. Minimalist design		Cognitive overload (2.4.1.3)	
K. Visibility of system status		Confusion (2.4.1.3)	
L. Error prevention and easy recovery from errors		Technical problems (2.4.1.3)	
M. Documentation and help		Students' absence of technical skills (2.4.1.3)	

Table 4.2: Recommendations for designing effective virtual learning environments for fully online education.

5 Evaluation of the set of recommendations

This chapter evaluates the suitability of the proposed recommendations in a real fully online scenario (research objective O2). This is structured as follows:

- First, the main characteristics of the procedures that were used to evaluate the recommendations suggested in this work are described:
  - Real-world evaluation with final questionnaire (see section 5.1.1)
  - Interviews (see section 5.1.2)
- Next, it explains how the set of recommendations proposed in Chapter 4 was put into practice by means of three prototypes of a small VLE called AdVisor. Each prototype is described in a section:
  - AdVisor 0.0 (see section 5.2).
  - AdVisor 1.0 (see section 5.3).
  - AdVisor 2.0 (see section 5.4).

  For each of them, their main features are explained by following a structure based on the the three cornerstones defined in section 3.3: pedagogical approach, information structure and interface (i.e. usability). Moreover, the details of their real-world tests are shown together with the results obtained from their respective questionnaires filled out by students. Regarding AdVisor 2.0, besides the results of the questionnaire, the main conclusions drawn from the interviews conducted with teachers are presented too.
- The chapter ends with the general conclusions on the set of recommendations which were drawn from the real-world evaluation and the interviews.

5.1 Introduction

To evaluate the suitability of the recommendations presented in Chapter 4, a small VLE called ***AdVisor*** was built. This platform was developed by using ***prototyping*** as the systems development methodology (see section 1.4.1). From January 2009 to September 2011, ***three prototypes*** of AdVisor were created. As prototyping is an incremental process, each prototype (or version) included new features and, at the same time, attempted to improve the existing ones.

Both students and teachers evaluated the recommendations suggested by this thesis. In this regard, two different procedures can be distinguished:

Evaluation procedures conducted in this thesis

- Real-world evaluation by using AdVisor prototypes
- Interviews (supported by AdVisor 2.0)

Next, each of them is described.

5.1.1 Real-world evaluation

Each version of AdVisor was tested in a ***real-world evaluation*** at the Universitat Oberta de Catalunya (UOC). More specifically, each prototype was tested in two half-yearly courses which belonged to the Bachelor's Degree in Telecommunications of the UOC and whose lecture periods were about four months and a half. The first prototype (called AdVisor 0.0) was tested during the 2009-2010 academic year (September 2009 - June 2010, i.e. two semesters), whereas the other two versions of the platform (i.e. AdVisor 1.0 and 2.0) were only tested during one semester, i.e. March 2001 - June 2011 and September 2011 - December 2011, respectively. At the end of each semester, an ***online self-administered questionnaire was sent to the students*** so as to know their opinions and, thereby, to have evidence to validate the recommendations proposed in this thesis. With regard to the teachers who were in charge of the courses which participated in the tests, they gave their opinions about the tool throughout the semester in an informal way.

The selected courses were taught both in Spanish (89) and in Catalan (19)[1]. Before proceeding with this chapter, it is worthwhile to read the section A.4 in order to understand the assessment model of the UOC. The courses that took part in the tests were:

- **Electric Circuit Analysis (.002)**: this subject focuses on basic concepts related to analyzing electric circuits, e.g. Ohm's law, Kirchhoff's laws, resistors, inductors, capacitors, etc. This course has its own lecture notes that include all the contents and, at the same, guide students through the semester. Due to the large number of new concepts that are taught, the forums are very active and, hence, they usually have a lot of messages at the end of the semester.

[1] Henceforth, the classrooms can be referenced by its code. For instance, the Spanish classroom of Mathematics II will be 89.008, whereas the Catalan one will be 19.008. As seen, the code of Mathematics II is .008.

Regarding the assessment, three optional continuous assessment assignments (CAAs) are suggested by the teacher. In order to pass the course, students compulsorily have to do two practicals and take an on-site final exam. To do the practicals, students use a protoboard.

This subject was chosen to test the last two versions of the platform, i.e. AdVisor 1.0 and 2.0.

- **Mathematics II (.008)**: this is based on a part of the book *"Signals and systems"* (Oppenheim et al., 1996), mainly: continuous-time and discrete-time Fourier transforms. Learners are provided with short guides that indicate the sections of the book that they have to read.

  As as far the assessment model is concerned, students are free to do four CAAs, but they all have to take a mandatory final exam on site.

  This course was used in the three versions of AdVisor.

- **Signals and Systems (.011)**: this subject reviews the concepts taught in Mathematics II and adds new ones, mainly: the study of the linear systems. Like Mathematics II, the main learning material is made up of the book *"Signals and systems"* and short guides.

  As for the assessment, four optional CAAs are proposed. If the average grade of the CAAs is C+, then the student must take a final validation test on site, otherwise, an on-site final exam.

  Only the Catalan classroom of this course tested the first prototype, i.e. AdVisor 0.0.

With regard to the test/evaluation stages, it is important to emphasize several aspects:

- The teachers in charge of the three courses attempted to control, as much as possible, those factors that could change from test to test and, at the same time, could influence the results. To this end, the instructors tried that both their attitudes and the difficulty of the CAAs, exams and any other assignments were similar to those of the previous test/semester.

- The researcher monitored each course and each teacher daily so that he could ensure that the behavior of the different teachers were practically identical. Any technical problem was managed by the researcher, thereby the instructors only focused on teaching.

- Although Table 5.1 shows that the heuristics related to usability (i.e. I-M) were assessed individually, these were really evaluated globally under the term *usability* since it was not possible to have usability experts or a lab where end-users could test the tool at our disposal. Hence, ***this thesis focused on the recommendations linked to pedagogy and information structure (from A to H)***. However, this did not mean that the most general usability criteria were not taken into account during the development of the prototypes.

Table 5.1 shows the recommendations (or heuristics) that were put into practice in each version of AdVisor as well as the courses in which each prototype was tested. Similarly, Figure 5.1 displays the timeline of the process that was carried out. Due to the lack of resources and time in the development stages, not all the recommendations were implemented identically.

Prototype	Development stage														Test stage	
	Date	Recommendations													Date	Courses
		A	B	C	D	E	F	G	H	I	J	K	L	M		
AdVisor 0.0	Jan 2009 Sept 2009		X	X				X	X	X	X	X	X	X	Sept 2009 Jun 2010	Mathematics II[1] Signals and Systems[1]
AdVisor 1.0	Jun 2010 Mar 2011	X	X	X			X	X	X	X	X	X	X	X	Mar 2011 Jun 2011	Electric Circuit Analysis Mathematics II
AdVisor 2.0	Jun 2011 Sept 2011	X	X	X	X	X[2]	X	X	X	X	X	X	X	X	Sept 2011 Dec 2011	Electric Circuit Analysis Mathematics II

[1] Only the Catalan classroom of this course tested the prototype.

[2] This recommendation was implemented by another tool called FACRO and it was evaluated by means of interviews with teachers.

Table 5.1: Recommendations evaluated in each prototype as well as the courses in which were tested.

5.1.2 Interviews

In order to collect instructors' opinions in a systematic way, ***eight semi-structured interviews with UOC instructors were conducted***. Each instructor was asked a predetermined set of questions and, moreover, was at liberty to discuss and comment anything that she wanted. The interviews addressed specific questions to elicit information about teachers' impression and opinions on the usefulness/suitability of the features proposed by AdVisor 2.0 (i.e. the last prototype). These interviews were conducted in December 2012.

At this point, it is worth explaining that ***a new tool called FACRO (FAceted Class ROster) was embedded in AdVisor 2.0*** in order to evaluate the ***recommendation E*** (i.e. to provide teachers with a student monitoring tool). FACRO was designed and developed from January to May 2012. Details of this tool are presented in section 5.4.2.4.

5.1.3 Explanatory notes

The rest of the chapter is devoted to explaining each prototype in detail. For each of them, the following items are described: the recommendations that were evaluated, the main features, the details of the test, the results obtained from the evaluation, and the conclusions that were drawn.

At this point, the reader should know that ***the results shown in this chapter are a summary*** of the most significant findings and conclusions. For this reason, frequency tables and graphics are not shown. Likewise, statistical coefficients and tests, such as Cronbach's alpha coefficient and the Mann-Whitney (MW) test, are only given when they are really relevant. For example, the result of the MW test is provided when there is evidence that the two groups disagreed about some aspect.

Appendices D, E and F contain the in-depth analyses of the tests and the interviews on which this chapter is based. Moreover, they three include the set of questions used in each evaluation.

As seen, different statistical measures and tests are used throughout the chapter and, especially, in the appendices. For this reason, before proceeding, it is strongly recommended reading the Appendix C, since it details all the statistical concepts and assumptions used in this chapter and in the three aforesaid appendices.

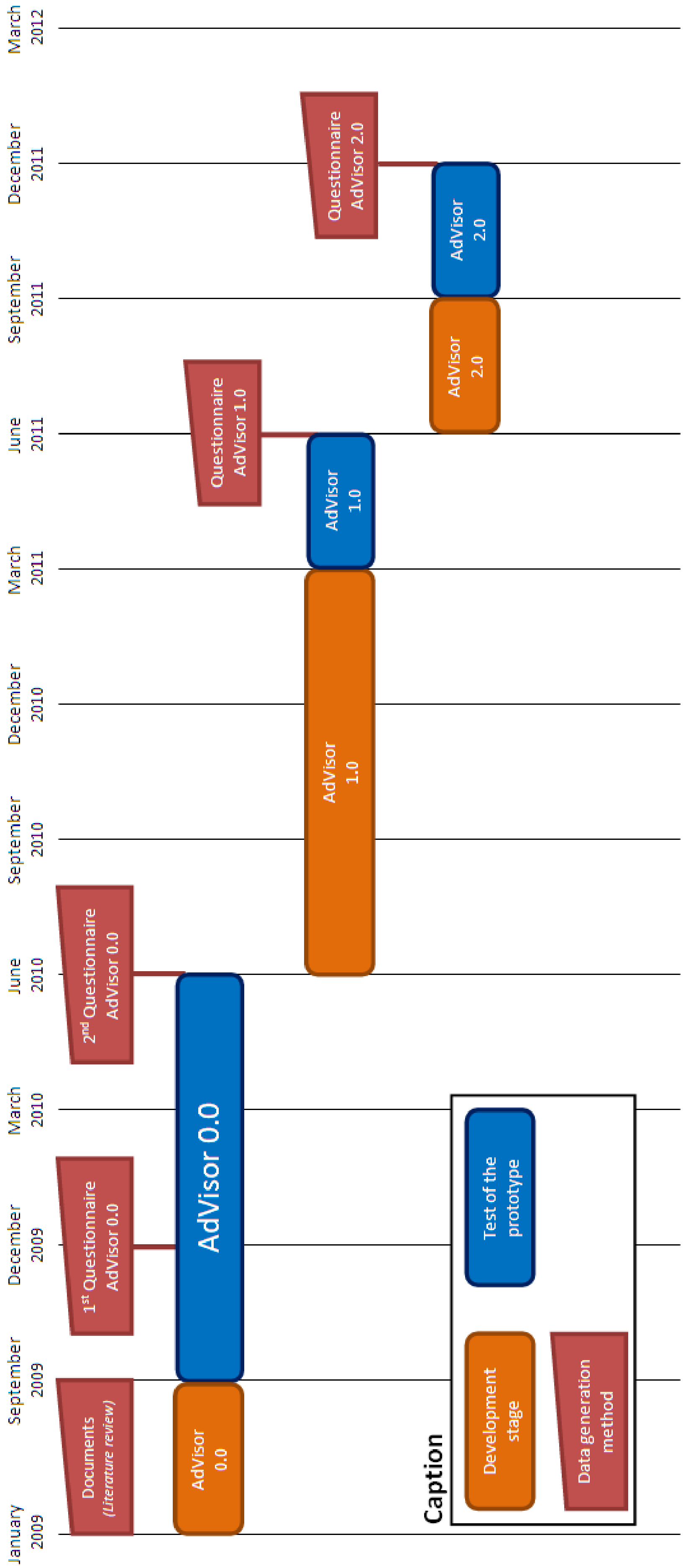


Figure 5.1: Timeline of the prototyping process that was carried out in this thesis.

5.2 AdVisor 0.0

5.2.1 Introduction

Once the recommendations described in the Chapter 4 were identified from the literature review, AdVisor 0.0 was developed from January to September 2009. This first prototype focused on evaluating the suitability of the following three recommendations:

Recommendations on which AdVisor 0.0 mainly focused

B. To guide students through the course (see section 4.3.4.1)

C. To provide self-awareness (see section 4.3.4.1)

G. To provide multiple views of the course (see section 4.3.4.2)

Likewise, AdVisor 0.0 took the first steps toward:

H. To provide a comprehensible and flexible schema (see section 4.3.4.2)

Regarding the questionnaire, this tried to collect information in order to:

F. Help teachers to design their courses (see section 4.3.4.1)

As for the recommendations related to the usability criteria (i.e. from I to M), these were evaluated globally with the term *usability*.

5.2.2 Design

The main features of AdVisor 0.0 in terms of pedagogical approach, information structure and interface are described below.

5.2.2.1 Pedagogical approach

The underlying pedagogical approach of AdVisor 0.0 (and the next versions of this VLE) was based on the one described in section 4.3.3. Moreover, the UOC's educational model (see Appendix A.3) was taken into consideration too.

5.2.2.2 Information structure

In order to meet the ***recommendation G***, i.e. to provide multiple views of the course, ***the information structure of AdVisor 0.0 consisted of two parts: the table of contents (TOC) and the schedule***.

As for TOC, this was defined as a hierarchical structure which was made up of four elements (see Figure 5.2):

- **Block**: it was the first element of the hierarchy and represented a global concept, e.g. *arithmetical operations* in a Mathematics course. It consisted of a description and a list of competences that were developed in the block. Moreover, this was comprised of a set of units. Finally, a start date and a finish date set its duration.

- **Unit**: it was a synonym of chapter or topic. For instance, following the previous example, that block could include the units *addition* and *subtraction*. Each unit had a description as well as a list of sessions. Like the block, start and finish dates indicated how long it took.

- **Session**: it was equivalent to an F2F lecture. A session consisted of one or more activities. This had a description and its duration was measured in days by using start and finish dates.

- **Activity**: it was a task that the students had to do, e.g. a reading, a continuous assessment assignment (CAA), etc. Thus, this was linked to a resource, e.g. PDF, video, etc. Its duration was measured in 15-minute intervals, while its start and finish dates were the same as those defined for the session to which it belonged. An activity only could belonged to one session.

Besides the previous features, ***the block, the unit and the session had a schedule based on their child item***. For instance, a block provided a schedule based on the units which it contained.

The reason for including these four elements was that the teachers were familiar with them, since these items already existed in most of UOC subjects. For example, the lecture notes of an UOC course are organized by units and, likewise, the sessions of AdVisor were similar to the short weekly guides that are usually provided in each subject (see Appendix A.3). Hence, the structure was, a priori, easy for teachers and students to understand (i.e. ***recommendation H***).

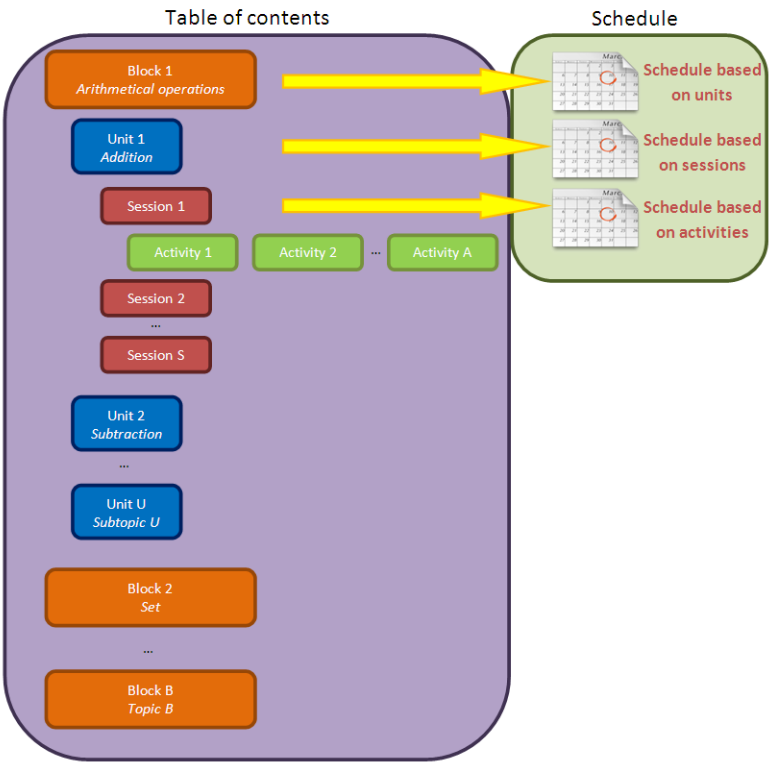


Figure 5.2: AdVisor 0.0 – Information structure.

5.2.2.3 Interface

The interface of AdVisor 0.0 (and the rest of the versions) was developed by using web technologies. Furthermore, the five recommendations related to the usability criteria identified in the Chapter 4 were taken into consideration. The interface of AdVisor 0.0 mainly consisted of two parts:

- Dashboard
- Workspace

Dashboard

When the users accessed to AdVisor 0.0, this first showed a dashboard with personalized information (see Figure 5.3). On the left, the dashboard had a list of the courses in which the student was enrolled. When a learner clicked on a course from the list, the following information about that subject was displayed on the right: (1) the number of activities that the subject had, (2) the number (and percentage) of activities that the student had already finished, (3) the last session that the learner had finished, (4) the date in which she had finished the last session, and (5) the next session to do. By default, when a student logged in, the data of the first course were shown.

In addition to the previous information, two visual indicators were displayed too:

- **Studying pace**: this was in the shape of a rectangle and allowed each student to visually compare her studying pace (in blue) with the course's pace (red line). Moreover, the percentage of activities performed by the student, i.e. the same information as the one represented by the blue area, was shown in the middle of the rectangle. As for the teachers, they saw the class's studying pace in blue, i.e. the average of all learners' studying pace.
- **Continuous assessment**: this indicator looked like an emoticon and informed about the continuous assessment (CA) grade of the student (or the class). There were three different emoticons: happy (for grades A and B), neutral (C+ and C-) and sad (D and NP).

As it can be noticed, ***the idea of the dashboard was to provide a learner with enough information in order that she was able to be aware of the status of her learning process***. Therefore, the dashboard was totally aligned with the ***recommendation C***.

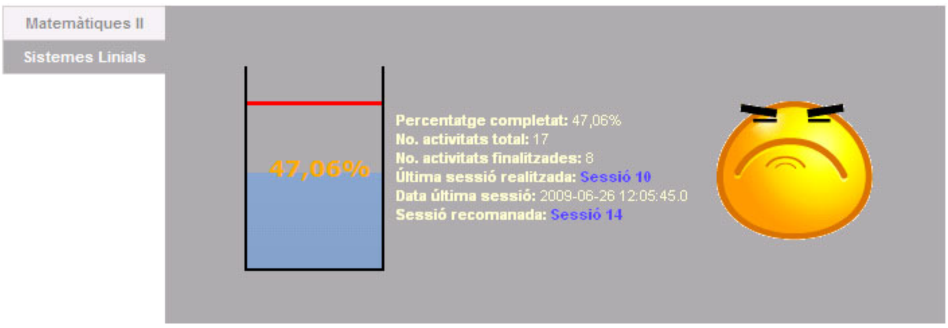


Figure 5.3: AdVisor 0.0 – Dashboard. This example shows data about the course *Signals and Systems*.

Workspace

In addition to the dashboard, AdVisor 0.0 had a workspace (see Figure 5.4). This was comparable to an online classroom. Regardless of the subject, the workspace was divided into ***two complementary ways of navigation (or views) which could be used simultaneously***. Each of them was linked to one part of the information structure:

- **Treeview**: this was placed on the left and its structure was a hierarchical tree that enabled to navigate through the course based on its table of contents (TOC), regardless of the dates of the course schedule. Hence, this navigation was similar to exploring a book index.

  This view only showed the first three items of the structure (i.e. blocks, units and sessions). When an item of the tree was clicked, it was either expanded to reveal its children or collapsed to hide them.

- **Gantt chart**: this view showed the schedule of the course or, in other words, the ideal studying pace proposed by the teacher. Thus, this view was related to ***recommendation B***.

  This view was placed in the main area of the page and showed the elements that were included in the item chosen by the user. For example, the Gantt displayed units if the student had chosen a block. Each course element was represented by a bar whose length was the period of time set by the item's start and finish dates. Moreover, each bar was colored according to the status of the element. In this regard, three colors were used:

  - **Green**: this meant that the student had completed all the tasks related to that item.
  - **Blue**: this color indicated that the element was not complete and the current date was previous to the item's finish date.
  - **Red**: this showed a item that was behind schedule, i.e. this was not complete and its finish date was prior to the current date.

  The completion of an activity was marked by the students manually. The other items (i.e. block, unit and session) were automatically marked as complete when all their children were finished. Hence, the completion process was bottom-up (from the activity to the block). This feature tried to help learners to be aware of the status of their learning process (i.e. on, behind or ahead of schedule) and, hence, it accorded with ***recommendation C***.

Both types of navigation were connected. Thus, when an item of the TOC (i.e. treeview) was clicked, in addition to revealing/collapsing its subitems, the main page showed its description and the Gantt chart with its subitems. Similarly, when a user clicked on a bar of the Gantt chart (i.e. an element), the same item in the treeview was expanded and, in turn, its description and Gantt chart were displayed in the main page. Moreover, the Gantt had a link to go back to the parent item.

Last but not least, when an activity was selected (only possible from the Gantt chart), its resource (e.g. PDF, video, simulation, web link, etc.) was shown by using a lightbox, i.e. an effect that fades the page in the background to show new content in the foreground (see Figure 5.5). Besides the resource, two radio buttons were displayed at the bottom of the lightbox. These two buttons allowed learners to mark the activity as *finished* or *unfinished*.

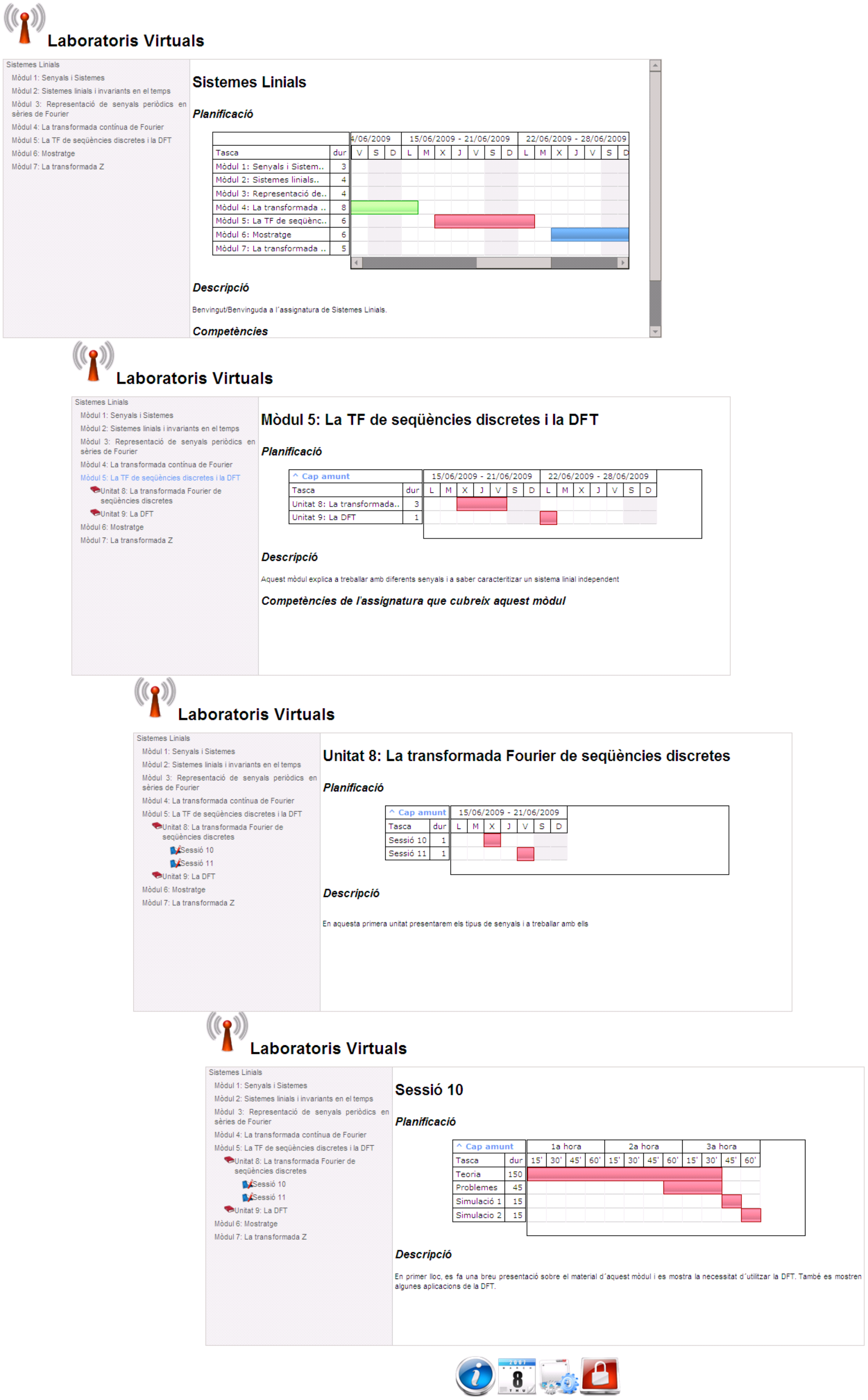


Figure 5.4: AdVisor 0.0 – Interface and navigation through the structure of the subject: course, block, unit and session (top-down). The last picture, i.e. the session, shows a Gantt chart that displays activities. Its timeline is based on periods of 15 minutes, unlike the rest of Gantts that are divided into days.

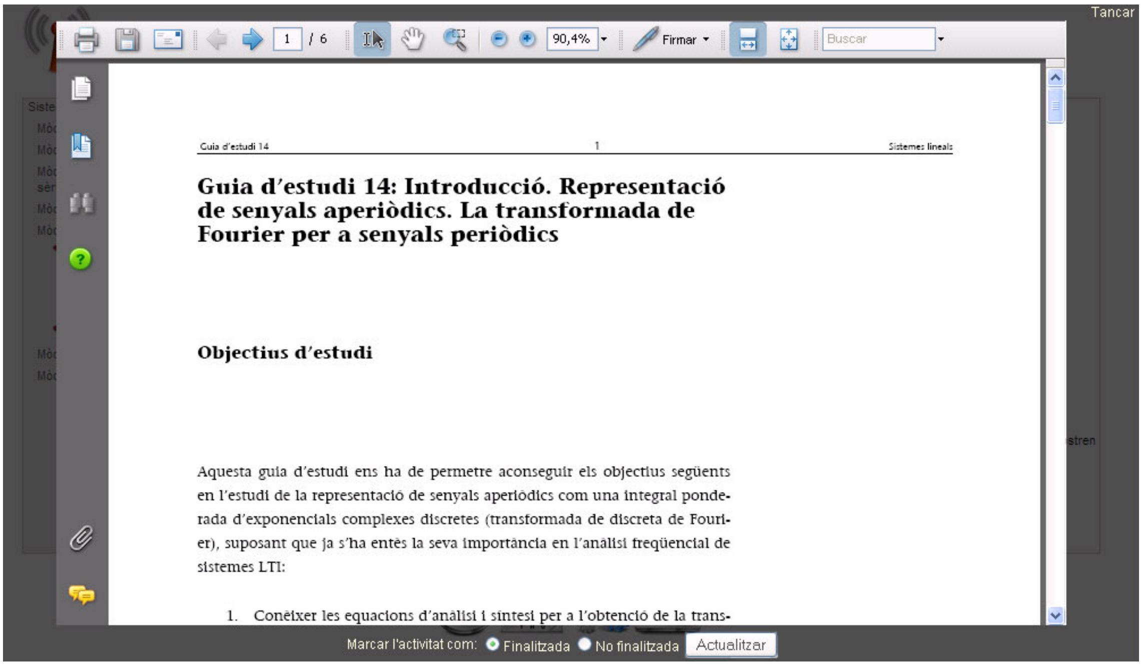


Figure 5.5: AdVisor 0.0– Activity's lightbox. In this example, the resource is a PDF file.

5.2.3 Test

During two semesters, September-December 2009 and February-June 2010, AdVisor 0.0 was tested by the Catalan students from Mathematics II (.008) and Signals and Systems (.011). The use of AdVisor 0.0 was voluntary and it could be used together with the online classroom of the UOC's Virtual Campus. Because this prototype did not have any type of two-way communication tool, all the students had to use the forums of the UOC classroom.

5.2.4 Evaluation

In order to evaluate AdVisor 0.0 and the recommendations that were put in practice, a questionnaire with 21 questions was created. Most of the questions were based on a 5-point Likert scale, but also there were some open text questions that enabled the students to write their opinions and suggestions. Likewise, there were multiple-choice questions that allowed the respondents to choose more than one option. As said in section 5.2.1, this prototype and, hence, ***the questionnaire, mainly focused on evaluating recommendations B, C and G*** (see sections 4.3.4.1 and 4.3.4.2). The questionnaire is available in Appendix D.1.

At the end of each semester, the questionnaire was sent to all the students who were enrolled in some of the two courses[2]. As for the first semester, this was sent on December 18, 2009 and was available until February 10, 2010. The number of students was 120 (89 from Mathematics II and 31 from Signals and Systems). Regarding the second semester, the questionnaire was sent to 106 students (58 from Mathematics II and 48 from Signals and Systems) and was available from July 2 to August 8, 2010. As a result, the total number of potential respondents was 226, i.e. 147 from Mathematics II and 79 from Signals and Systems.

[2] The learners who were in both courses received the e-mail once and were labeled as students of Mathematics II.

5.2.5 Results

This section presents the main conclusions and results extracted from the collected responses. Appendix D.2 contains much more details about the responses to each question. Besides the results of the questionnaire, this section shows the remarks made by the teachers during the test.

5.2.5.1 Reliability of the results

As for the reliability of the test, one of the most important aspects to be considered was the voluntary use of the platform. This meant that ***most of the respondents had not used AdVisor 0.0 all the time***. Hence, it was needed to be cautious about the significance of the results obtained, since the responses, despite being useful, may have been based on an incomplete vision of the platform.

Considering the optional use of AdVisor 0.0, the response rate (20.8%, 47 of 226 learners) was a good figure. However, although over 91% of the respondents were older than 25 (i.e. the average age of online students according to Gilbert (2000)), the sample was biased. The main reason was that they all belonged to Engineering courses and 89.4% of them were men. More details about the respondents' profile are given in Appendix D.2.2.

For all of these reasons, the answers from the questionnaire could not be generalized to all online learners. Thus, ***the results could only be used to extract trends*** of online students' opinions of the recommendations proposed in this work, rather than drawing definitive conclusions.

5.2.5.2 To guide students through the course (recommendation B)

As said in section 5.2.1, one of the goals of AdVisor 0.0 was to evaluate if it was suitable that VLEs guided students through the course (i.e. ***recommendation B***). To this end, an organizational element called *session* was specially designed (see section 5.2.2.2).

The questionnaire revealed that ***86.9% of the respondents found the course organization based on sessions useful*** (4, 39.1%, median) ***or very useful*** (5, 47.8%, mode). However, 1 out of 4 respondents said ***the sessions were overloaded***, i.e. the real workload was greater than the estimated one. In this regard, 72.3% of those polled indicated that the ***optimal workload of a session would be between 1 and 2 hours***. This range included the average duration of the respondents' study sessions, i.e. 1 hour and 45 minutes (see section 5.2.5.5).

From the aforesaid results (see an in-depth analysis in Appendix D.2.5), it was concluded that ***recommendation B seemed to be suitable*** and, thus, the session should be promoted in future.

5.2.5.3 To provide self-awareness (recommendation C)

Another goal of AdVisor 0.0 was to provide students with enough information that allowed them to monitor their own learning process and, thereby, to be aware of their status in the course (i.e. ***recommendation C***). To this end, a dashboard with personalized data was shown (see section 5.2.2.3).

According to the results, ***only 6.8% of those questioned rated the dashboard 1*** (*very poor*, 4.5%) ***or 2*** (*poor*, 2.3%). Moreover, 50% of the responses were 4 (*useful*, mode and median).

The excellent result of the dashboard (see more details in Appendix D.2.6) led to the conclusion that the students considered having personalized information on their learning progress to be very important. In other words, ***recommendation C seemed to be appropriate for online education***.

Finally, although the proposed dashboard still lacked a lot of data (e.g. to show assessment information, the unfinished activities that have expired, etc.), this seemed to be adequate for meeting ***recommendation C***. As a result, this element would have to be in AdVisor 1.0.

5.2.5.4 To provide tools that help students to be self-regulated (recommendations B and C)

Recommendations B and C aim to help students to self-regulate their learning process. Thus, they two could be part of a single recommendation: *to provide tools that help students to be self-regulated*. As they both have a common goal, the session and the dashboard (i.e. the two items related to these heuristics) would have to be correlated. According to Spearman's correlation coefficient, there was a moderate correlation ($\rho = .411$) that was highly significant ($p = .006$). Hence, it seemed that ***those students who found the sessions useful also rated the dashboard positively***.

Besides the session and the dashboard, other items, such as the Gantt chart and the option that enabled to mark an activity as complete, were created to support self-regulation. With the aim of evaluating all these characteristics as a whole, the following question was asked: *"to what extent did AdVisor help you to self-regulate your learning process?"*. ***40.5% stated that AdVisor 0.0 had helped them to be self-regulated significantly*** (scores 4 and 5), being 3 (*normal*, 38.1%) the mode and median. Furthermore, those who rated 1 (*nothing*, 9.5%) could have been considered outliers.

Despite the necessity of being careful with the significance of this result, everything seemed to indicate that ***AdVisor 0.0 laid the foundations of a platform for supporting self-regulated learning***. Lastly, Appendix D.2.7 expands on the analysis provided in this section.

5.2.5.5 To help teachers to design their courses (recommendation F)

Providing teachers with the study habits of their online learners may help them to design their courses better (i.e. ***recommendation F***), e.g. to determine what type of activity to use and its duration. Likewise, these data may be useful to improve the effectiveness of learning tools. Due to this, learners were asked about their study habits. From the answers collected, the study strategy used by most of the respondents can be characterized as follows (more data in Appendix D.2.4):

Study strategy of the respondents

- **Preferred study place**: home
- **Preferred days to study**: indistinctly, i.e. both weekdays and on the weekend
- **Number of days per week in which the learner studies**: about 4.5 days
- **Average duration of a study session**: 1 hour and 45 minutes
- They often study more when continuous assessment assignments' deadline is close

As all the respondents were enrolled in the UOC, it was difficult to generalize the previous study strategy to the population of all online students. However, this showed tendencies of behavior of a small sample. Consequently, this information could, in some way, help the teachers to effectively design their courses thenceforth (i.e. ***recommendation F***). For example, they could try to adapt the sessions to the optimal workload suggested by the respondents, i.e. 1 hour and 45 minutes.

Apart from being useful to the instructors, this information about the study habits could also be used to create a smart course authoring tool in the future. Such a course editor could, for instance, warn the instructor when she created a session whose workload exceeded the optimal duration.

5.2.5.6 To provide multiple views of the course (recommendation G)

AdVisor 0.0 was a first step toward providing students with multiple views of the same course. In this regard, the information structure organized the courses into two views (section 5.2.2.2): (1) the table of contents (TOC), and (2) the schedule. This organization was also reflected in the interface via the two kinds of navigation that were part of the workspace: (1) the treeview, and (2) the Gantt chart (see section 5.2.2.3). As observed, the workspace involved a radical change compared to the UOC classroom, since the learners simultaneously saw the two types of navigation/views of the course. Despite this change, ***66.7% found the workspace good*** (4, 48.9%, mode and median) ***or very good*** (5, 17.8%), being the score 1 (*very poor*, 4.4%) an exceptional value.

Likewise, according to 38.5% of the respondents, the two types of navigation (or views) were *equally useful*. By contrast, 33.3% found the *Gantt chart/schedule* more useful, whereas 28.2% opted for the *treeview/TOC*. Such was the similarity between the two views that there were no reasons for removing any of them. As a result, ***they both would have to remain in future prototypes***.

In the light of the aforesaid results, ***it could be concluded that providing multiple views made sense and, consequently, recommendation G seemed to be suitable***. Thus, AdVisor 1.0 would have to deal with the provision of different perspectives of the same course in depth. In this regard, some students requested for a view that displayed the CAAs. The reason for that could have been that a significant number of learners studied according to the CAAs' deadline (see section 5.2.5.5).

Finally, an extended analysis of the previous results can be found in Appendix D.2.8.

5.2.5.7 To provide a comprehensible and flexible schema (recommendation H)

The teachers in charge of the two courses which were part of the test stated that the information structure was ***easy to understand***, but also they argued that it was ***too rigid*** and thus restricted the design. In fact, this forced instructors to create courses which had both a table of contents and a schedule. Therefore, ***AdVisor 0.0's schema met the recommendation H partially*** and, consequently, AdVisor 1.0 would have to focus on designing a more flexible information structure.

5.2.5.8 Usability (recommendations I-M)

As said in section 5.2.1, the ***recommendations I-M*** were evaluated globally with the term *usability*. More specifically, the students assessed the usability of the double navigation, i.e. the core of the workspace. In this regard, ***only 4.3% found the double navigation not at all usable*** (score = 1). The rest rated it 3 (*neither usable nor useless*, 31.9%) or higher, being 4 (*usable*, 38.3%) the mode and median. Hence, ***the usability of the double navigation was evaluated very positively***, especially if the differences between AdVisor and the UOC classroom are taken into account.

Moreover, it was asked how to display the activities. From the responses, it was concluded that it would be suitable to replace the lightbox with web browsers' tab and window.

More details about the usability evaluation of AdVisor 0.0 can be found in Appendix D.2.9.

5.2.5.9 Future improvements

To improve AdVisor in the next version, a list of items to be added/improved was given to the respondents (multiple choices were allowed). From the responses (extended data is given in Appendix D.2.10), it was concluded that ***the next prototypes should focus on assessment and forums***.

5.2.6 Conclusions

Broadly speaking, ***AdVisor 0.0 was well received by the students***. To check that this positive evaluation was uniform in the whole platform, a Spearman's correlation was run to determine the relationship between the two main sections of AdVisor, i.e. the dashboard and the workspace. The correlation was strong ($\rho = .775$) and highly statistically significant ($p = 0$). Therefore, ***those learners who rated the dashboard positively also evaluated the workspace with high scores***. In other words, the whole platform was evaluated in the same direction which, as seen, was positive.

Some comments supported the previous result: *"good system"*, *"very good"*, *"I think that it is suitable"*, *"it has been very useful"*, *"I find it perfect. Any help like this is well received"*. *"I think this system should be promoted"*, *"I think that all the courses should have a similar platform"*, etc.

Because one had to be careful about the significance of the results obtained (see section 5.2.5.1), the main conclusion to be drawn from this test/questionnaire was that it seemed that ***the respondents had found recommendations B, C and G suitable***. This tendency would have to repeat itself in future tests/prototypes. In this regard, to guarantee that all the respondents of the future tests had a well-founded opinion about the platform before filling out the questionnaire, the use of AdVisor would thenceforth be mandatory. Thereby, a more reliable analysis would be conducted.

Lastly, the main aspects that would have to be improved by AdVisor 1.0 are enumerated below:

Main improvements to make in AdVisor 1.0

- The balance between the sessions' real and estimated workload.
- The dashboard should display more information, e.g. the grade of each CAA.
- To add more views. One of the them would have to be linked to the CAAs.
- To create a flexible schema which allows to use the views that are really required.
- To replace the lightbox with web browsers' tabs/windows.

5.3 AdVisor 1.0

5.3.1 Introduction

AdVisor 1.0 was developed from June 2010 to March 2011 by taking all the suggestions and possible improvements collected from AdVisor 0.0 into account. This second prototype continued with the evaluation of the same recommendations that were studied in AdVisor 0.0 and added another one: ***recommendation A***. Hence, the principal recommendations studied in AdVisor 1.0 were:

Recommendations on which AdVisor 1.0 mainly focused

A.To define competences and objectives clearly (see section 4.3.4.1)

B.To guide students through the course (see section 4.3.4.1)

C.To provide self-awareness (see section 4.3.4.1)

G.To provide multiple views of the course (see section 4.3.4.2)

Like AdVisor 0.0, this new prototype also tried to:

H. Provide a comprehensible and flexible schema (see section 4.3.4.2)

Moreover, the information on study habits obtained from the questionnaire of AdVisor 0.0 was provided so as to:

F. Help the teachers who participated in the test to design their courses (see section 4.3.4.1)

With regard to the recommendations which dealt with issues related to usability (I-M, see sections 4.3.4.3), despite not being the main focus of this thesis (see section 5.1), a more in-depth evaluation was conducted compared to that of AdVisor 0.0.

5.3.2 Design

As said, the development of AdVisor 1.0 lasted about ten months. This meant that this prototype had a large number of new features and changes, which mainly affected the information structure and the interface. Next, the most relevant aspects that were improved/added are described.

5.3.2.1 Pedagogical approach

The underlying pedagogical approach of the platform remained exactly as that of AdVisor 0.0, i.e. the pedagogical approach described in section 4.3.3 plus the UOC's educational model (see Appendix A.3), but including ***degree competences and course objectives*** in order to meet ***recommendation A***. According to the UOC[3], the terms *competence* and *objective* can be defined as follows:

[3] Retrieved from http://www.uoc.edu/portal/en/universitat/model-educatiu/eees/eees/faq/ (March 18, 2013)

Competence and objective

- **Competence**: it is the group of skills that a person puts into practice when carrying out their professional and academic activity in an efficient, independent and flexible way. With the EHEA, the design of degrees is based on the competences that different academic and professional profiles require in the reality of the labor market.
- **Objective**: this is the group of knowledge, skills and attitudes, expressed with regard to learning, which the student has to achieve during the course of the subject. The achievement of the objectives of each subject contributes to acquiring the competences of the degree.

As it will be explained in sections 5.3.2.2 and 5.3.2.3, the inclusion of these two elements entailed some changes in AdVisor 1.0's information structure and interface.

Thanks to the information collected from the questionnaire of AdVisor 0.0, some guidelines were given to the teachers who used AdVisor 1.0. These mainly focused on the design of the schedule. For example, as it has been shown in the third screenshot of the Figure 5.4, the sessions in AdVisor 0.0 were designed in such a way that many of them had a duration of one day (i.e. start date = finish date), since the teachers understood a session as totally equivalent to an F2F class. Given that many online students are not able to follow a proposed schedule to the letter, one could realize the importance of defining a more flexible session design. Thus, it was suggested distinguishing between the *duration* and the *workload* of the sessions as follows:

Distinction between the workload and the duration of a session

- **Workload**: the sum of the durations of all the activities which belong to the session.
- **Duration**: interval of time in which is advisable to perform all the activities of the session. This is defined by the start and finish dates of the session.

As a result, for instance, a session could last one week and have a workload of two hours. This would mean, in other words, that the students would have one week to perform a set of activities which would last two hours. Thanks to this recommendation, the workload was the same as that of an F2F lecture, but the duration available to do it was more flexible. This directly meant two improvements: (1) the teachers were provided with a design guideline that was more suitable for online courses (this improvement was aligned with ***recommendation F***), and (2) the information provided by the Gantt chart was more realistic since the students clearly saw the time which they had in order to perform the activities that belonged to each session.

Likewise, as 26.2% of the respondents found the sessions of AdVisor 0.0 overloaded (see section 5.2.5.2), teachers were advised that sessions' workload would have to last about 1 hr and 45 min.

5.3.2.2 Information structure

The information structure underwent the most significant change. As it was concluded in section 5.2.5.7, one of the main problems that the previous prototype had was the rigidness of its structure. Due to this, teachers were forced to organize their courses by using four elements: block, unit, session and activity. The question was obvious: *what happened if an instructor preferred another hierarchy?* This was simply impossible. Moreover, the teachers had to mandatorily provide data about the table of contents and the schedule so as to fill out the hierarchical tree and the Gantt chart. *What happened if a course did not have a schedule or a table of contents?* AdVisor 0.0 could not manage that course correctly and, therefore, the workspace did not work. Thus, the design of the courses was clearly limited by the information structure of AdVisor 0.0.

As a result of the aforesaid problems, a new information architecture was proposed (see Figure 5.6). Firstly, taking ***recommendation G*** into account, ***a course was divided into four independent and optional information spaces (or views) that focused on specific parts of the subject***: (1) schedule, (2) table of contents (TOC), (3) competences and objectives, and (4) assessment. As seen, the two first spaces already existed in AdVisor 0.0, but the other two were new. The first one, i.e. the schedule, remained exactly the same as in AdVisor 0.0. However, the TOC underwent a significant change in order that the teachers were at complete liberty to organize it as they wanted. ***Thenceforth there were not blocks, units and sections any longer, there were only a hierarchy of labels. As a result, the instructors could create as many sublevels as needed***. As regards the space of competences and objectives, this was designed to include these two new elements into the course structure and thereby meeting ***recommendation A***. Lastly, as for the assessment space, this was added to satisfy one of the requests that were made in AdVisor 0.0 (see section 5.2.5.6).

Likewise, there was not any direct relationship between the information spaces. Instead, ***they all were interrelated through the closest element to the students' learning process: the activity***. Consequently, the activities became the core of the structure and, at the same time, the unique link between all the spaces. For that reason, thenceforth, ***the TOC and the Gantt chart were not directly connected any longer***. All this reorganization allowed to have a flexible structure that adapted to different teaching styles and types of course. For instance, an instructor could create the schedule only, without defining the rest of information spaces. Actually, AdVisor 1.0 only required teachers to create the learning activities in order that it could work.

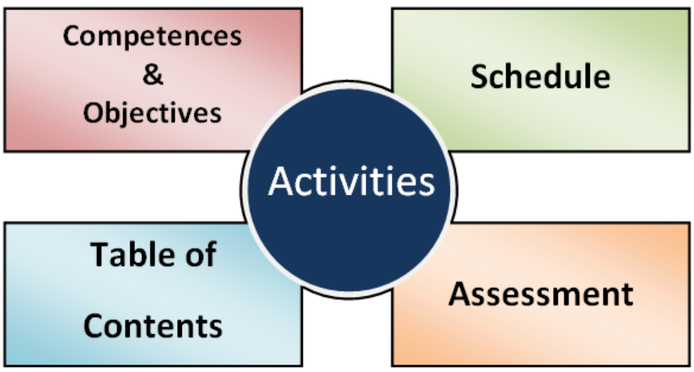


Figure 5.6: AdVisor 1.0 – Information structure.

Furthermore, ***as recommendation H suggests, the proposed structure was modular so that its modification was easy***. For example, adding a new information space was as easy as creating the tables of the new space in the database and establishing a link between them and the table of the activities. Likewise, this new organization seemed to be easy for any teacher to understand.

Finally, ***unlike AdVisor 0.0, an activity could have more than one resource*** (i.e. PDF, video, audio, etc.). This change enabled the instructors to define activities that were more complex.

5.3.2.3 Interface

The interface was redesigned radically too. The most significant changes are described below. To report these modifications, this section is divided into three subsections:

- Visual elements
- Dashboard
- Workspace

Visual elements

First of all, this version of AdVisor promoted the use of visual elements to inform students about the completion and the assessment of the items at any place of the platform. As did AdVisor 0.0, this new prototype employed a color code (i.e. green, blue and red) to show the activities' status (see section 5.2.2.3). However, the use of the color code was expanded to display CAAs' status. This visual item was closely related to ***recommendation C*** (i.e. self-awareness).

In addition to the colors, three letters were used so as to indicate the assessment type of activities, sessions and CAAs: (1) *T* meant *totally graded*, (2) *P* was *partially graded*, and (3) *N* was *normal* (i.e. no graded). In this regard, an activity could only be either *normal* or *totally graded* (this meant that it belonged to one or several CAAs), whereas a CAA was always *totally graded*. Regarding the sessions, they could belong to any of the three types: (1) *T* indicated that all the activities of the session belonged to some CAA, (2) *P* meant that the session included normal and graded activities, and (3) *N* pointed out that the session only had normal activities. This visual element was linked to ***recommendation B*** (i.e. guidance through the course).

In order to convey the information of these visual elements (i.e. color and letter) at a glance, they were often put together by means of an icon (see Figure 5.7).

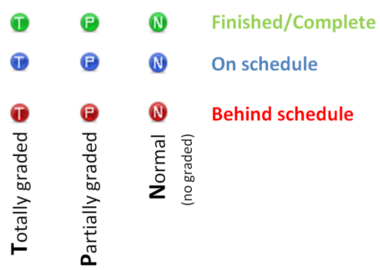


Figure 5.7: AdVisor 1.0 – Icons that show the status (color) and the type of assessment (letter) of an item.

Dashboard

In this version, the concept of learning process was expanded. Thenceforth, there was not only a learning process for each subject like this was in AdVisor 0.0, but there was also a global learning process that encompassed all the courses in which the learner was enrolled. As a result, ***the new dashboard did not only focus on giving a student awareness of each of the courses in which she was enrolled individually, but it also provided an overview of the learner's status in all her courses***. Hence, the principal goal of this new version was that the student simultaneously had both a fine-grained (i.e. each individual course) and a coarse-grained vision (i.e. the overview of all the courses). This tool was clearly related to ***recommendation C***.

Likewise, the dashboard was enriched with new information and, at the same time, was redesigned (see Figure 5.8). This was organized into four areas which summarized different types of information that were important for the students. The four areas of the dashboard were:

- **Agenda** (top left): this showed the sessions that had to be performed in the next 15 days ordered by finish date ascendingly, regardless of the course to which the sessions belonged.
- **Pace** (top right): for each course, this view compared the learner's studying pace (in orange) with the course pace (green line). As seen, this information was already shown in AdVisor 0.0 (see section 5.2.2.3). As for teachers, they saw the class's average studying pace in orange.
- **Assessment** (bottom left): for each course, this area displayed its continuous assessment assignments (CAAs) and the grades that the student had obtained. As regards teachers, they saw the class's average grade for each CAA.
- **Feedback** (bottom right): this stored the messages that the teachers had written to the student or the whole class. The messages were displayed from the newest to the oldest, regardless of the course to which these belonged.

This dashboard was in line with other research works, e.g. (Duval, 2011; Govaerts et al., 2010).

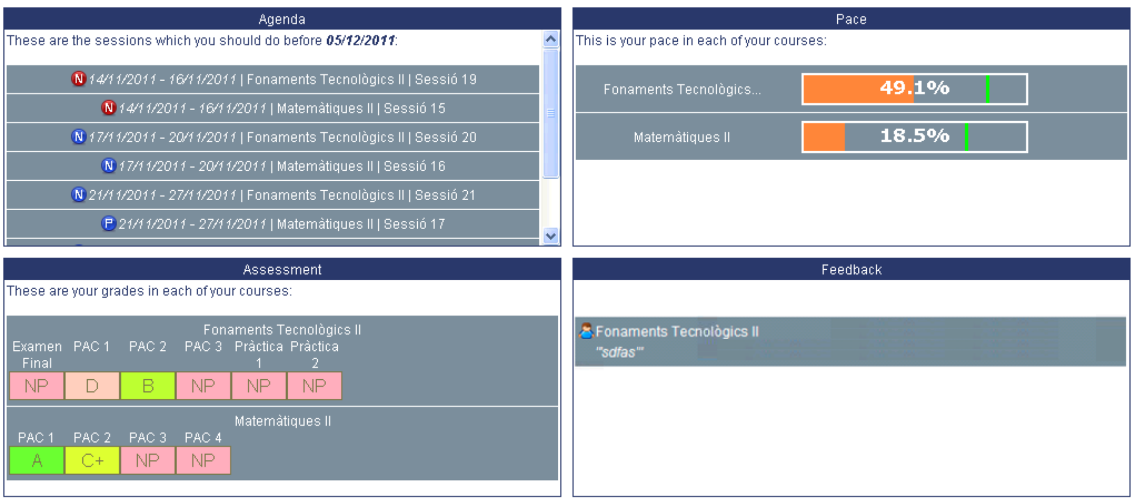


Figure 5.8: AdVisor 1.0 – Dashboard.

Workspace

The workspace was divided into two parts (see Figure 5.9): (1) the navigation area (top), and (2) the description area (bottom). As for the navigation area, depending on the choice of the student in each moment, this area could display one of the following ***four visualizations or views*** (***recommendation G***): (1) a Gantt chart (related to the schedule), (2) a treeview (linked to the TOC), an elastic list (related to the competences and objectives), and (4) a simple list:

- **Gantt chart** (see Figure 5.9a): one significant difference with its predecessor was that AdVisor 1.0's Gantt chart only displayed sessions and activities. Hence, the Gantt chart of this prototype was related to the course's schedule exclusively (not to the table of contents). Despite this change, it worked in a similar way. Like AdVisor 0.0, a session bar could be clicked to see a Gantt chart that displayed the activities which belonged to that session. That Gantt chart allowed a learner to know what activities she had to do, in which status they were, how long they were, what sequence she had to follow and what activities belonged to a CAA.

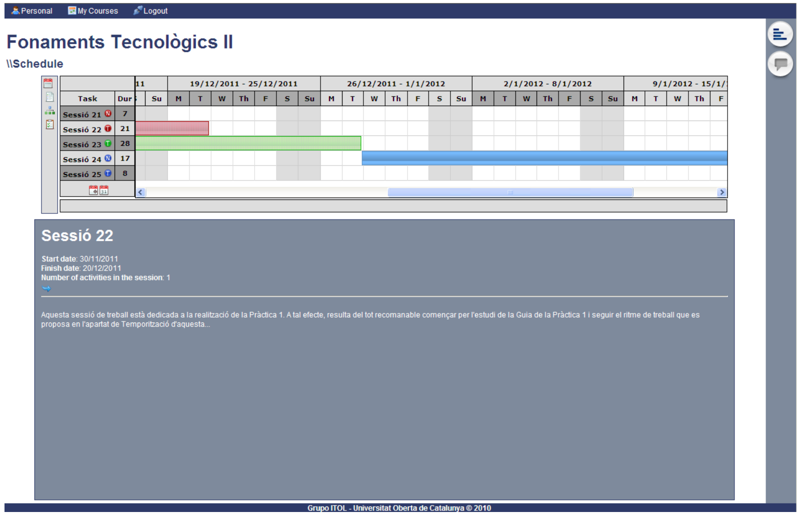
  Unlikely AdVisor 0.0's Gantt chart, the one of Advisor 1.0 worked like a book and always listed the same number of bars (i.e. sessions or activities): five. As a result, if a course had, for example, more than five sessions and a student wanted to see them, then she could use two buttons that allowed to go forward and back or, in other words, turn page. Likewise, although the course's Gantt chart (this showed sessions) always displayed the first page by default, there was a button that enabled to place the Gantt chart in the current date.

  With regard to the visual elements, in addition to the colors (see page 101), each bar had a fill pattern that acted as a letter: (1) a *thin striped* bar meant totally graded (T), (2) *thick striped* bar were partially graded (P), and (3) a *plain* bar was normal/no graded (N).

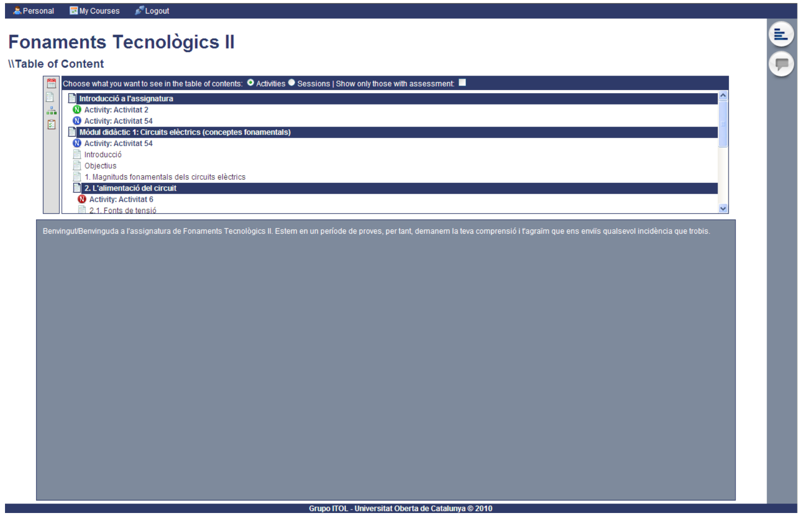
- **Treeview** (see Figure 5.9b): the main innovation of this view was due to the elimination of the predefined structure based on blocks, units and sections. Consequently, this view showed a hierarchy of labels which could have as many sublevels as the teachers needed. Moreover, a student could choose if she wanted to see activities or sessions when a label was expanded. Likewise, there was a checkbox that if it was marked, then the treeview only displayed the activities/sessions that were totally or partially assessed.

- **Elastic list** (see Figure 5.9c): this view, which was inspired by the work of Stefaner and Muller (2007), consisted of three columns that contained degree competences, course objectives and activities, respectively. The height of a competence and an objective indicated the proportion of items associated with it. Hence, the taller the competence/objective was, the more items it had. The height of each competence indicated the number of objectives linked to it, whereas that of an objective represented the number of activities that it included. By contrast, all the activities had the same height.

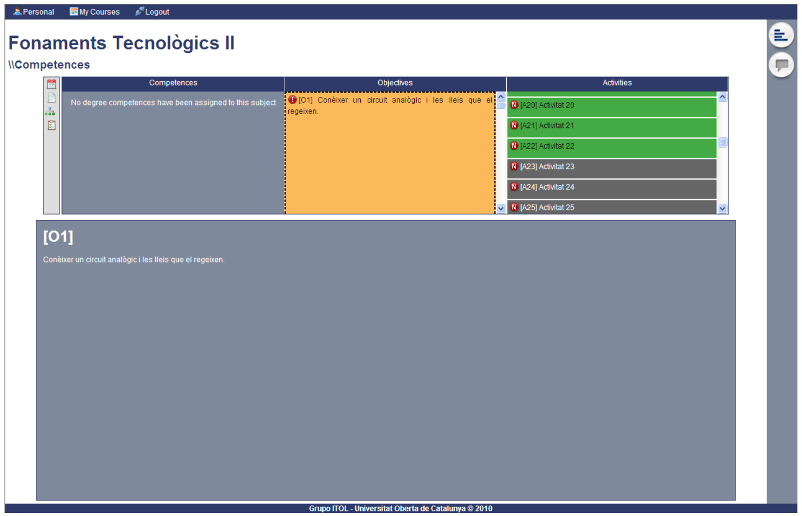
  Likewise, each competence and objective had an icon that informed whether it had been achieved by the student (green tick) or not (red exclamation). A competence/objective was attained when all the items linked to it had been finished. As for the activities, these had an icon with the status color and the assessment letter (see Figure 5.7).



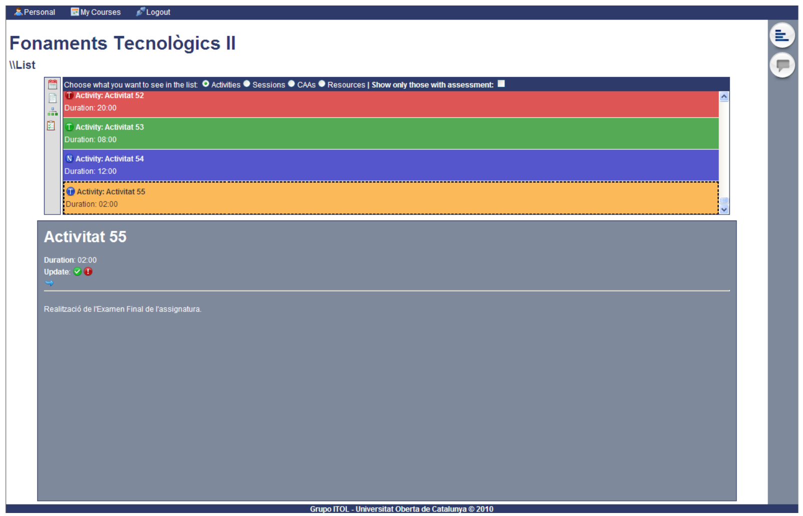
(a) Course's Gantt chart which shows sessions. The second session is behind schedule (red), the third one is complete (green) and the fourth one is on schedule (blue).



(b) Treeview in which activities are the leaves.



(c) Elastic list. The list of competences is empty and the objective O1 was chosen (yellow). Three activities (in green) are related to objective O1.



(d) Simple list. Activity 55 was clicked (yellow) and the other three activities are behind schedule (red), complete (green) and on schedule (blue), respectively.

Figure 5.9: AdVisor 1.0 – The four views of the workspace's navigation area.

With regard to the interaction of this view, a student could click on any item to see what elements from the other two columns were related to it. For instance, if an activity was clicked, then the competences and objectives linked to it were highlighted. Thanks to this, students were able to see the relationships between competences, objectives and activities at a glance.

- **Simple list** (see Figure 5.9d): depending on the student's preference, this view showed a list of activities, resources, sessions or CAAs. The activities and resources were ordered by name, whereas the sessions and CAAs by start date. The background color of each item indicated its status, except for the resources, which did not have status.

As seen, the four views displayed learning activities. Moreover, the session played a significant role in this version of the platform, since three views (i.e. the Gantt, the treeview and the simple list) showed it. Consequently, the session was considered almost as important as the activity.

Regarding the description area, this showed information about the item that had been clicked by the user. Hence, if the clicked item was:

- **Session**: as shown in Figure 5.9a, the description area displayed the session's name, the start and finish dates, the number of activities included in the session, a description as well as a button with the shape of a blue arrow that showed the session's Gantt in the navigation area.
- **Competence or objective**: if a competence or an objective was clicked in the elastic list, its full statement was shown in the description area (see Figure 5.9c).
- **Activity**: if an activity was clicked in any view, then its name, its duration and a part of its description were displayed (see Figure 5.9d). In addition to the previous information, the description area also showed two buttons, a green tick and a red exclamation, which allowed the students to indicate if they had completed the activity or not, respectively. The presence of these two buttons avoided opening an activity's resource so as to update the activity's status. Hence, a lot of time was saved and the usability of the system was improved.

  The description area also showed a blue arrow that took students to the activity's page (see Figure 5.10). This page had three parts: (1) basic information (e.g. duration, status and buttons to update), (2) description, and (3) a list of the resources that were used in the activity. Each resource could be clicked to be opened in a new tab or window depending on the web browser. Finally, a blue button on the top left corner returned to the workspace.
- **CAA**: if a CAA was selected in the simple list, then the following data were shown in the description area: name, start date, deadline, solution date, grades date and the total number of activities that belonged to the CAA. Likewise, a blue arrow took learners to the CAA's page. The appearance of this page was similar to the activity's one and it also had three parts: (1) basic information, (2) description and (3) a list of the activities that were related to the CAA. The information area showed the name and the four dates that a CAA had. Unlike the activity's page, this did not have the buttons that updated the status, since the CAA's status depended on the status of the activities that were related to it. Furthermore, this area showed the grade that the student had obtained and a link to the CAA's solution.

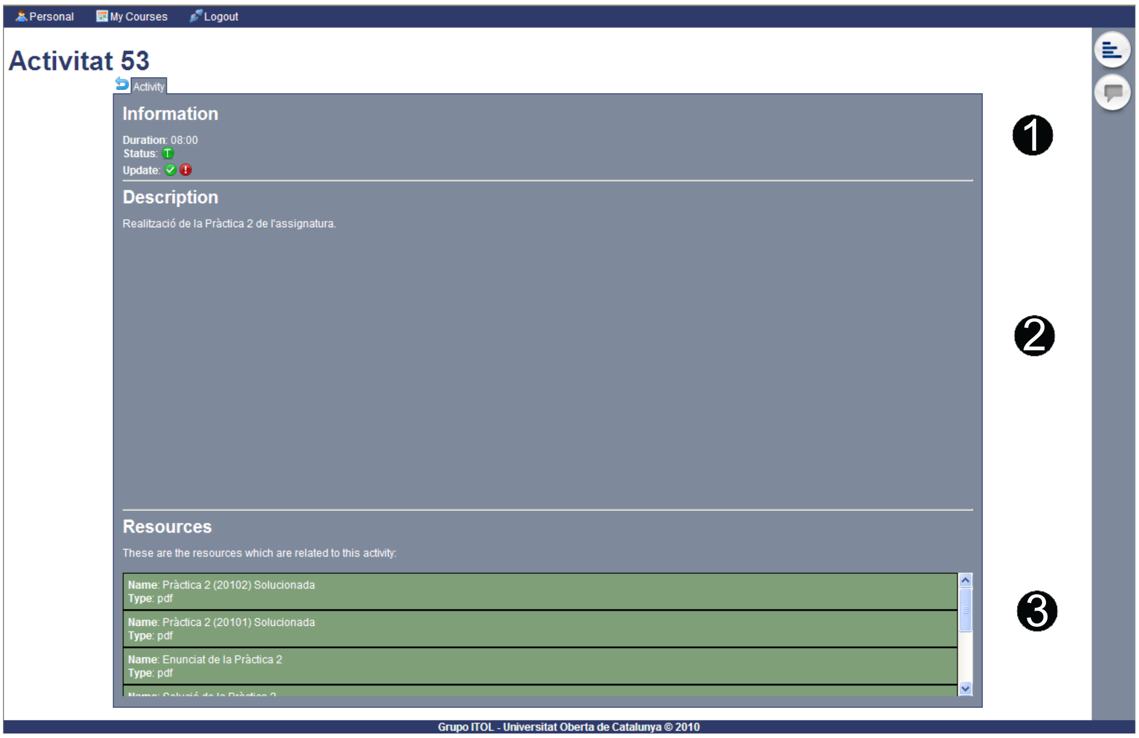


Figure 5.10: AdVisor 1.0 – Activity's page with the three parts: (1) basic information, (2) description, and (3) list of resources.

5.3.3 Test

From March to June 2011, AdVisor 1.0 was tested by the Catalan and Spanish learners from two courses that covered different topics: Electric Circuit Analysis (.002) and Mathematics II (.008). Unlike AdVisor 0.0, ***the use of this new prototype was mandatory for all the students*** who participated in the test throughout the semester. Thereby, the answers of the respondents could be considered more reliable that the ones of Advisor 0.0 (whose use was optional).

Likewise, it is important to stress that, like AdVisor 0.0, this prototype did not have discussion forums either. Due to the importance that communication has in an online course, the forums and bulletin boards of the UOC classroom were utilized. Therefore, AdVisor 1.0 provided the students with the content of the course, whereas the UOC classroom gave the communication tools.

5.3.4 Evaluation

At the end of the semester, more specifically, on June 21, 2011 (i.e. at the end of the semester), a web-based self-administered questionnaire was sent to all the students (115) who were enrolled in some of the two courses[4]. The questionnaire comprised 21 questions, most of which were based on a 5-point Likert scale. Nevertheless, there were also open questions that asked the respondents to write their opinions and suggestions freely. The questionnaire was available from June 21 to July 31, 2011 and it can be found in Appendix E.1.

[4] The learners who were in both courses received the e-mail once and were labeled as students of Mathematics II.

5.3.5 Results

This section presents the main conclusions drawn from the questionnaire filled out by the students after testing AdVisor 1.0. Furthermore, the comments of the teachers who participated in the test are shown too. Appendix E.2 expands on the analysis of the questionnaire presented below.

5.3.5.1 Reliability of the results

Before showing the results from the questionnaire, it is important to determine the reliability, and consequently the significance, of the responses. First, unlike the test of AdVisor 0.0, it could be ensured that all the respondents had used the platform during the semester. Moreover, the response rate increased by 15.7% compared to that of AdVisor 0.0. Finally, given that the average response rate for online surveys is about 33% (Nulty, 2008), ***36.5% was a good figure*** (42 students).

Likewise, ***the sample of online students met two features of the archetype of online learner*** (more details in Appendix E.2.2): (1) older than 25 (around 93%), and (2) online learning experience (92.9% enrolled in the UOC at least 3 semesters). This led us to think that the sample was a representative picture of all online students. However, like in AdVisor 0.0, the sample was biased since all the participants were enrolled in Engineering courses and 95.2% of them were men.

According to the aforementioned aspects, the results were much more reliable than those of the previous prototype. Nevertheless, ***a possible extraneous variable was detected*** too: a few of the respondents who belonged to Electric Circuit Analysis (.002) were annoyed for having to use two environments simultaneously, i.e. AdVisor and UOC classroom's forums. The reason for this may have been that the forums played a significant role in that subject (see section 5.1) and, as a result, learners had had to access to these communication tools a lot. Due to this nuisance, some of the respondents from Electric Circuit Analysis filled out the questionnaire in less than 4 minutes and indiscriminately evaluated some aspects with low scores (i.e. 1 or 2). However, these students were not removed from the analysis because it was essential to collect all the opinions. Consequently, the results from Electric Circuit Analysis (.002) were, in general, slightly worse than those from Mathematics II (.008).

Although the responses were much more reliable than those of AdVisor 0.0 due to the mandatory use, it was needed to be careful with the conclusions which were drawn. Even so, ***the results gave an insight into the suitability of the proposed recommendations*** as well as an interesting range of responses that could be used to extract trends, possible improvements, etc.

5.3.5.2 To guide students through the course (recommendation B)

The questionnaire asked the respondents to rate three items related to the guidance through the course: (1) sessions, (2) detailed activities, and (3) assessment type of the tasks by means of a visual element (i.e. a letter or fill pattern). Next, the main results of each item are briefly described.

According to the MW tests, there was disagreement between the groups of Electric Circuit Analysis and Mathematics II about the organization based on sessions ($U = 119.5$, $Z = -2.545$, $p = .011$) and the provision of detailed activities ($U = 133$, $Z = -2.189$, $p = .029$). Despite the lack of consensus, when the two groups were studied together, ***around 62% of the respondents rated these two features 4*** (*useful*, sessions: 33.3%, activities: 35.7%) ***or 5*** (*very useful*, sessions: 28.6%, activities: 26.2%). At this point, it is worth stressing that all the students who rated both items 1 (*not at all useful*, 11.9% and 14.3%) were enrolled in Electric Circuit Analysis. Some possible reasons for this are given in Appendix E.2.4.

As for the assessment letter (or fill pattern in the Gantt chart), ***about 44% found this visual element useful*** (4, 24.4%) ***or very useful*** (5, 19.5%). However, the option *neither useful nor useless* (3, 29.3%) was the mode and the median. Given that assessment is important to students (see section 5.2.5), the previous result may mean that the assessment letter was not at all correct.

In any case, it could be concluded that ***recommendation B seemed to continue being suitable***.

5.3.5.3 To provide self-awareness (recommendation C)

In AdVisor 1.0, the number of items related to self-awareness that were evaluated increased to 5: (1) status color, (2) the dashboard as a whole, (3) dashboard's agenda area, (4) dashboard's pace area, and (5) dashboard's assessment area. Next, an overview of the main conclusions drawn from the responses is presented. A more exhaustive analysis can be found in Appendix E.2.5.

Regarding the dashboard, only 17.1% chose the options *poor* (2, 9.8%) or *very poor* (1, 7.3%), being the latter an exceptional value. Likewise, 56.1% of the responses were equal or greater than 4 (*good*, 31.7%). As seen, the evaluation of the dashboard in AdVisor 1.0 was good and accorded with that of AdVisor 0.0 (59.1% responses ≥ 4). ***This similarity between the results of AdVisor 0.0 and 1.0 meant a reinforcement of the usefulness of the dashboard***. Consequently, this element became a key element of the platform.

Likewise, the evaluation of the dashboard's information areas (except for the feedback area due to technical problems) enabled to confirm some preferences of online students. For example, the good evaluation of the pace area (87.5% responses ≥ 3), taken in conjunction with the high score of the status color (41.5% responses = 5; 14.6% responses ≤ 2), allowed to affirm that ***the items which helped to be aware of the studying pace had been considered to be useful*** and, hence, these would have to be promoted in future. Similarly, the fact that the assessment area had the same result (87.5% responses ≥ 3) proved that the students demanded to be aware of the evaluation, e.g. to clearly know how many CAAs a course has as well as the grades that they have obtained.

In short, due to the good results of the status color and the dashboard (as a whole and each information area individually), it could be concluded that ***it would be important that recommendation C***, i.e. providing online learners with information that helps them to be aware of their learning process, ***was implemented by VLEs***.

5.3.5.4 To provide tools that help students to be self-regulated (recommendations B and C)

As said in section 5.2.5.4, ***recommendations B and C*** aim to provide tools that help students to be self-regulated. In this regard, the Cronbach's alpha coefficient ($\alpha = .95$) indicated that the items of these two recommendations and the aspects *"how useful was the option of marking an activity as complete?"* and *"to what extent did AdVisor help you to self-regulate your learning process?"*

were intertwined and, hence, measured the same construct: the usefulness of the elements that support self-regulated learning. The results of the two new aspects are briefly explained below. A more detailed analysis can be found in Appendix E.2.6.

As for the feature of marking the completion of an activity, the MW test revealed that the difference between Electric Circuit Analysis and Mathematics II was statistically significant ($U = 113$, $Z = -2.732$, $p = .006$). Once again, the students from Electric Circuit Analysis rated worse. A possible explanation for this disagreement is given in Appendix E.2.6. At this point, it is worth saying that, when the two courses were analyzed together, the result was that ***around 62% had found marking the completion of an activity useful*** (4, 23.8%, median) ***or very useful*** (5, 38.1%, mode).

In regard to the second question, ***66.6% thought AdVisor 1.0 had helped them to be self-regulated in a normal*** (3, 26.2%, mode and median) ***or significant way*** (score = 4 and 5, 40.4%). However, in comparison with the previous prototype, a few more negative responses were obtained. In spite of this worsening, the global result was good.

At this point, it is important to stress that the result of the two new questions may have been biased by the extraneous variable explained in section 5.3.5.1, because all the respondents who rated both items *1*, except for one, were enrolled in Electric Circuit Analysis.

Despite the possible extraneous variables, most of those items of AdVisor 1.0 that were aligned with self-regulated learning achieved good results (also see sections 5.3.5.2 and 5.3.5.3). Thus, ***there was evidence to state that AdVisor 1.0 had helped students to be self-regulated somehow***.

5.3.5.5 To help teachers to design their courses (recommendation F)

The teachers who participated in the test were provided with the information about the study habits that had been collected from the questionnaire of AdVisor 0.0. The objective was to help the instructors to design their courses. However, as it is explained in Appendix E.2.4, the teachers (especially the one of Electric Circuit Analysis) did not design the schedule appropriately, e.g. too many sessions, imbalance between the real workload and the estimated one, etc.

The available evidence clearly led to the conclusion that the courses still needed to be improved, being the sessions the principal problem. ***As a result of the design problems, recommendation F gained importance***.

5.3.5.6 To provide multiple views of the course (recommendations G)

This section deals with the evaluation of ***recommendation G*** by analyzing:

- Usefulness of the relationships between the activities and the rest of the course elements
- Use of each view

Next, the results of each aspect are shown. More details are given in Appendix E.2.7.

Usefulness of the relationships between the activities and the rest of the course elements

As the information structure of AdVisor 1.0 revolved around the learning activity, the questionnaire asked the students how useful was to know the relationship that existed between the learning activities and each of the course elements provided by AdVisor 1.0 during their learning process. From the responses, the following ranking was created:

1. **CAAs**: the relationship between the activities and the CAAs was clearly the first one because 64.3% of the respondents rated it *very useful* (score = 5), being the mode and the median.
2. **Schedule/session**: this had a median and a mode of 4 (*useful*, 57.1%). Although this and the next two relationships shared the same median and mode, the distribution of the responses of the schedule/session was slightly better than the TOC's and course objectives' one. In fact, its percentage of responses equal or greater than 4 was 88.1%, whereas thoses of the TOC and the objectives were 80.9% and 76.2%, respectively.
3. **Table of contents (TOC)**: based on the previous explanation, this relationship was third.
4. **Course objectives**: this ranked fourth since it was evaluated a little bit worse than the TOC.
5. **Degree competences**: although its mode and the median were the same as those of the previous three relationships (i.e. 4, *useful*, 41.5%), its distribution was the most right-skewed.

Use of each view

As said in section 5.3.2.3, the workspace of AdVisor 1.0 consisted of four views that were related to the information spaces of the structure. Knowing the amount of time that each view had been used by the students could be helpful to discover, together with the responses of the previous question, which parts of the course (i.e. information spaces) had been more important/useful. Thus, the following question was asked: *"how long did you use each view provided by AdVisor 1.0?"*. A ranking, from the most to the least useful view, was compiled from the responses obtained:

1. **Gantt chart** (schedule): its mode and median were 4 (*quite a lot*, 33.3%), becoming the most used view. This result, along with that of the dashboard's pace area, suggested that the respondents had found useful to have information on the course pace and their own studying pace. Likewise, this view may have been useful to the learners who studied in a constant way.
2. **Simple list** (assessment + activities + resources): the second position of this view (mode = 4; median = 3.5) revealed that many students may have preferred knowing what activities they had to do during the semester without considering the proposed dates. Another reason may have been the fact that this view listed the CAAs (i.e. the mandatory activities) at a glance. Hence, this view matched the necessities of an significant proportion of students who organized their learning process according to the CAAs' deadlines (see section 5.2.5.5).
3. **Treeview** (table of contents): the fact that this view was not directly related to either assessment or schedule, the two most important aspects to the students according to the previous question, may have been the reason for its third place (mode = 3 and 4; median = 3). Despite

being less important than the previous two views, the treeview might have been useful when the learners wanted to review a specific concept.

4. **Elastic list** (competences and objectives): its fourth position (mode = 2, 3 and 4; median = 3) was to be expected, because the current students may not yet be used to seeing a course from a perspective based on degree competences and course objectives.

Conclusions

As seen, ***the assessment and the schedule were the most useful pieces of information to the students***. First of all, the relationship between the learning activities and the CAAs was ranked first, whereas the one between the activities and the sessions was second. Likewise, the Gantt chart was the most used view, which meant that knowing the course schedule was very important to online students during the semester. As for the simple list, which showed the CAAs, this was the second most used view. Hence, ***the most useful items were those that were closer to the coursework***, i.e. what activities are part of the assessment and when they have to be performed.

Broadly speaking, ***the new information structure seemed to encompass the most important aspects of a course***, except for the discussion forums. In this regard, a comment suggested that each activity had its own forum. Moreover, in order to avoid the problems arisen in Electric Circuit Analysis, the inclusion of forums would have to be a priority in the next prototype.

In conclusion, ***it seemed that the provision of multiple views (i.e. recommendation G) was accepted by all the respondents***. Actually, two people even proposed another view: one that displayed the relationship between one course and the rest of the subjects of the degree. In that view, the courses could be linked through the prerequisites, shared topics, etc.

5.3.5.7 To define competences and objectives clearly (recommendation A)

As seen in the previous section 5.3.5.6, the relationships between the activities and the course objectives and the degree competences were ranked in the penultimate and last position, respectively. Furthermore, the respondents expressed that the elastic list (i.e. the visual representation that showed them) had been the least used view. As a result, the fact that the teachers had defined the degree competences and the course objectives clearly ***(i.e. recommendation A) was not found useful by the respondents***. This trend would have to be confirmed in the next prototype.

As observed, there was still a long way in order that students got used to paying attention to degree competences and course objectives. For that reason, it would be important to promote the use of these items in future, because they are essential when any course is designed and, at the same time, they may be very useful to help students to be self-regulated (they indicate what is expected from learners). To this end, it would be essential the support of teachers.

5.3.5.8 To provide a comprehensible and flexible schema (recommendation H)

AdVisor 1.0 had a new information structure which provided students with more views. Thus, the platform could better adapt to their preferences and necessities. Moreover, this schema was devised to create independence between the information spaces so that the design of a course was a more flexible task than it had been in AdVisor 0.0, e.g. (1) it did not force teachers to use a view that they did not want, and (2) it allowed to add/remove spaces easily without affect the rest.

Likewise, the teachers who participated in the test expressed that the schema included parts of a course with which instructors were familiar. As a result, the schema was easy to understand.

In conclusion, ***AdVisor 1.0 seemed to meet recommendation H***.

5.3.5.9 Usability (recommendations I-M)

As said in section 5.3.2.3, each information space was displayed by using a specific visual representation (i.e. a view). In this regard, the schedule used a Gantt chart, the competences and objectives were represented by an elastic list, a treeview displayed the table of contents, and the CAAs were shown by a simple list. Each representation was evaluated by the respondents in terms of:

- Usability
- Suitability

The first aspect asked: *"to what extent was each view easy to use?"*. The second issue in turn focused on knowing to what extent each representation was suitable for the data that it showed. To understand the difference between both concepts, let us imagine a view that uses a calendar to show the schedule. This could be easy to use, but other representation could be more suitable, e.g. a Gantt chart. From the responses, the next ranking was derived (more details in Appendix E.2.8):

1. **Simple list**: 50% found this representation *usable* (4, 40%, mode) or *very usable* (5, 10%). As for its suitability, 45.2% thought that the simple list was *suitable* (4, 26.2%) or *very suitable* (5, 19%), being the option *normal* (3, 35.7%) both the mode and the median.

2. **Treeview**: 45% found it *usable* (4, 27.5%) or *very usable* (5, 17.5%). However, the two groups disagreed about its suitability (MW test: $U = 125$, $Z = -2.242$, $p = 0.025$). Once again, the students from Electric Circuit Analysis rated worse. Even so, 39% of all the respondents had found the treeview *suitable* (4, 22%) or *very suitable* (5, 17.1%).

3. **Gantt chart**: the evaluation of this visual representation in terms of usability and suitability was quite similar to that of the elastic list. However, the score of the Gantt chart was slightly better, especially regarding suitability (see more details in Appendix E.2.8).

4. **Elastic list**: in regard to usability, this view obtained a mode and a median of 3 (*neither usable nor unusable*, 33.3%). As for suitability, its mode and median were also 3 (*normal*, 42.5%).

As seen, ***the simple list and the treeview were the best rated representations in terms of usability and suitability***. One reason for this may have been that both visualizations already existed in any operative system (OS) and, therefore, the learners were used to utilizing them. By contrast, the Gantt chart and the elastic list required the students to learn how they worked.

Considering AdVisor 1.0 was a prototype whose design mainly focused on aspects related to pedagogy and information structure, ***the evaluation of the usability (and suitability) could be considered good***. Nevertheless, several problems were detected: (1) interaction was not intuitive enough, (2) some students remarked that some information was not visible at a glance, (3) too many clicks were needed to reach the resources that were linked to activities, and so on. As a result, ***the page layout should be rethought to be more effective***.

Moreover, some views lacked functionalities. This hindered the learners from having a satisfactory experience. For example, the Gantt chart had two drawbacks: (1) it did not allow to mark a whole session as complete, each activity had to be marked individually instead, and (2) it always showed the first sessions of the course by default, instead of the current ones based on the date.

Due to all the aforesaid problems, ***AdVisor's interface would need to be redesigned so as to be more user-friendly and aesthetically pleasing***.

5.3.5.10 Overall experience

The questionnaire revealed that 73.8% of the respondents had had at least an acceptable experience with AdVisor 1.0 (responses ≥ 3), being the value 4 (*good*, 33.3%) the mode and the median. Hence, ***the respondents' experience was, in general, satisfactory***. However, the individual analysis of each course brought to light some latent issues. For example, 33.33% of the respondents from Electric Circuit Analysis expressed that they had had a very bad experience (score = 1).

Moreover, ***69% of the respondents expressed that they would use the platform again***. However, there was discrepancies between the two groups (MW test: $U = 137$, $Z = -2.144$, $p = .032$). In fact, ***there was much more rejection in Electric Circuit Analysis*** (44.4% responses = *no*) ***than in Mathematics II*** (12.5% = *no*). The main reasons for this difference may have been the same as the ones that have already been explained previously (see section 5.3.5.1 and page 229).

An extended analysis of this section is given in Appendix E.2.9.

5.3.6 Conclusions

Like the previous prototype, ***AdVisor 1.0 was favorably received***. As said in section 5.3.5.1, despite the possible bias caused by the lack of discussion forums within the framework of the platform, ***the results really gave a first insight into the suitability of the recommendations proposed in this thesis***. In this regard, the findings of this test would have to be confirmed in the next prototype.

Lastly, the main aspects that would have to be improved by AdVisor 2.0 are enumerated below:

Main improvements to make in AdVisor 2.0

- The balance between the sessions' real workload and estimated one.
- To add discussion forums to the information space as a new view.
- To improve the usability of the platform, especially the views of the workspace.

5.4 AdVisor 2.0

5.4.1 Introduction

Thanks to the lessons learned from AdVisor 1.0, a new version of the platform was developed from June to September 2011. This third prototype, in addition to focusing on the recommendations evaluated in AdVisor 1.0, put ***recommendation D*** in practice due to the inclusion of forums.

Likewise, from January to May 2012, a new tool called FACRO (FAceted Class ROster) was developed in order to meet ***recommendation E***. This new tool was embedded in AdVisor 2.0.

Recommendations on which AdVisor 2.0 mainly focused

A. To define competences and objectives clearly (see section 4.3.4.1)

B. To guide students through the course (see section 4.3.4.1)

C. To provide self-awareness (see section 4.3.4.1)

D. To promote social interaction (see section 4.3.4.1)

E. To provide teachers with a student monitoring tool (see section 4.3.4.1)

G. To provide multiple views of the course (see section 4.3.4.2)

Likewise, AdVisor 2.0 tried to:

H. Provide a comprehensible and flexible schema (see section 4.3.4.2)

Moreover, the data on study habits collected from AdVisor 0.0's questionnaire was provided to:

F. Help the teachers who participated in the test to design their courses (see section 4.3.4.1)

Finally, although the evaluation of the usability (i.e. ***recommendations I-M***) was not one of the main goals of this thesis, a more exhaustive analysis than that of AdVisor 1.0 was carried out.

5.4.2 Design

This new prototype was developed in only three and a half months. In that period, two goals were mainly set: (1) to add discussion forums, and (2) to improve the usability of the interface.

Likewise, as said previously, a new tool called FACRO was created to meet ***recommendation E***. Later, this was embedded in the framework of AdVisor 2.0.

Next, the most important improvements of AdVisor in terms of pedagogical approach, information structure and interface are described below. Moreover, the main features of FACRO are explained too.

5.4.2.1 Pedagogical approach

There were not changes in the underlying pedagogical approach of the platform. This remained as that of AdVisor 1.0 (see section 5.3.2.1). Hence, this was based on the pedagogical approach described in section 4.3.3 and took the UOC's educational model into account (see Appendix A.3).

5.4.2.2 Information structure

The information structure of AdVisor 1.0, which consisted of 4 information spaces and one shared element (i.e the activity), was expanded. In this new prototype, in order to implement ***recommendation D*** and avoid using two platforms, a space related to the discussion forums was added. Like the rest of the spaces, this was also linked to the learning activities. Thereby, each activity had its own discussion forum. This meant that all the messages were categorized based on the activity to which they belonged. Hence, the implicit structure of the platform promoted that messages were better organized by following a logical classification. This design was totally in accord with one comment written by a respondent of AdVisor 1.0 (see section 5.3.5.6).

As a result of the new space, ***the information structure of AdVisor 2.0 had 5 spaces which revolved around the learning activity*** (see Figure 5.11).

5.4.2.3 Interface

As discussed in section 5.3.5.9, the usability of the interface was one of the aspects which needed more improvements. Hence, the interface of AdVisor 1.0 was redesigned to enhance the user experience. For this purpose, the comments of the questionnaire of AdVisor 1.0 were taken into account. The most important changes, categorized into three classes, are described below:

- Style
- Dashboard
- Workspace

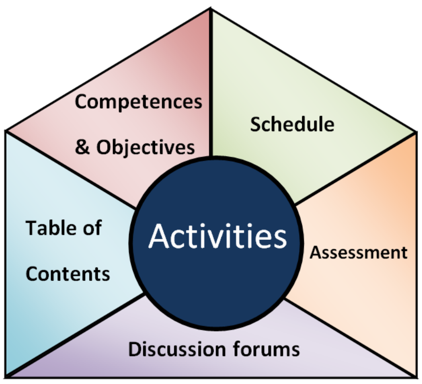


Figure 5.11: AdVisor 2.0 – Information structure.

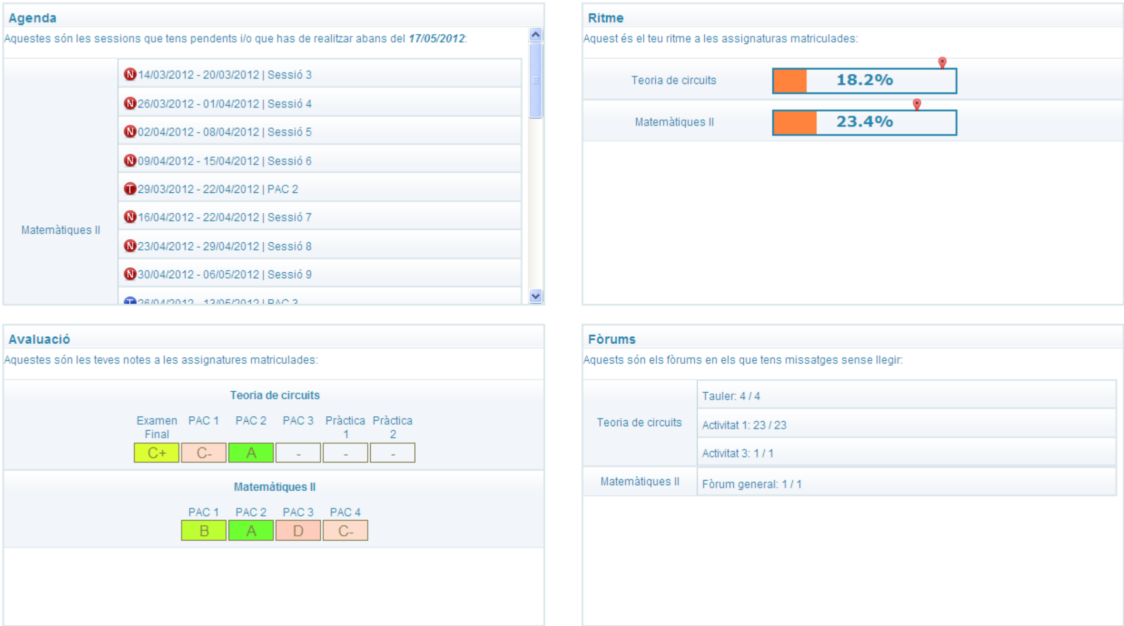


Figure 5.12: AdVisor 2.0 – Dashboard.

Style

The visual style of the platform was changed completely. This new version tried to be ***closer to the UOC campus's style*** by using similar colors, font family, etc. Thereby, users (both students and teachers) could feel more comfortable with AdVisor 2.0.

Dashboard

As said in section 5.3.5.3, the dashboard's feedback area did not work in AdVisor 1.0 because of technical problems. Likewise, because the new information space of AdVisor 2.0 had a forum for each activity, it was needed to provide users (both learners and teachers) with a summary which showed, at a glance, what forums had unread messages. As a result, ***the fourth area of the dashboard was devoted to displaying the unread messages of the discussion forums***, instead of providing feedback messages (see Figure 5.12).

The other three areas remained identical, except for some visual changes. In this regard, the agenda was the one which underwent a major change. In this version, the sessions were ordered by date like in AdVisor 1.0, but, at the same time, they were grouped by course.

Workspace

The workspace continued being divided into two parts (see Figure 5.13): (1) the navigation area (top), and (2) the activity area (bottom). With regard to the navigation area, this had six tabs at the bottom. They each took the user to a different view (see Figure 5.14). This prototype kept the views of AdVisor 1.0, but it included some changes. Firstly, the Gantt chart enabled to mark a session as finished, which marked all the activities that belonged to it as complete (see Figure 5.14a). This made the interface more usable.

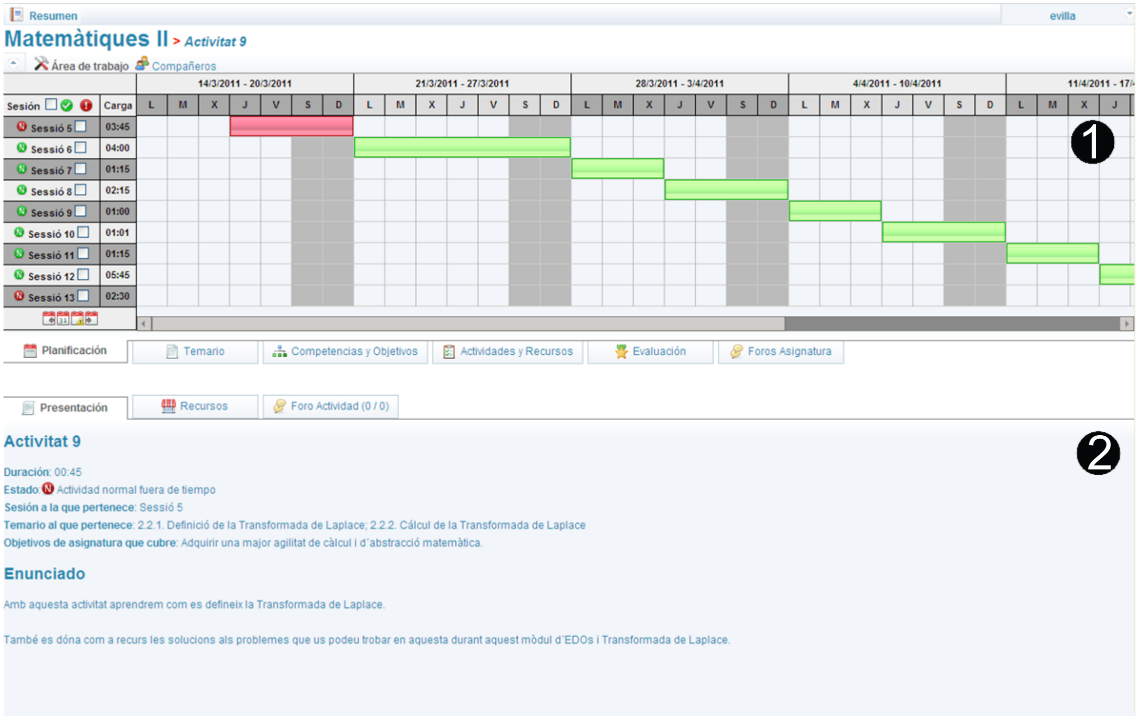


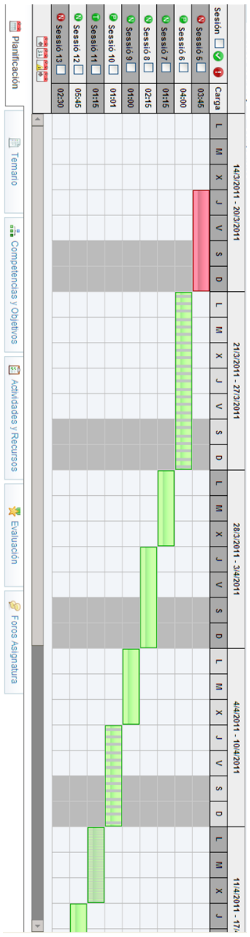
Figure 5.13: AdVisor 2.0 – Workspace: (1) the navigation area (at the top) displays the course's schedule through the Gantt chart, and (2), at the bottom of the workspace, the activity's page is shown.

Another change was the fact that ***the simple list was divided into two new views***:

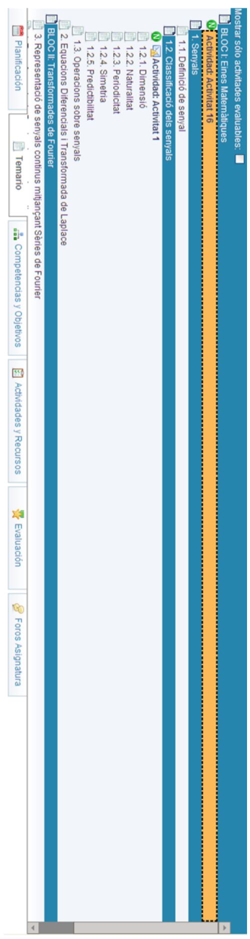
- **Activities and resources**: this only showed activities and resources, depending on the user's preference. Hence, this was a limited version of the former simple list (see Figure 5.14d).
- **Assessment**: due to the large importance that the respondents attached to assessment, it was created a view specially designed to show CAAs (see Figure 5.14e). Unlike the activities and resources, this view had an ad hoc design.

Besides the modification in the simple list, ***a new view was devised to display the learning activities' discussion forums*** (see Figure 5.14f). This view consisted of two parts. On the left hand, there was a list with all the forums (one per activity), whereas the main area showed the messages. For each message, the following information was provided: writer, title, preview of the text of the message, number of attachments, number of replies, number of like-it's, and if the message had been marked as relevant by the teacher. Furthermore, depending on the user's role, different actions could be performed. If the user was a student, then she could indicate if she liked the message by using the thumb-up/like-it button. Otherwise, if the user was a teacher, she could grade the messages from 1 to 5 as well as labeling them as relevant (by using the star button).

As a result of the aforesaid changes, the available views in AdVisor 2.0 were (see Figure 5.14): (1) schedule (i.e. Gantt chart), (2) table of contents (i.e. treeview), (3) competences and objectives (i.e. elastic list), (4) activities and resources (i.e. part of the former simple list), (5) assessment (i.e. part of the former list, but displayed in a new way), and (6) discussion forums (i.e. new view). Moreover, with regard to the layout, ***the size of the navigation area was increased*** until taking up the width of the page. Likewise, ***the icons that allowed to change of view was replaced with tabs***.

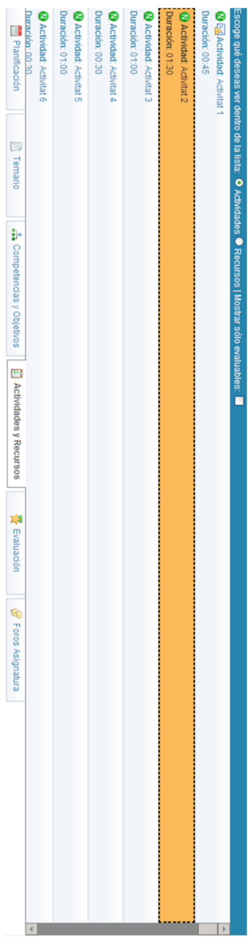


(a) Course's Gantt chart in which the sessions of the course are displayed.

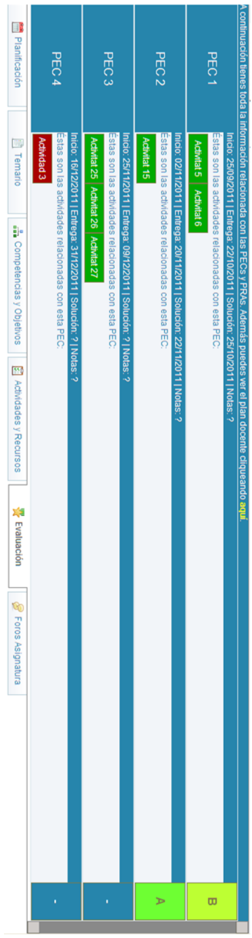


(b) Treeview with the activity 16 chosen.

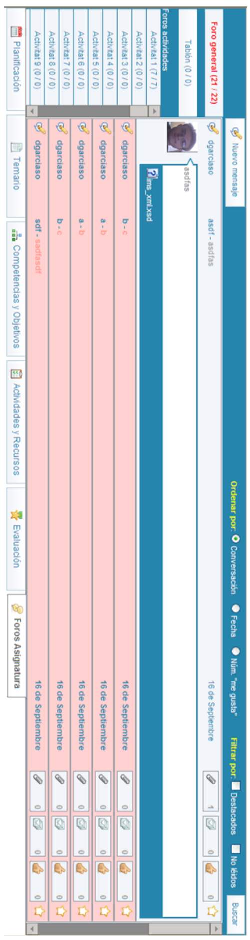
(c) Elastic list. The list of competences is empty and the activity 2 is chosen (in yellow). One objective (in blue) is related to it.



(d) Simple list. The activity 2 was clicked (yellow).



(e) Assessment view which shows four CAAs. A grade was assigned to two of them.



(f) Forums view with an open message.

Figure 5.14: AdVisor 2.0 – The six views of the workspace's navigation area.

As for the bottom area, this displayed a redesigned activity's page instead of showing any item's description. Thanks to this new use of the bottom area, the activity's information could be shown without removing the top space (i.e. the navigation area). However, if the student wanted to focus on the activity's page, an arrow button enabled to hide the navigation area and expand the bottom space until taking up all the page. The expanded page looked like the activity's page of AdVisor 1.0. Due to its new position in the workspace, ***the activity's page was redesigned***. This was made up of three tabs/sections (see Figure 5.13):

- **Information (first tab)**: this showed the following information: title, duration, status (i.e. finished, delayed, pending), the session to which it belonged, part of the table of contents that it covered, the course objectives that were achieved by doing the activity, and the description of the activity. Moreover, by clicking on the status, this changed from pending/delayed to complete and vice versa. The content of this tab is shown in Figure 5.13.
- **Resources (second tab)**: this section showed the list of resources that belonged to the current activity. The resources could be any kind of multimedia resource, e.g. PDF, video, hyperlink, etc. If the mouse hovered over a resource, then a tooltip showed the activities that used it.
- **The activity's forum (third tab)**: this tab showed the activity's forum. From here, students and teachers could write and read any message that was related to the chosen activity. Its look and feel was the same as that of the navigation area, but without the left menu.

To show the description of an element of the navigation area that was not an activity (i.e. session, competence, objective, CAA or resource), a tooltip was shown when the mouse was over it.

5.4.2.4 FAceted Class ROster (FACRO)

FACRO was ***a graphical interactive educational monitoring tool which used information visualization (InfoVis) techniques***. This enabled instructors to monitor the class and, at the same time, look at the details of a particular student. This tool was made up of two parts:

- Faceted browsing
- Data portrait

Both parts are explained below. This section only focuses on the features of the tool, the literature review on educational monitoring tools is given in Appendix G.

Faceted browsing

Faceted browsing is becoming a popular method to allow users to interactively search and navigate through complex information spaces (Koren et al., 2008). This is widely used on many e-commerce websites such as eBay® and Wal-Mart®. ***A faceted browser provides users with facet-value pairs that are used for query refinement***. Faceted browsing is made up of three stages (Yee et al., 2003):

Figure 5.15: FACRO – The opening stage of the faceted browser proposal. Students remain anonymous.

- **Opening**: in this stage, the interface shows the whole collection and all the facets that can be used to do the search.
- **Middle game**: this allows users to iteratively narrow down the result set by defining constraints on the values of one or several facets. This process refines the search query.
- **End game**: this occurs when the user finishes the search by selecting an individual item from the result set and its information is detailed.

At this point, the question that arises is: *why can faceted browsing be suitable for educational monitoring in an online environment?*. Unlike the other proposals, which show graphics with predefined attributes or queries (see Appendix G), ***faceted browsing allows teachers to perform an exploratory search strategy by using a wide range of orthogonal variables (i.e. facets)***. Thanks to this, instructors can gain an insight into the behavior of their students by iteratively submitting tentative queries based on more than one facet at the same time. This iterative process (i.e. the middle game) finishes when teachers find relevant information that they did not know or when the result set meets a specific set of requirements that instructors wanted. At that moment, teachers can either use the information found to make decisions (e.g. to send an e-mail or start a new search), or click on a student to see detailed information about her. As seen, faceted browsing seems to be good at monitoring a classroom, since it allows instructors to define any tailored query and find relevant information that they did not know while they explore/refine the result set.

The faceted browser included in FACRO (see Figure 5.15) used information visualization (InfoVis) techniques to effectively display data collected from AdVisor 2.0, leaving knowledge inference in teachers' hands. Hence, data mining techniques were not used to obtain underlying information.

With regard to its interface, ***2D graphics*** were used and its layout consisted of two areas. The main one showed the class roster. Unlike the other monitoring tools which use graphical symbols

Category	**Facet**	**Values**	**Type**
Basic information	Gender	male, female or all	Nominal
	Status	new (i.e. first time in the course), repeat or all	Nominal
Performance	Studying pace	[0%, 100%]	Numerical
	Assignments grade	[NA (Not Assessed),NP (Not Presented),D,C-,C+,B,A]	Nominal
Forums participation	Num. initial posts	[0, max. num. messages posted by a student]	Numerical
	Num. replies	[0, max. num. replies written by a student]	Numerical
	Num. messages read	[0, num. messages in the forum]	Numerical
	Average grade of messages	[0, 5]	Numerical
	Num. highlighted messages	[0, num. messages highlighted by the teacher]	Numerical

Table 5.2: FACRO – Facets of the faceted browser.

(e.g. points, squares, bars, etc.) to represent students, FACRO represented the class as a set of cards in which each one included the ***student's name and photo***. Hence, given that there is evidence for the existence of a dedicated face processing system in human's brain (Zhao et al., 2003), FACRO took advantage of the effectiveness of students' pictures.

On the left, there was a menu that had different facets whereby the teachers could narrow down or order the class. Table 5.2 gathers the facets that were included along with their possible values. The chosen facets encompassed the three aspects studied by Mazza and Dimitrova (2003): (1) sociality (i.e. forum participation), (2) cognition (i.e. assignments grade), and (3) behavior (i.e. studying pace). At this point, it is important to stress that the facets related to resources, such as the number of times that an item has been accessed, were not included because AdVisor 2.0, the platform from which FACRO collected the data, did not provide this information.

As shown in Table 5.2, facets could have either nominal or numeric values. Those facets that allowed gradation were represented with sliders. Likewise, to indicate the number of students in each facet value, numbers in parentheses and histograms were used. Moreover, their values were updated depending on the data set that was shown in the main area. This helped teachers to set more meaningful queries during the middle game.

As said, teachers could sort out the result set. This could be ordered by the learners' name, the studying pace or the average grade of the assignments, in ascendant or descendant order.

Finally, different visual elements were used to represent more variables in the main area. The ***background color of each card indicated the learner's studying pace***. As a result, the more orange the background was, the more advanced the student was. Besides the background color, the card could have a ***red border that meant that the average grade of the assignments was C- or less*** and, hence, that student would not pass the course if the term finished at that moment. Moreover, the border of the photo could be drawn with ***black dashes, which indicated that the student was repeating the subject***. Likewise, and because the result set could be ordered, ***the position of the cards*** was another visual element that gave extra information to instructors. For instance, if a teacher sorted their learners by the average grade of the assignments in ascendant order, then the students with lower grades were place in the top positions.

To better understand how the proposed faceted browser worked, let us see an example. From the opening stage shown in Figure 5.16a, a teacher could define any query. For example: *"to retrieve, ordered by studying pace in a descendant way, those students who, regardless of their participation in forums, are not repeating the course and, at the same time, have achieved 24% of activities as well as they have an average grade of the assignments equal or greater than C+"*. If the previous query were executed, then the result set would be that of Figure 5.16c. In this regard, Figure 5.16b shows the transition between the opening (see Figure 5.16a) and the middle game (see Figure 5.16c). As seen, instructors could see how some of their students would change their positions or even how some of them would disappear. Thanks to the possibility of seeing the transition, teachers would obtain an extra cue that would help them during the exploration.

Lastly, it is worth stressing that Figure 5.16c could be either an intermediate step of the middle game or the last one. This depends on whether the teacher prefers to narrow down the result set by changing some facets or she wants to select one student (i.e. the end game).

Data portrait

In addition to the information about the whole class, instructors also need to know details of a specific learner quite often. In this regard, the great majority of monitoring tools usually show the same kind of graphic for both the class and the learner. In contrast, FACRO suggested using a novel technique, called data portraits, to display an individual student's information.

According to Donath et al. (2010), *"data portraits depict their subjects' accumulated data rather than their faces. They can be visualizations of discussion contributions, browsing histories, social networks, travel patterns, etc. (...). Data portraits depict a person through their digital archive"*. In short, ***the idea behind data portraits is to compactly show a large amount of information from an individual in a single graphic***. Some examples of data portrait are:

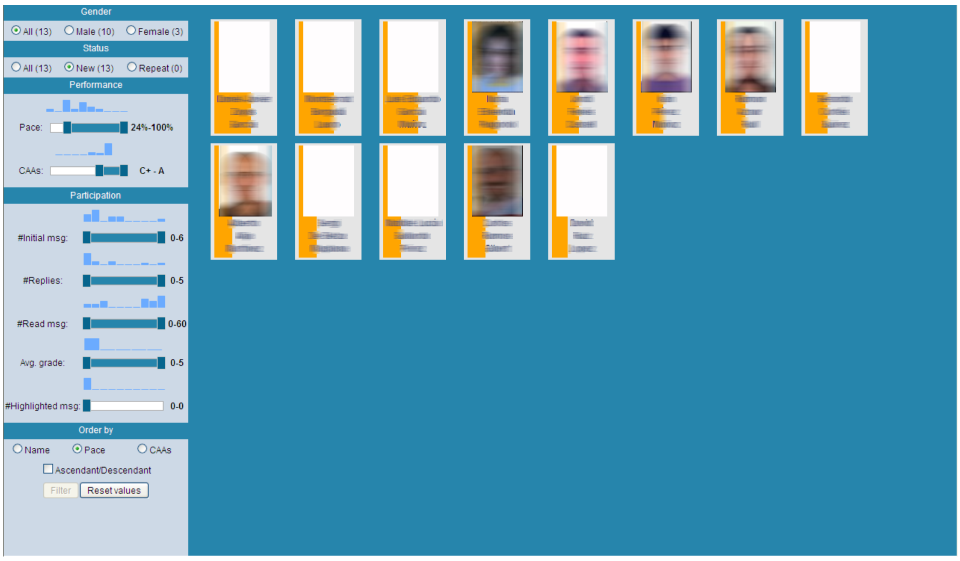
- **PeopleGarden** (Xiong and Donath, 1999): this is a metaphor in which each user is a flower and, consequently, the forum is a garden. Each petal symbolizes a message written by the user. Thus, the number of petals indicates the user's posting frequency. Hence, the more petals a flower has, the more active the user is. Likewise, the color of the petal represents if the message is an initial post (in magenta) or a reply (in blue). Moreover, pistil-like circles are used at the top of the petals to show how many responses each message has received. To display how old a message is, petals, like in the real life, fade over time.

- **Authorlines** (Viégas, 2004): it is an horizontal timeline with vertical monthly dividers that represents the user's yearly posting behavior in a set of newsgroups. Each month is divided into weeks, and each week is shown as a vertical lineup of circles. Each circle represents a conversation and its size indicates the number of the author's messages in that thread. Authorlines places threads that were initiated by the author above the timeline, whereas the rest of threads to which she contributed are placed underneath the timeline.

- **Daisy maps** (Icke and Sklar, 2008): this is a star-shaped glyph that displays the scores received on different parts of an assignment (e.g. reading, writing, etc.). Therefore, each student is a daisy map and each ray has a color depending on the score attained.

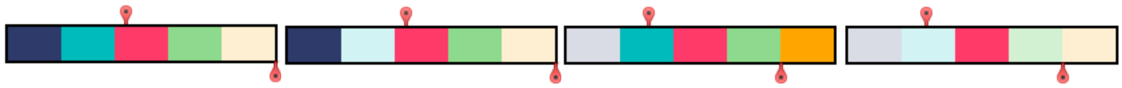
(a) Opening

(b) Transition

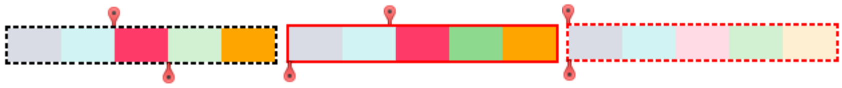


(c) Middle game

Figure 5.16: FACRO – Execution of a query in the proposed faceted browser.



(a) Active ***(b)*** Threads initiator ***(c)*** Replies a lot ***(d)*** Lurker



(e) Pass and repeat ***(f)*** Fail and no repeat ***(g)*** Drop out and repeat

Figure 5.17: FACRO – Different examples of student data portraits.

- **Lexigraphs** (Dragulescu, 2009): it is a group of data portraits in which each user is represented as a face-like outline. Each one is drawn by the words written in the user's Twitter account. As a result, silhouettes are updated with each new tweet.

FACRO's data portrait (see Figure 5.17) ***created a snapshot of an individual student from the data of her learning process***, i.e. the facets of Table 5.2, except gender. The data portrait appeared over the faceted browser when the teacher moved the mouse over the student's card.

Visually, the proposed data portrait was ***a bar which was divided into five squares***: (1) number of initial posts (in dark blue), (2) number of replies (light blue), (3) number of read messages (pink), (4) the average grade of the messages (green), and (5) the number of highlighted messages (orange). As observed, these five squares represented the student's forums participation. Each one of them changed its opacity so as to indicate the level of achievement. The lighter the color of the square was, the lower student's performance in that item was, and vice versa.

Likewise, ***the border of the bar could be red or black***. The color red meant that the student would not pass if the course finished at that moment. Moreover, ***the border could be drawn with dashes***. This indicated that the learner was repeating that course.

There were also ***two red markers*** above and underneath the bar. The former represented the studying pace (in percentage), i.e. how many activities the learner had already finished. Hence, the top of the bar worked as a continuous axis that went from 0% to 100%. Regarding the second marker, this indicated the average grade of the assignments. In this case, the bottom of the bar worked as a discrete axis whose values were: NA/NP (no attendance/no presented), D, C-, C+, B and A. Each value coincided with the ends of each square.

In order to better understand how FACRO's data portrait should be interpreted, Figure 5.17 shows several examples of students' behaviors. For instance, the learner in Figure 5.17a participates actively in the forums, since she has written (opaque dark blue) and replied (opaque light blue) a lot. Moreover, she has read most of the messages (opaque pink).

As for the student in Figure 5.17b, she has initiated a lot of conversations (opaque dark blue), but she has not replied to other messages (transparent light blue). Therefore, she only writes when she initiates the conversation. By contrast, the learner in Figure 5.17c helps her classmates by participating in threads initiated by others (opaque light blue). However, she has not initiated any conversation. Moreover, the teacher has highlighted some of her messages (opaque orange). As seen, the students of Figures 5.17b and 5.17c participate in forums actively, but in an opposite way.

According to Taylor (2002), the learner in Figure 5.17d would be a lurker, i.e. a user that writes occasionally or not at all (transparent dark and light blues), but she regularly participates as a reader (opaque pink). Furthermore, lurker students usually obtain similar grades to more active learners. For example, in Figure 5.17d, the student has a B as the average grade of her assignments (see the bottom axis), whereas the learner of Figure 5.17a has an A.

The last three data portraits show: Figure 5.17e) a student who is repeating (dashed border) and, at that moment, she would pass the course (she has a C+); Figure 5.17f) a lurker who does activities, but she would fail because she has not handed in any CAA (red border and bottom marker in the beginning); and Figure 5.17g) a student who has dropped out (all the squares are transparent, her studying pace is null and she has not handed in any CAA) and, moreover, is repeating.

As seen, thanks to the proposed data portrait, it is possible to compact a student's learning process in a single image. Thereby, teachers may be able to get an overall idea of a learner at a glance and compare students with each other easily.

5.4.3 Test

AdVisor 2.0 was tested in a *real-world scenario* from September to December 2011. Like the previous prototype, AdVisor 2.0 was used in Electric Circuit Analysis (.002) and Mathematics II (.008) mandatorily. Both courses were taught in Spanish (89) and Catalan (19). Likewise, they both did not undergo significant changes compared to the previous semester, being the teaching staff and the learning material the same. Moreover, the difficulty of the CAAs was very similar.

5.4.4 Evaluation

On January 20, 2012, a web-based self-administered questionnaire was sent to the 115 students who were enrolled in Electric Circuit Analysis (.002) or Mathematics (.008)[5]. The questionnaire had 27 questions, most of which were based on a 5-point Likert scale (see Appendix C.2). However, some questions were open, allowing the respondents to write their opinions freely. The questionnaire was available until February 24, 2012 and can be found in Appendix F.1.1.

Besides the students' responses, the opinions of eight teachers were collected too. However, instead of a test and a subsequent questionnaire, eight semi-structured interviews were conducted with teachers who belonged to the UOC. Each of the interviewees was asked a predetermined set of questions, leaving her free to discuss and comment anything that she wanted.

The interviews addressed specific questions to elicit information about teachers' impression and general comments, as well as their opinions about the usefulness of the proposed features of AdVisor 2.0. Moreover, some impromptu questions were added depending on the interviewees' speech. Appendix F.2.1 shows the predetermined set of questions which was asked.

The interviews were conducted in December 2012, after the test of AdVisor 2.0 and once the first version of FACRO had been finished. During the interviews, the audio was recorded and the researcher wrote down the most significant comments. At this point, it is worth stressing that the interviewees had not seen any version of AdVisor before the interview.

[5] The learners that were in both course received the e-mail once and were labeled as students of Mathematics II.

5.4.5 Results of the questionnaire

This section discusses the results of the questionnaire conducted with students as well as the comments made by the teachers who participated in the test. Appendix F.1.2 contains an in-depth analysis about the responses to each question.

5.4.5.1 Reliability of the results

The use of AdVisor 2.0 was mandatory for all the students. This allowed to ensure that the respondents had used the platform in depth and, hence, their opinions were well-founded. However, this was not enough to state that the results were reliable. Apart from the compulsory use, the following question had to be answered positively: *were the respondents a representative sample of the potential end-users of the system?*. In this regard, one of the aspects that allows to achieve a high degree of representativeness is the size of the sample. Regarding the test of AdVisor 2.0, 42 students filled out the questionnaire, which meant a good response rate (38.3%). However, the size per se does not guarantee that the sample is able to represent a target population accurately. Besides the size, it is also essential to select a sample which represents the target population in so far as it possesses all the characteristics of the population. As detailed in Appendix F.1.2.2, ***the profiles of the respondents and the population were practically identical***, except for the fact that 86.4% of those questioned were men. Even so, considering the response rate as well as the size and the profile of the sample, it could be concluded that ***the sample was acceptable***.

Regarding the variables that could have affected the reliability of the results, these were minimized as much as possible. For example, thanks to the inclusion of the discussion forums, AdVisor 2.0 allowed the students to carry out the whole learning process without using the UOC classroom. Students only had to use the UOC classroom in order to submit their solutions to the CAAs. During the semester, this action was done five times in Electric Circuit Analysis and four times in Mathematics II. As a result, ***the extraneous variable of the test of AdVisor 1.0 was removed***.

However, it is worth emphasizing that the generalization of the results may have been affected by the fact that all the respondents were enrolled in a technological degree.

In conclusion, despite the limitations of the sample, this was quite representative (and more reliable than that of AdVisor 1.0) to gain an insight into the suitability of the recommendations proposed in this thesis. Therefore, ***the results from AdVisor 2.0, along with those of AdVisor 1.0, provided a first validation of the suitability of the recommendations proposed in this thesis***. Moreover, these results laid the foundations for future research on this field, e.g. new experiments with students from different degrees and universities.

5.4.5.2 To guide students through the course (recommendation B)

As in AdVisor 1.0, ***recommendation B*** was also evaluated through: (1) the organization based on sessions, (2) the detailed activities, and (3) the assessment letter/fill pattern. A detailed analysis can be found in Appendix F.1.2.4.

As for the sessions, 51.2% of the respondents found them *useful* (4, 25.6%, median) or *very* *useful* (5, 25.6%), being the distribution multimodal with values 3, 4 and 5. Likewise, 55.8% rated the provision of detailed activities 4 (*useful*, 30.2%, mode and median) or 5 (*very useful*, 25.6%). As seen, the percentage of positive responses (≥ 4) was very similar for both elements, but it was worse than that of AdVisor 1.0, which was equal to 62% (a possible explanation for this decrease is given in Appendix F.1.2.4). Even so, over 74% of the responses were equal or greater than 3 (*neither useful nor useless*) in both elements.

As regards the assessment letter (fill pattern in the Gantt chart), this was evaluated very positively, because ***only 10% thought this item had been not at all useful*** (1, 2.5%) ***or not very useful*** (2, 7.5%). This figure was 26.7% in AdVisor 1.0. Moreover, in the case of AdVisor 2.0, the score 1 (*not at all useful*, 2.5%) was an outlier value. Hence, the evaluation of this element improved a lot.

In short, it could be concluded that ***the guidance through the course (i.e. recommendation B) had been found useful by the respondents***, since, for the previous three items, the percentage of responses that was equal or greater than 3 (*neither useful nor useless*) was: 76.7%, 74.4% and 90%, respectively, being at least 51% of the responses equal to 4 (*useful*) or 5 (*very useful*).

5.4.5.3 To provide self-awareness (recommendation C)

The usefulness of providing information that helps students to be self-aware of their learning process was measured by means of an explicit question, *"to what extent did AdVisor help you to be aware of your situation in the course?"*, and the evaluation of six items: (1) the status color, (2) the dashboard as a whole, (3) the dashboard's agenda area, (4) the dashboard's pace area, (5) the dashboard's assessment area, and (6) the dashboard's forums area. Next, a summary of the results is presented. Appendix F.1.2.5 expands on the analysis provided in this section.

Only 13.6% of the respondents said that AdVisor 2.0 had not helped them to be self-aware (i.e. scores 1 and 2). By contrast, most of those questioned said that the platform had helped them *quite a lot* (4, 43.2%, median). This was an excellent result which was supported by the results of the items related to self-awareness:

- **Status color**: 77.3% of the respondents found it *useful* (4, 40.9%, mode and median) or *very useful* (5, 36.4%). Moreover, the values 1 (*not at all useful*, 4.5%) and 2 (*not very useful*, 2.3%) could have been considered outliers.

- **Dashboard**: 81.8% rated it 3 (*fair*, 29.5%) or greater, being those who chose *not at all useful* (1, 4.5%) outliers. Its evaluation was very similar to that of AdVisor 1.0 (82.9%). This similarity and the good results suggested that ***the dashboard had been really useful to the students***.

- **Dashboard's agenda area**: the responses were very scattered (IQR = 3). As a result, the median was 3 (*fair*, 25%) and the mode was 5 (*very good*, 27.3%). This meant 70.5% of the respondents rated the agenda area 3 (*fair*) or greater (AdVisor 1.0: 79.4%).

- **Dashboard's pace area**: the usefulness of the this area was surprisingly low in comparison with the previous prototype: 69.8% rated it 3 (*fair*, 27.9%, mode and median) or greater (AdVisor 1.0: 87.5%). From the questionnaire, no explanation could be found.

- **Dashboard's assessment area**: 90.9% of the respondents rated it 3 (*fair*, 38.6%, mode) or greater (AdVisor 1.0: 87.5%), being the score 1 (*very poor*, 2.3%) an exceptional value and the score 4 (*good*, 29.5%) the median. This proved that the assessment information had been very important to the learners.
- **Dashboard's forums area**: this obtained a mode equal to 5 (*very good*, 36.4%) and a median equal to 4 (*good*, 22.7%), being 81.8% of the responses equal or greater than 3 (*fair*, 22.7%). Nevertheless, it is needed to be cautious about this result because it is highly probable that the large number of forums that AdVisor 2.0 had (i.e. one forum per activity) may have implied the strong necessity (and usefulness) of having this information area.

As seen, the evaluation of the status color and the dashboard confirmed the result of the explicit question which stated that AdVisor 2.0 had helped the students to be aware of their learning process. Consequently, ***it seemed that recommendation C was suitable for online education***.

5.4.5.4 To provide tools that help students to be self-regulated (recommendations B and C)

As the Cronbach's alpha coefficient indicated ($\alpha = .932$), all the items related to ***recommendations B and C***, together with the questions *"how useful was the option of marking an activity as complete?"* and *"to what extent did AdVisor help you to self-regulate your learning process?"*, measured the same construct: the usefulness of the elements that support self-regulated learning.

As for the feature that enabled to mark the completion of an activity/session, ***only 18.6% considered it to be not very useful*** (2, 16.3%) ***or not at all useful*** (1, 2.3%). In other words, 81.4% of the respondents rated this feature 3 (*neither useful nor useless*) or greater, being around 58.1% of the responses *useful* (4, 27.9%, median) or *very useful* (5, 30.2%, mode) (AdVisor 1.0: 61.9%).

Regarding the second question, ***it could be concluded that AdVisor 2.0 had helped the students to self-regulate their learning process***, because about 77% of the responses were equal or greater than 3 (*normal*, 20.5%) and all the responses with value 1 (*nothing*, 11.4%) could have been considered exceptional. Likewise, unlike AdVisor 0.0 and 1.0, the mode and the median were 4 (*quite a lot*, 40.9%) instead of 3 (*normal*).

As seen, most of those items related to self-regulated learning continued being evaluated positively. Moreover, the two explicit questions commented in this section obtained better results. Therefore, ***it could be concluded that the elements which help to self-regulate learning process seem to be useful to online students***. A more detailed analysis is given in Appendix F.1.2.6.

5.4.5.5 To promote social interaction (recommendation D)

This section focuses on evaluating the usefulness of three of the features that the forums of AdVisor 2.0 had: (1) one forum per activity, (2) like-it button, and (3) to highlight messages. Before presenting the analysis, it is important to stress that these two last items were not used too much. Thus, their results had to be interpreted with prudence (more details in Appendix F.1.2.7). In short:

- **One forum per activity**: 79.1% of the respondents scored this organization of the forums with 3 (*neither useful nor useless*, 20.9%) or a greater value. In this regard, ***58.1% found it***

useful (4, 27.9%, median) ***or very useful*** (5, 30.2%, mode). This could be considered a very good result, since this organization of the forums was totally new to the students.

- **Like-it button**: each message had this button which allowed a student to express that she liked, enjoyed or supported the content of that message. When the learner clicked on the button, a counter increased and she could not click again. Thanks to this button, any student was able to know how many classmates liked that message.

  The assessment was worse than it was expected, because ***39% did not find it useful*** (scores 1 and 2). However, the mode was 4 (*useful*, 31.7%) and the median was 3 (*neither useful nor useless*, 20.5%). As a result, the only conclusion that could be drawn was that this item would have to be studied in depth in the future, because the result was not conclusive enough.

- **Highlight**: the teacher could label a message as important so that their students saw a star beside the message. This meant that the learners had to pay attention to that message.

  The respondents found this feature much more useful than the like-it button. ***81.6% rated it 3*** (*neither useful nor useless*, 31.6%) ***or higher***.

From the previous results, it could be concluded that, on the one hand, the use of a forum per activity was useful to the respondents and, on the other, more research on like-it button and highlighting messages would have to be done in future so that well-founded conclusions could be drawn. To this end, elements related to social interaction would have to promoted a lot more.

5.4.5.6 To help teachers to design their courses (recommendation F)

Despite giving the teachers information on learners' study habits as well as guidelines about how to create sessions, they were not able to design sessions whose estimated and real workloads were really balanced. Moreover, there was an excess of learning activities (see Appendix F.1.2.4).

As a result of the aforesaid problems, it seemed that the teachers could need some kind of assistance beyond the guidelines when they designed their courses (i.e. ***recommendation F***). In this regard, a smart course editor which warn the instructors of inconsistencies/mistakes could be a possible solution. The suitability of this type of automatic assistance was asked to some teachers via individual interviews (see section 5.4.6.7).

5.4.5.7 To provide multiple views of the course (recommendation G)

Next, the results of all the questions related to ***recommendation G*** (i.e. provision of multiple views) are analyzed. The following analysis is divided into two categories:

- Usefulness of having multiple views
- Use of each view

Next, the results of each category are shown. More details are provided in Appendix F.1.2.8.

Usefulness of having multiple views

The respondents were first asked to explicitly evaluate the usefulness of having multiple views of the same course. ***Only 13.6% of the respondents found the provision of multiple views useless*** (i.e. scores 1 and 2), being the value 1 (*not at all useful*, 6.8%) an outlier. 52.3% of the responses were 3 (*neither useful nor useless*, mode and median). As a result, ***it could be concluded that the evaluation of the provision of multiple views was neutral to good***.

As seen in section 5.4.2.2, all the views were linked to the learning activities. The questionnaire revealed that ***only 18.7% rated it not at all useful*** (1, 4.7%) ***or not very useful*** (2, 14%), being the respondents who chose the score 1 outliers. Likewise, the mode was 3 (*neither useful nor useless*, 30.2%) and the median was 4 (*useful*, 27.9%). Hence, ***the connection between the information spaces through the activities was found suitable***.

One of the goals of providing multiple views was to avoid that the students only paid attention to continuous assessment assignments (CAAs), i.e. the mandatory activities. In this regard, ***61.4% stated that AdVisor 2.0 had helped them to have an overview of the course beyond the learning activities and the CAAs*** (i.e. scores 4 and 5), being the mode and the median equal to 4 (*quite a lot*, 40.9%). Moreover, the score 1 (*nothing*, 9.1%) could be considered an exceptional value. These results were quite good, since a lot of learners usually study according to the deadlines of the CAAs (as an example, see the study habits of the respondents of AdVisor 0.0 in page 95).

Use of each view

While the respondents of AdVisor 1.0 had had to indicate the use of each view by using a 5-point Likert scale, the ones of AdVisor 2.0 had to rank the views from the most used to the least. Thereby, it was possible to create a more exhaustive ranking. The result was as follows:

1. **Gantt chart** (schedule): this view held the same position as that in the questionnaire of AdVisor 1.0. In this occasion, 50% of the respondents chose the option *1st most used* (mode and median).

2. **Simple list** (activities + resources): this view had the same style as that of AdVisor 1.0. The mode (27.3%) was *2nd* and *3rd*, whereas the median was *3rd*.

3. **Assessment view** (CAAs): although the mode and the median were *2nd* (27.3%) and *3rd* (20.5%), respectively, this view obtained more responses within the range *3rd*-*6th* than the simple list. Therefore, this was ranked third.

4. **Forums view**: its mode and median were *3rd* (22.7%). This fourth position may have been due to the fact that forums are a key element in online learning.

5. **Treeview** (table of contents): this, together with the elastic list, was the least used view. Its mode was *5th* (27.3%) and its median was *4th* (18.2%).

6. **Elastic list** (competences and objectives): this view, with a mode and a median of *5th* (29.5%), obtained the same position as that of Advisor 1.0.

Conclusions

From the previous responses, it could be come to the conclusion that ***recommendation G were suitable for online education***. Actually, only less than 14% of the respondents did not find having multiple views of a course useful. This suggested that this feature, which affects the information structure, was interesting for online students. Moreover, the fact that the activities were the core of the structure and the common item between information spaces was also rated positively. Likewise, according to the respondents, the multiple views had helped, to some extent, to have an overview of the course beyond the activities and CAAs. Nevertheless, it could be observed that, like in AdVisor 1.0, the most used views were clearly those which were linked to the schedule and the assessment. Moreover, the fact that the forums view had been more used than the treeview and the elastic list confirmed, in some way, what the literature states: social interaction is important in online education (see section 2.4.1.2).

Finally, it could be concluded that ***the set of views offered by AdVisor 2.0 was quite complete***, since none of the learners suggested adding or removing some view.

5.4.5.8 To define competences and objectives clearly (recommendation A)

As seen in the previous section, the elastic list (related to the competences and objectives) held the last position. This meant that ***recommendation A*** (i.e. to define competences and objectives clearly) ***did not accord with the habits and preferences of online students yet***.

As EHEA courses are designed based on the degree competences and the course objectives, learners should get used to using these two elements. To this end, instructors should stress the importance of both items and teach students to use them effectively during the learning process.

5.4.5.9 To provide a comprehensible and flexible schema (recommendation H)

The inclusion of the forums view did not affect the design of the courses and, what is more, this new view allowed to demonstrate that the ***information structure was flexible and easy to modify***. Therefore, ***AdVisor 2.0 met recommendation H***.

5.4.5.10 Usability (recommendations I-M)

Before detailing the results, it is important to stress that, although Chapter 4 recommended five usability recommendations, it was not carried out an individual evaluation for each. Instead, a global evaluation of the usability of AdVisor 2.0 was conducted. The results can be divided into:

- Usefulness of different elements of the interface
- Ease of use of each view
- Usability of the whole platform

Next, each of the three aspects is briefly analyzed. More details are given in Appendix F.1.2.9.

Usefulness of different elements of the interface

The usefulness of three elements of the interface was evaluated: (1) the tooltip, (2) the workspace divided into sections (navigation and activity areas), and (3) the arrow button that enabled to show/hide the activity area. In this regard, the evaluation of the three items was quite similar: (1) mode and median equal to 4 (*useful*, around 50%), (2) the percentage of bad scores (i.e. 1 and 2) was lower than 14%, and (3) those who chose the value 1 (*not at all useful*) were outliers. As a result, ***it could be considered that the three elements had been suitable and helpful***.

Ease of use of each view

Like in AdVisor 1.0, the questionnaire asked the respondents to evaluate the usability of each view by using a 5-point Likert scale. The following ranking was derived from the results:

1. **Assessment**: the new view which was specially designed to show CAAs was the most usable (81.8% responses ≥ 3), with median and mode equal to 4 (*usable*, 45.5%).
2. **Gantt chart**: thanks to the changes that were made in this view, the usability of the Gantt chart improved a lot compared to that of AdVisor 1.0. Such was case that 80.9% found its usability *neither usable nor unusable* (3, 33.3%, median) or better (AdVisor 1.0: 73.1%).
3. **Activities and resources**: this view, which was practically identical to AdVisor 1.0's simple list, obtained a distribution that was more disperse than that of the Gantt chart. However, its usability was acceptable: the median was 3.5, the mode was 4 (*usable*, 36.4%) and 50% of the respondents found this view *usable* (4, 36.4%) or *very usable* (5, 13.6%).
4. **Forums**: 75% of the respondents rated its usability 3 (*neither usable nor unusable*, 34.1%, mode and median) or higher.
5. **Elastic list**: the distribution of the responses was practically identical to that of the treeview, but the percentage of responses equal or greater than 3 (*neither usable nor unusable*, 35%, mode and median) was higher for the elastic list: 70%.
6. **Treeview**: 67.6% of the respondents rated it 3 (*neither usable nor unusable*, 39.5%, mode and median) or higher, becoming the least usable view.

At this point, it is worth stressing that it was surprising that the treeview went from the second position in the previous prototype to the last one in this version. However, this did not have to be attributed to the worsening of the usability of the treeview, since this was evaluated in AdVisor 1.0 and 2.0 in a similar way, but to the improvement of the rest of the views, specially the Gantt chart.

In conclusion, ***the usability of the views was, in general, considered acceptable. In some views, the appraisal of the usability was even better than in the previous prototype***.

Usability of the whole platform

Besides studying the usability of each of the views, six aspects that affected the usability of the platform were evaluated. The assessment of each of them are briefly described below.

- **Learning curve**: 59.1% of the respondents agreed (4, 38.6%, mode and median) or strongly agreed (5, 20.5%) about the fact that AdVisor 2.0 had a quick learning curve. However, 29.6% expressed that learning to use AdVisor 2.0 had been hard (scores 1 and 2). Thus, the interface would have to be improved to be more intuitive and, consequently, faster to learn.

- **Ease of navigating without getting lost**: this aspect obtained a disparity of opinions. On the one hand, 43.2% indicated that the navigation had been complex (scores 1 and 2, being 2 the mode), whereas 43.2% expressed that it had been easy (scores 4 and 5). In consequence, the median was 3 (*neutral*, 13.6%). Thus, it could be concluded that the respondents found the navigation through the platform *normal* to difficult.

- **Finding whatever was fast**: more students from Mathematics II (57.1%) than from Electric Circuit Analysis (30.4%) pointed out that too many clicks had been required to find a specific activity or information. In general, 43.2% of the respondents considered that they had had to click a lot and, hence, finding something had not been a fast task.

- **Important information could be seen at a glance**: 29.5% said that the design and the layout of the interface had not helped them to see important information at a glance (scores 1 and 2). Because the interface maybe wanted to convey too many and very different types of information (e.g. type of assessment, activity status, etc.) simultaneously, the students may have been overwhelmed by the amount of colors, icons, symbols, and so on.

- **The visual style**: this aspect encompasses different items: font size, colors, icons, etc. In this regard, although the median was 3 (*normal*, 27.3%) and the mode was 4 (*suitable*, 29.5%), about 30% expressed that the visual style would have to be improved (scores 1 and 2).

- **Response time**: 72.7% stated that this was *normal* (3, 27.3%, mode and median) or fast (scores 4 and 5). This result was considered quite good, since, unlike the UOC campus which uses several distributed servers, AdVisor 2.0 only used one server. Moreover, the appreciation of the response time also depends on multiple factors such as the user's ADSL speed.

At this point, it is important to emphasize the following aspects:

- As said in section 5.1, the development of the three prototypes mainly focused on those aspects related to pedagogy and information structure (i.e. recommendations A-H).

- AdVisor 2.0 was not a stable platform, but a prototype. As a result, it was obvious that it was needed to spend more resources and time on its development, above all, in terms of usability.

- Users usually have a natural resistance to change and, in this case, most of the respondents was used to using the UOC classroom, as evidenced by the fact that 84.1% of them had been enrolled in the UOC for three or more semesters (see Appendix F.1.2.2).

Considering the previous three aspects and the results of the questionnaire, ***the overall score of the usability of AdVisor 2.0 could be considered acceptable***. Nevertheless, the usability of Advisor would have to be improved a lot in future, since usability is a cornerstone of any application, including VLEs (see section 3.3).

5.4.5.11 Overall experience

47.7% of the respondents stated that their overall experience had been *good* (4, 31.8%) or *very good* (5, 15.9%). Moroever, ***only 15.9% of the respondents had had a bad*** (2, 11.4%) ***or very bad*** (1, 4.5%) ***experience***. This figure was lower than that of AdVisor 1.0 (26.2%) and those who rated 1 (*bad*) were outliers. Therefore, ***the overall experience could be considered satisfactory and even better than that of AdVisor 1.0***.

Likewise, the questionnaire asked if the respondents would use AdVisor 2.0 in other courses. In general, the result was worse than that of AdVisor 1.0, since the number of affirmative responses decreased 14.51%, i.e. from 69.05% in AdVisor 1.0 to 54.55% in AdVisor 2.0. But this did not mean a bad result, because 14.51% of the responses that stopped being affirmative mainly went to the *no response* option, which increased from 4.76% to 13.64% (+8.88%). The negative response, in turn, only increased 5.63%, i.e. from 26.19% to 31.82%. As seen, the negative responses did not increase significantly, but there were more respondents who were undecided about if they would use or not the platform. Some possible reasons for the increase of the *no response* option can be found in Appendix F.1.2.10. In short, ***the respondents' overall experience was good and over 50% would use AdVisor again***.

5.4.6 Results of the interviews

The previous section allowed to know the opinion of a sample of UOC learners about different features of AdVisor 2.0 and, consequently, about the set of recommendations. Now, it is teachers' turn. To collect instructors' opinions, ***eight semi-structured interviews with UOC teachers were conducted***. This section presents a summary with the most significant results from those interviews. In order to see an in-depth analysis, it is suggested reading Appendix F.2.2.

5.4.6.1 Interviewees' profile

As said, eight teachers who worked at the Universitat Oberta de Catalunya (UOC) were interviewed. 5 of them were men and 3 were women. The men belonged to IT, multimedia and telecommunication department, whereas the women were members of psychology and education sciences department. Moreover, two interviewees were, in addition to teachers, academic directors.

Broadly speaking, they had wide experience on online teaching and they all are usually in charge of at least 4 courses per semester.

5.4.6.2 To define competences and objectives clearly (recommendation A)

The teachers who participated in the interviews were convinced that most of their students are not interested in the degree competences and course objectives. For this reason, they thought that the elastic list (the view which showed these two elements) would be the least useful view and, therefore, the least used one.

In contrast, the interviewees attached importance to the competences and objectives because, based on their experience, these were essential to design courses. According to their opinions, *"[competences and objectives] define the learning process (...)"* and *"(...) show teachers the main goal of the course"*. Likewise, teachers considered that both items may guide learners through the course, since these tell learners what is expected from them.

From the responses, it could be concluded that ***recommendation A made sense because degree competences and course objectives are very important during the course design stage***. Nevertheless, it would still be needed to research on how to show the information of both items to the students so that it is useful. More information about this recommendation is provided in Appendices F.2.2.2 and F.2.2.3.

5.4.6.3 To guide students through the course (recommendation B)

Firstly, the session was found *useful* (4, 37.5%) or *very useful* (5, 62.5%, mode and median). Moreover, 75% thought the functionality of marking an activity/session as finished was *very useful*. This explained why the Gantt chart was one of the preferred views of the teachers (see section 5.4.6.8).

In short, it seemed that the fact that a virtual classroom guides the students through the course was found useful by the interviewees. In other words, ***they supported recommendation B***. More information is given in Appendix F.2.2.4.

5.4.6.4 To provide self-awareness (recommendation C)

The idea of providing both students and teachers with a dashboard was rated 4 (*good*, 62.5%, mode and median) and 5 (*very good*, 37.5%). The interviewees mainly stressed that *"[the dashboard] provides a large amount of relevant information in a very visual way"*.

It is worth stressing that the interviewees had different opinions of the usefulness of AdVisor 2.0's dashboard depending on whether this was used by the learners or the teachers. In this regard, they all thought the dashboard would be *useful* (4, 50%) or *very useful* (5, 50%) to students, whereas 62.5% thought this tool would be *useful* or *very useful* to teachers. The informants indicated that the current proposal of the dashboard was devised to students rather than teachers and, therefore, several changes should be made in order to satisfy instructors' needs. The interviewees suggested some improvements that can be found in Appendix F.2.2.4.

In conclusion, ***the dashboard proposed in AdVisor 2.0 as well as its purpose (i.e. recommendation C) were well received by the teachers who were interviewed***.

5.4.6.5 To promote social interaction (recommendation D)

The responses to the first question related to this recommendation demonstrated how important forums are in online courses, since 6 out of 8 interviewees answered *great a deal* (5, 75%, mode and median). As a result, ***recommendation D was supported by the teachers***. However, some of the informants said there is evidence that the participation in the forums is decreasing semester after semester. Despite this, the forums continue being useful, although only a small proportion of students take advantage of them.

With regard to AdVisor 2.0, the organization based on one forum per activity was found *good*

(4, 37.5%) or *very good* (5, 37.5%) by 75% of the interviewees. In this regard, most of them said that they usually organize the forums based on one folder per continuous assessment assignment.

Regarding the functionalities that AdVisor 2.0's forum provided, the like-it button was the least useful according to the interviewees. By contrast, the option of allowing teachers to highlight messages was found *very useful* (5, mode and median) by 87.5%. Likewise, to grade messages was found *useful* (4, 50%) or *very useful* (5, 50%). More information about this recommendation is provided in Appendix F.2.2.5.

5.4.6.6 To provide teachers with a student monitoring tool (recommendation E)

This recommendation was the one that was studied more in depth during the interview, since it had not been addressed yet. Appendix F.2.2.6 expands on the information provided in this section.

7 of the 8 interviewees stated that monitoring online students during the semester is very important (5, 87.5%, mode and median). To this end, they usually use the grades of the continuous assessment assigments (CAAs), since *"[continuous assessment] allows teachers to monitor their students' progress"*. Besides CAAs, they use other items: participation in the forums, quality of the messages, e-mails to teaching collaborators, last log-in date, etc. However, they do not obtain all this information from a single tool, they have to collect it from different sections of the UOC campus instead. For that reason, they argued that it is *necessary* (4, 25%) or *very necessary* (5, 75%) that UOC campus provides teachers with a tool which helps them to monitor their students.

87.5% thought FACRO, the monitoring tool proposed in this work, ***would be useful*** (4, 25%) ***or very useful*** (5, 62.5%). In fact, all the interviewees said that they would use it if this were available.

As seen, monitoring online students is very important and providing teachers with a single tool from which they can do this task is essential. For all of these reasons, ***recommendation E seemed to be totally justified***.

5.4.6.7 To help teachers to design their courses (recommendation F)

75% of the lecturers interviewed said that it would be *useful* (4, 62.5%, mode and median) or *very useful* (5, 12.5%) to have a smart course editor which supported teachers while they designed their subjects. According to the interviewees, this tool could be especially useful to check that the design of the course was correct. In short, instructors appreciate any help. Therefore, ***recommendation F seemed to make sense*** (see Appendix F.2.2.2).

5.4.6.8 Multiple views from students' point of view (recommendation G)

All the instructors who were interviewed found the fact of providing learners with multiple views good (4, 75%, mode and median) ***or very good*** (5, 25%). Moreover, 87.5% were convinced that this feature would enrich the vision of the course that learners usually have *quite a lot* (score = 4). In fact, they thought that if multiple perspectives were shown, then many students would go beyond CAAs and organize their learning process considering other items. Hence, ***it could be concluded that the interviewees found recommendation G suitable***. Appendix F.2.2.3 gives more details.

Lastly, the teachers considered that ***the Gantt chart would be the most used view by their learners, because this shows information about the course schedule that is essential for any student***, i.e. what activities learners must do and when. As said in section 5.4.6.2, the elastic list would be the least used.

5.4.6.9 To provide a comprehensible and flexible schema (recommendation H)

The teachers believed that the database schema of AdVisor 2.0 included the most important parts of a course. Moreover, the interviewees were familiar with each of those parts and appreciated the flexibility of the structure. Therefore, ***the information structure seemed to meet recommendation H***, since this was complete, flexible and easy to understand (for more details, see Appendix F.2.2.2).

5.4.6.10 Usability (recommendation I-M)

The interviewees were not asked to evaluate the usability of AdVisor 2.0. However, they indirectly spoke about this aspect through their comments. In this regard, a few teachers said that, although the interface was very visual, ***this was overloaded with information***. Likewise, the fact that ***the interface was so different from that of the UOC classroom*** was considered a drawback. Nevertheless, they were convinced that UOC students and teachers would get used to using AdVisor quickly.

5.5 General conclusions

After the evaluation of the three prototypes of AdVisor (especially the versions 1.0 and 2.0), some general conclusions about the proposed recommendations can be drawn. To explain them, the following order will be used:

- To define competences and objectives clearly (recommendation A)
- To guide students through the course (recommendation B)
- To provide self-awareness (recommendation C)
- To help students to be self-regulated (recommendations B and C)
- To promote social interaction (recommendation D)
- To provide teachers with a student monitoring tool (recommendation E)
- To help teachers to design their courses (recommendation F)
- To provide multiple views of the course (recommendation G)
- To provide a comprehensible and flexible schema (recommendation H)
- Usability (recommendations I-M)

5.5.1 To define competences and objectives clearly (recommendation A)

The interviews with the eight instructors revealed that degree competences and course objectives are considered to be essential during the design of a course. Despite this, the teachers were convinced that the students are not interested in these two items and they would not use the elastic list (i.e. the view that displayed both elements). The results of the tests of AdVisor 1.0 and 2.0 confirmed that hunch which the instructors had. As it could be seen in sections 5.3.5.6 and 5.4.5.7, the elastic list was ranked last by the students in terms of use/preference.

As a result of the tests and the interviews, the fact that a VLE allows teachers to define the degree competences and course objectives makes sense, since they both are the core of any EHEA subject. For this reason, ***recommendation A is suitable***. However, there is still a long way until most of the online students get used to utilizing the valuable information provided by the competences and objectives (i.e. what is expected from learners at the end of the course) during their learning process. To help them to take advantage of these two items, the role of teachers is very important.

Regarding AdVisor, the information of competences and objectives could remain in the background, since this is not essential during the daily learning. Therefore, ***AdVisor's elastic list could be put in a secondary position within the workspace's interface*** in order that the interface gives prominence to other views, such as the Gantt chart, which are more important in the day-to-day learning. Likewise, as assessment is very important to learners, one way to promote the use of the competences and objectives could be to connect these two elements with CAAs.

5.5.2 To guide students through the course (recommendation B)

Figure 5.18 shows the percentage of scores equal or greater than 3 of the three aspects related to the guidance through the course (i.e. ***recommendation B***): (1) organization based on sessions, (2) to have the activities detailed, and (3) the assessment letter/fill pattern. As it can be seen, the first two elements in AdVisor 1.0 obtained more responses within this interval than in AdVisor 2.0. The

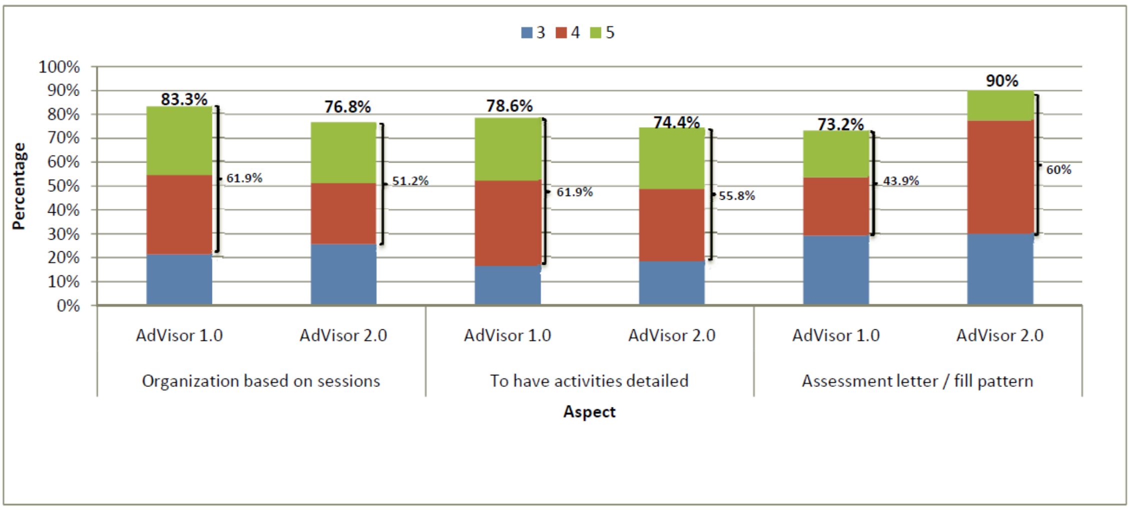


Figure 5.18: Recommendation B (to guide students through the course) – Evaluation of the related aspects in AdVisor 1.0 and 2.0.

reason was that the excess of detail of the activities/sessions made some students of AdVisor 2.0 get confused and, consequently, they rated these two items worse. This problem suggests that if it is wanted to properly guide students through a course, ***the design of the sessions and the activities is a key aspect of the instructional design of the course***. In this regard, there is not a unique way to create them, since this depends on the idiosyncrasy of each course. However, the research carried out in this work showed that instructors should be careful to create an appropriate number of sessions (around 1 or 2 per week) whose ***workload is around 1 hour and 45 minutes***. Likewise, the number of activities should be minimal or, in other words, ***an activity only should be split into two or more activities when this is really required***.

As it can be observed, the definition of the sessions as well as detailing the activities require teachers to put more effort into the design of a course. Despite this, the instructors who were interviewed found the sessions *useful* (4, 37.5%) or *very useful* (5, 62.5%) to guide their students.

As for the assessment letter/fill pattern, this achieved a significant better result in AdVisor 2.0. Specifically, the percentage of responses equal or greater than 3 (*neither useful nor useless*) went from 73.2% to 90%. This increase, together with the good position of the assessment view in terms of use in both versions of AdVisor, may mean assessment information is important to learners.

Despite some problems, the percentage of answers equal or greater than 3 for the previous three items was higher than 73%. This good result implied that ***online students need to be guided through the course***. Thus, ***recommendation B seems to be appropriate for online education***.

5.5.3 To provide self-awareness (recommendation C)

As seen in this chapter, the status color and the dashboard were the two elements that were linked to self-awareness (see Figure 5.19). With regard to the status color, which showed if a activity/session was on time, behind or ahead of schedule, over 85% and 93% of the responses were equal or greater than 3 (*neither useful nor useless*) in AdVisor 1.0 and 2.0, respectively. ***These excellent results prove the importance that the respondents attached to know the status of the sessions/activities***. At this

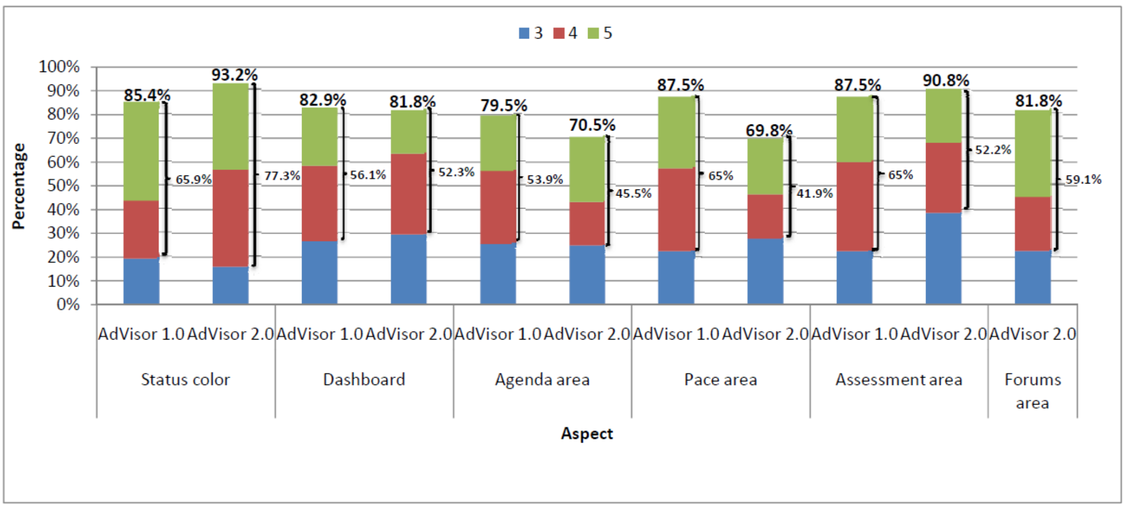


Figure 5.19: Recommendation C (to provide self-awareness) – Evaluation of the related aspects in AdVisor 1.0 and 2.0.

point, it is worth stressing that the evaluation of the status color can be considered independent of AdVisor, because this item is a simple visual input. Hence, the results obtained and the subsequent conclusions could be generalized to other contexts.

Regarding the dashboard, ***the overall rate was very good in both AdVisor 1.0 and 2.0***: 82.9% of the responses were 3 (*neither useful nor useless*) or greater in AdVisor 1.0, whereas this figure was 81.8% in AdVisor 2.0. More specifically, 56.1% and 52.3% found the dashboard *useful* (4) or *very useful* (5), being the median and the mode equal to 4 (*useful*) in both prototypes. Moreover, the respondents who rated the dashboard 1 (*not at all useful*, AdVisor 1.0: 7.3%; AdVisor 2.0: 4.5%) were outliers in the two tests. Likewise, the instructors who participated in the interviews thought that the dashboard could be *useful* (4, 50%) or *very useful* (5, 50%) to students. By contrast, they also considered that the design of the dashboard for teachers would have to be rethought in order to really satisfy their necessities. In any case, the good evaluation of the dashboard proposed in this thesis suggests this may serve as a base for future implementations.

The result of the dashboard, taken in conjunction with the good evaluation of the status color, demonstrated that providing students with information and tools that help them to be aware of their own learning process was found useful. Actually, as said in section 5.4.5.3, only 13.6% of the respondents stated that AdVisor 2.0 had not helped them to be aware of their learning process (scores = 1 and 2). Therefore, ***it can be stated that recommendation C meets one of the needs of online students and, consequently, VLEs should put it into practice***.

5.5.4 To provide tools that help students to be self-regulated (rec. B and C)

As said in this chapter, ***recommendations B and C are interrelated*** in such a way that a new recommendation which encompasses them may be defined: *to provide tools that help students to be self-regulated*. As seen, besides the items of recommendations B and C, there was another one which was closely related to self-regulation and whose results were a clear indicator of the suitability and the importance of self-regulation in an online learning environment, i.e. the functionality that allowed students to mark an activity/session as finished (see Figure 5.20). The results of this feature in both prototypes were practically identical. The percentage of responses equal or greater than 3 was 80.9% in AdVisor 1.0 and 81.4% in AdVisor 2.0. Moreover, in both cases, the median was 4 (*useful*) and the mode 5 (*very useful*). And what is more, 75% of the instructors who participated in the interviews found it *very useful* (5, mode and median). ***Given these good results, it may be stated that this functionality is suitable and, consequently, this may be applicable to other VLEs***.

Furthermore, the respondents evaluated the degree in which the platform had helped them to be self-regulated. In AdVisor 2.0, which had more functionalities and improvements, 22.2% of the respondents stated that it had not helped them. This meant a decrease of 11.2% compared to the previous prototype. Moreover, in AdVisor 2.0, the responses equal to 1 (*nothing*) were outliers and both the median and the mode went from 3 (*normal*) to 4 (*quite a lot*). Likewise, a relevant fact was that the Gantt chart, which was closely linked to the schedule and hence to self-regulation, was the most used view both in AdVisor 1.0 and AdVisor 2.0.

Finally, it is worth stressing that the questionnaire of AdVisor 2.0, by means of an open ques-

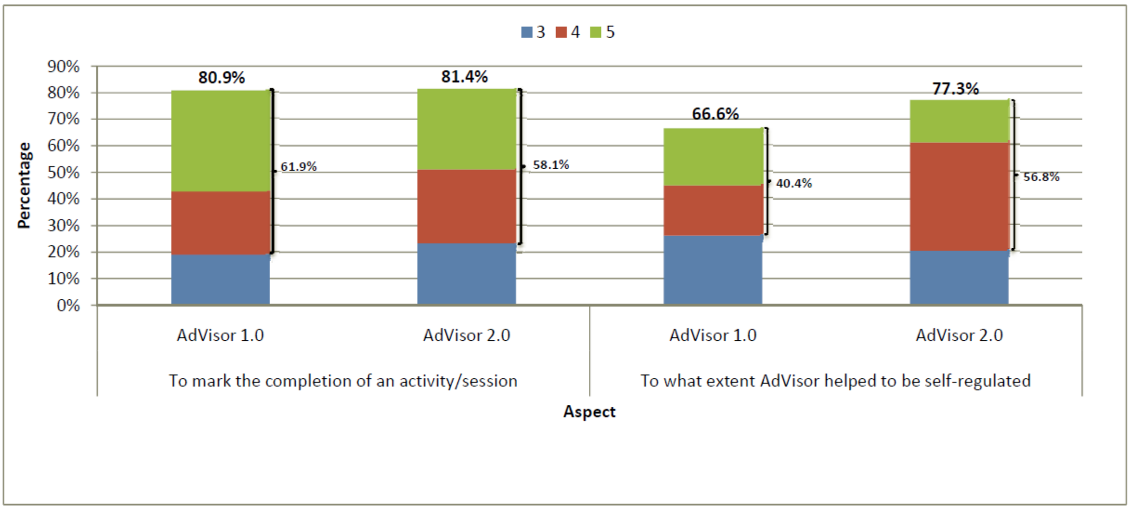


Figure 5.20: Recommendations B and C (to help students to be self-regulated) – Evaluation of the related aspects in AdVisor 1.0 and 2.0.

tion, asked the respondents to write the most useful/interesting things of the platform (see F.1.2.11). 39.2% and 31.4% of the snippets were related to guidance (i.e. ***recommendation B***) and self-awareness (i.e. ***recommendation C***), respectively.

In conclusion, broadly speaking, ***the functionalities related to self-regulation were found useful by the students and teachers*** as evidenced by the previous results. Hence, it may be recommended that VLEs support self-regulation. In other words, ***it can be concluded that recommendations B and C are suitable for VLEs***.

5.5.5 To promote social interaction (recommendation D)

As explained in sections 2.4.1.2 and 4.3.4.1, social interaction is an essential aspect in online education. Such importance was evidenced by the discontent that the lack of embedded forums in AdVisor 1.0 aroused among some students from Electric Circuit Analysis (.002). Likewise, the forums view of AdVisor 2.0 was more used than the treeview (i.e. table of contents) and the elastic list (i.e. competences and objectives). Moreover, 75% of the teachers interviewed said that, although less and less students participate, the forums are very important in their courses.

In summary, ***VLEs should take the recommendation D into account***, i.e. to promote social interaction between students and teachers. To this end, forums should include functionalities that make interaction easier, e.g. like-it button, to highlight a message, etc. In this regard, more research on this field is needed, e.g. how to make use of items of social networks for learning.

5.5.6 To provide teachers with a student monitoring tool (rec. E)

This recommendation was only evaluated by the instructors who were interviewed. As said in section 5.4.6.6, 7 of 8 interviewees stated that monitoring online students throughout the semester is *very important* (5, 87.5%, mode and median). To do this task, they gather information from different sources, e.g. forums, grades, campus, etc. This is a tiresome task, since they do not have a tool that shows these data at a glance. Instead, they have to visit different parts of the UOC campus to retrieve that information. For that reason, 87.5% of the interviewees thought a tool like FACRO, the student monitoring tool proposal, would be *useful* (4, 25%) or *very useful* (5, 62.5%).

The available evidence clearly leads to the conclusion that ***it is strongly recommended providing teachers with a student monitoring tool that enables them to retrieve useful data easily***.

5.5.7 To help teachers to design their courses (recommendation F)

The creation of an online course is not an easy task, because a comprehensive design should be carried out before starting the semester. If this was not enough, a lot of teachers have difficulty in creating online courses due to lack of skills (see section 2.4.2.3), an awkward course editor, etc. Inevitably, the tests conducted in this thesis had some problems related to design. Two of them were: (1) the mismatch between the estimated and the real workload of a session, and (2) the excess of the number of sessions and, especially, activities. These drawbacks may have affected students' experience negatively and, in consequence, the results of the questionnaire.

To avoid any type of design problem, ***it could be useful that instructors had some kind of assistance when they designed online courses***. In this regard, 75% of the teachers interviewed would find *useful* (4, 62.5%) or *very useful* (5, 12.5%) to have a smart course editor which supported them while designing their subjects. According to the interviewees, this tool could be especially useful to check that the design of the course was correct. As it can be observed, the fact that VLEs actively help instructors to design their courses can prevent serious problems during the course.

In short, ***recommendation F is not accessory and, therefore, this should be put in practice***.

5.5.8 To provide multiple views of the course (recommendation G)

According to the questionnaire of AdVisor 2.0, ***only 13.6% did not like to have multiple views*** (scores 1 and 2), being those who rated 1 (*not at all useful*, 6.8%) outliers.

Likewise, as 87.5% of the teachers interviewed thought that, thanks to the multiple views provided by the platform, ***learners were more aware of the different parts of which the course consisted*** (i.e. table of contents, competences, etc.). Furthermore, as some instructors said, this variety of views reduced the focus on the CAAs. More specifically, 61.4% of the students questioned stated that AdVisor 2.0 had achieved this goal successfully (scores 4 and 5).

Although the assessment view still had a significant role (this was the third most used view in AdVisor 2.0), both the students questioned and the instructors interviewed reached the same conclusion regarding the use of each view. First, the learners who participated in the tests of AdVisor 1.0 and 2.0 stated that ***the Gantt chart had been the most used/useful view, whereas the elastic list had been the least used one*** (see section 5.5.1). The teachers also ranked these two views in the same positions based on the possible use that their students would make. In general, the reasons were that the Gantt chart shows information that is important daily, i.e. what activities student must do and when. By contrast, competences and objectives are still very new items to students and, hence, learners are not used to using them. Due to this, learners take it for granted that when they pass a course, they have acquired a set of the competences and attained a set of objectives.

Finally, it is worth stressing that an advantage of having multiple views is that learners can choose the representation that best meets their learning requirements and preferences at any time. Moreover, the existence of multiple views provides instructors with flexibility when they design their courses (see section 5.5.9).

In the light of the benefits that the provision of multiple views offers, ***it is highly recommended that VLEs have multiple views which, in addition, can be used simultaneously***.

5.5.9 To provide a comprehensible and flexible schema (rec. H)

Learners and teachers require that the organization of a course in VLEs be easy to understand as well as close to the features of an online subject. In this regard, this thesis, by means of AdVisor, has proposed a structure (see 5.4.2.2) which, according to the tests and interviews, includes the most important elements of a course with which teachers and students, moreover, are familiar.

Likewise, the database schema of the proposal allows the instructors to create their courses by using those views/perspectives that they really need (*activities and resources* is the only mandatory view, the rest are optional). This flexibility also appears in the students' side, since they can choose those views (if they have been defined by the teacher previously) that best meet their necessities/preferences. This flexibility was well received.

Moreover, the inclusion of the forums view in AdVisor 2.0 demonstrated that the information structure was modular. Adding this view did not affect the rest of information spaces.

To sum up, the information structure proposed in this work satisfied ***recommendation H*** and was welcomed by the users (i.e. both learners and teachers). In any case, the idea behind this proposal is that ***the course structure used in a VLE should be easy to understand by teachers and students as well as easy to modify by the system administrator***. In this regard, AdVisor 2.0's information structure may be a good solution to these two issues.

5.5.10 Usability (recommendations I-M)

As discussed in section 3.3.3, the usability of an interface has a big impact on the users' experience and, in the case of education, on the students' learning process. Hence, VLEs designers and developers must make an effort to create user-friendly interfaces.

Regarding this thesis, the usability was not the main topic due to the lack of resources, among other things. Instead, the emphasis of this dissertation was put on aspects related to pedagogy and information structure. Despite this, the respondents in general considered the usability of AdVisor to be acceptable. However, future versions of the platform should focus on usability, because aspects like reducing the number of clicks or showing important information at a glance are crucial factors to create a pleasant user experience. In fact, the students of AdVisor 2.0 expressed, by means of an open question, that the usability of the interface had been the worst aspect of the platform (see F.1.2.11). In this regard, although it cannot be demonstrated, some results of the questionnaires and interviews could have been conditioned by issues related to usability/interface.

In conclusion, ***usability is a key factor of any software tool, including VLEs***.

5.6 Summary

This chapter focused on the evaluation of the suitability of the set of recommendations proposed in Chapter 4 (***research objective O2***). First of all, it described the procedures which were used: real-world evaluation with final questionnaire and interviews.

During the different stages of the evaluation, three prototypes of a small VLE called AdVisor were used. This platform was developed by putting the recommendations suggested in this thesis into practice. In the three versions, the learners tested AdVisor in a real-world scenario during one semester. At the end of each test, the students were asked to evaluate different aspects of the tool by means of a questionnaire. The data obtained from the questionnaires were analyzed in depth and the most significant conclusions were presented.

With regard to the teachers, two types of evaluation may be distinguished. On the one hand, those who participated in the tests informally explained the problems that they had had to the researcher. On the other hand, eight UOC instructors were interviewed. During the interviews, AdVisor 2.0 was introduced.

Briefly, the recommendations related to self-regulation (i.e. guidance and self-awareness; recommendations B and C) and multiple views (recommendation G) were, in general, evaluated positively. Overall, the rest of the recommendations proposed in this thesis also were, to some extent, supported by most of the respondents and interviewees as well as evidenced by the facts observed during the tests. Nevertheless, more research would have to be carried out in future.

6 Conclusions

This last chapter summarizes the work done, emphasizes the main contributions and shows future research directions. More specifically, this chapter is organized into three sections:

- Summary of this research (see section 6.1)
- Contributions of this thesis (see section 6.2)
- Future work (see section 6.3)

6.1 Summary of this research

Nowadays a lot of universities are taking a firm step toward their virtuality. As a result, there is a steadily increasing number of fully online courses. To support them, virtual learning environments (VLEs) are being used as replacements of traditional classrooms. This implies that VLEs inevitably play a significant role in the online teaching-learning process, having a big impact on students and teachers. Therefore, developing effective VLEs has become an important challenge. In this regard, the main goal of this thesis was to identify those elements that could improve the effectiveness of virtual learning environments (VLEs) when they are used in fully online courses.

First of all, it was essential to know what implications online delivery has for the teaching-learning process. This also included identifing the requirements and barriers that online students and teachers usually have. These matters referred to the ***research questions Q1, Q2 and Q3*** (see section 1.2). To answer these three questions, a literature review was conducted to get an overview of the main issues surrounding online education. As a result of this task, Chapter 2 was written.

After gaining an understanding of the main issues of online education, Chapter 3 dealt with the principal topic of this thesis: virtual learning environments (VLEs). Although there are some publications (not too many) which analyze this kind of system, these analyses are usually carried out from a technological perspective, i.e. standards, interoperability, usability heuristics, types of tools that are provided (e.g. forums, wikis, tests, etc.). In contrast to these works, Chapter 3 took it for granted that VLEs can include any technologically possible feature. Therefore, this chapter focused on analyzing those aspects that directly affect the teaching-learning process: (1) pedagogy, (2) information structure, and (3) usability. Based on these three aspects, eight of the most popular VLEs were analyzed. This study, which answered the ***research question Q4*** (see section 1.2), showed that the design of the current VLEs lacks a sound pedagogical approach. This inevitably has ill effects on the functionalities, the information structure and the interface which, in turn, affect the learning process carried out within these platforms.

In order to contribute to the enhancement of VLEs and achieve the ***research objective O1*** (see section 1.2), this thesis has proposed a set of 13 recommendations/heuristics (see Chapter 4) which synthesizes the most important aspects that were identified both in Chapter 2 and in other related works (see Appendix B.2.3). The idea behind this set of heuristics is to provide designers and developers with a simple and effective instrument which guides them through the design of VLEs, so that these systems may increase its effectiveness in fully online educational scenarios.

Apart from defining the aforesaid recommendations, these were put into practice by means of a small ad hoc VLE called AdVisor (see Chapter 5). The development of this VLE was based on prototyping and three versions of AdVisor were created. Each of the prototypes had new features compared to its predecessor. Unfortunately, not all the recommendations could be developed to the same degree. In any case, the design and creation of the three prototypes of AdVisor allowed to show a way of putting the proposed recommendations into practice.

Likewise, thanks to the creation of the three prototypes of AdVisor, the recommendations suggested in this thesis could be evaluated (i.e. ***research objective O2***). First, the three versions of AdVisor were tested by a sample of the students from the Bachelor's Degree in Telecommunications of the UOC in a real-world scenario for one semester. At the end of each test, a questionnaire was sent to the participants in order to collect their opinion and satisfaction with the platform and, at the same time, to obtain an evaluation of the suitability of the recommendations proposed in this work (see Chapter 5 and Appendices D.2, E.2 and F.1.2). Secondly, eight teachers were interviewed so as to know their teaching habits and opinions about AdVisor 2.0, including a student monitoring tool called FACRO that was embedded in that version of the VLE (see Appendix F.2.2).

The results of the questionnaires and the interviews showed that, in general, the set of recommendations made sense and was suitable. In particular, it is worth stressing those recommendations related to self-regulation (i.e. to guide learners through the course and to provide students with self-awareness of their learning process), providing multiple views and giving a student monitoring tool to instructors. Likewise, although the recommendations linked to usability was not assessed individually, there was evidence that led one to believe that the interface of a VLE may affect the learning process of a student considerably.

In summary, it can be concluded that this dissertation has achieved the ***main research objective*** which it had set, i.e. *to provide designers and developers with a set of recommendations (or heuristics) that helps them to create VLEs which are effective for fully online education.*

6.2 Contributions of this thesis

This work has made some original contributions. Next, these will be described in descending order of importance:

Main contributions of this thesis

- Set of recommendations for creating effective VLEs for online education
- Examples of how to put the recommendations into practice
  - Information structure
  - Visual interface
  - Dashboard
  - FACRO: an educational monitoring tool
- State of the art on VLEs from an educational perspective
- Overview of online education for novices
- State of the art on learner-centered design

Next, each of the previous contributions are described. At this point, it is worth stressing the publications, listed in Appendix H, to which this dissertation has led.

6.2.1 Set of recommendations for creating effective VLEs for online education

In accord with the main research objective of this thesis, the principal contribution of this dissertation has been the set of 13 recommendations/heuristics which aims to help designers and developers to create effective VLEs for online teaching and learning. This set has the characteristic that it was created from an educational perspective, leaving the technological aspects aside. Therefore, it focuses on those elements and features that may help students and teachers to have a successful online teaching-learning experience. Moreover, in order to guarantee the suitability of the 13 recommendations, these were evaluated by students and teachers (see Chapter 5).

Finally, it is worth explaining why a format based on recommendations/heuristics was chosen. The reason was that this kind of organization is a way of providing important information in a simple and effective way. Furthermore, this format is versatile since it can be used as a checklist to both design new VLEs and evaluate the existent ones.

6.2.2 Examples of how to put the recommendations into practice

The development of AdVisor have allowed, in addition to evaluate the set of recommendations, to show possible ways to put these guidelines into practice. In this regard, it is worth emphasizing:

- Information structure
- Visual interface
- Dashboard
- FACRO

Next, each of these elements is described.

6.2.2.1 Information structure

The combination of the ***recommendations A, G and H*** led us to design a database schema which comprised multiples views and, at the same time, was easy to understand and flexible.

According to the results of the evaluation of AdVisor 2.0 (i.e. the last version), the information structure of this prototype seemed to include the most important elements of an online course. Likewise, placing the activities in the core of the schema also seemed to be a wise decision. Moreover, the teachers who were in charge of the courses that participated in the tests did not have difficulty in understanding the information structure.

Given the good results obtained by AdVisor 2.0's information structure, this may serve as a base for other VLEs.

6.2.2.2 Visual interface

As seen in section 3.4, the interfaces of most of current VLEs are textual rather than visual. For this reason, one of the objectives of AdVisor, in conformity with the ***recommendations I-M***, was to create a platform whose interface was much more visual. In principle, a visual interface should have been evaluated positively, but AdVisor's interface design was not suitable enough. The reason was that some users suffered from an information overload due to an excess of visual inputs.

Despite the information overload, there was also evidence that some visual items had allowed to convey information more effectively. A significant proportion of these effective visual elements tried to help students to self-regulate their learning process (i.e. ***recommendations B and C***), e.g. status color, dashboard, etc.

Although the interface of AdVisor 2.0 was not perfect, this was a first step toward a more visual interface which was in line with the possibilities that current web browsers offer.

6.2.2.3 Dashboard

One of the main contributions of this thesis was the learning dashboard. This proposal continues the work realized by other researchers, such as Govaerts et al. (2010) and Duval (2011).

The different tests and the subsequent questionnaires of this thesis have shown that a dashboard which helps students to be more awareness of their learning process (i.e. ***recommendation C***) may be a very useful tool.

Regarding its utility to instructors, the proposed dashboard should be redesigned so that this can really satisfy the needs of this group of users. Even so, the interviewed teachers thought this tool could have great potential as a student/class monitoring tool.

6.2.2.4 FACRO

According to Mazza and Dimitrova (2004), VLEs generally provide teachers with tracking data in a tabular format which is commonly poorly structured, incomprehensible and difficult to understand. To overcome this problem, a novel tool called FACRO (FAceted Class ROster) has been suggested (i.e. ***recommendation E***). This adopts information visualization (InfoVis) techniques to graphically render a vast amount of student tracking data collected by VLEs. More specifically, FACRO uses faceted browsing and data portraits, two techniques that had not been used to monitor learners up to now.

In comparison with other student monitoring tools that display graphics (e.g. bar charts), faceted browsing offers a much greater degree of flexibility in the way of monitoring students, since this allows teachers to filter data based on the attributes (i.e. facets) that they want. Likewise, data portraits enable to compact a student's learning process in a single image. Thereby instructors can gain an insight into a specific student' learning process at a glance.

Finally, it is worth emphasizing that Appendix G provides an up-to-date state of art on educational monitoring tools which can serve as a starting point for many researchers.

6.2.3 State of the art on VLEs from an educational perspective

Although there are many studies that compare different VLEs, most of them (Bri et al., 2008, 2009; Fertalj et al., 2006; Fuentes et al., 2011; Lewis et al., 2005) focus on technological aspects, i.e. the features and functionalities which these systems provide.

By contrast, the study presented in Chapter 3 analyzes VLEs by focusing on the three aspects that, according to (Mastoras et al., 2005), should be the cornerstones of any VLE, i.e. pedagogy, information structure and usability. Therefore, this chapter has offered a new way of analyzing these platforms that is closer to an educational approach than a technological one.

6.2.4 Overview of online education for novices

The principal addressees of this thesis are practitioners and researchers who engage in the creation of educational tools and not necessarily have a previous knowledge of online education (e.g. software designers and developers, IS and computing researchers, etc.). For this reason, Chapter 2 was written to be a *white paper* which was really useful to these people. More specifically, this chapter deals with the main issues of online education which are relevant to this work research.

When I began to write Chapter 2, I had to read a large amount of books, papers and online sources (e.g. blogs) about online education. During this process, I felt a little bit frustrated, since most documentation about this topic is written by taking it for granted that readers are experts in pedagogy. For this reason, and given that I am an engineer, I wanted to write Chapter 2 so that any people who need to learn about online education can gain an understanding of this topic easily.

For all of these reasons, it can be concluded that Chapter 2 may be considered a contribution of this thesis.

6.2.5 State of the art on learner-centered design

Many software designers and developers are used to following a user-centered design (UCD) approach, which includes Nielsen's heuristics. However, section 4.2 discussed the necessity of using a design approach that takes account of the particularities of the learning process when educational tools are being developed. This new approach is known as learner-centered design (LCD). In fact, this approach was taken into account when creating the recommendations of this thesis.

Because LCD is probably new to a lot of software designers and developers, Appendix B shows how UCD heuristics have evolved so as to adapt to the particular necessities of learners. In this regard, seven sets of LCD heuristics, which go from 1996 to 2007, are presented.

In short, this thesis has contributed to develop an awareness of the necessity of taking educational aspects (not only IT guidelines) into consideration when designing learning tools. Likewise, this dissertation can be a starting point for those researchers who are interested in LCD.

6.3 Future work

There is still a considerable work to be done. For example, the set of recommendations proposed in this thesis was evaluated in a specific context: the Bachelor's Degree in Telecommunications of the UOC. This evaluation allowed to obtain a first validation of the recommendations. However, due to the limited scope of the sample, more research in more contexts (i.e. other courses, degrees, universities, etc.) is still needed to guarantee the total suitability of the recommendations suggested. In other words, the more evaluated the set is, the more reliable this will be. Therefore, one of the future directions could be ***to continue evaluating the set of recommendations*** so that the present set of heuristics may be improved and, finally, totally validated.

In order to continue evaluating the set of recommendations, new prototypes of AdVisor could be used. Nevertheless, because this thesis has already presented a validation of this set, many of the ideas derived from its implementation could be integrated in the UOC classroom. This would allow to evaluate the set of recommendations with a wide range of students and teachers. Currently, we are speaking with Tecnologia Educativa[1] to initially add three features of AdVisor to the UOC campus: (1) the Gantt chart, (2) the functionality that enables to mark an activity as finished, and (3) the dashboard. As observed, the previous three elements are related to ***recommendations B and C***, which share the same goal: to support self-regulation, an aspect that was rated positively by both learners and instructors.

On the other hand, this work has opened several new research directions. One of them has been the use of information visualization (InfoVis) techniques for supporting the teaching-learning process. In this regard, three sub-topics can be distinguished in this thesis: (1) learning dashboard, (2) visual interface, and (3) FACRO. Next, possible actions for each of these three sub-topics are described briefly.

- **Learning dashboards**: this dissertation has revealed that online students find this type of tool very useful to have a visual overview of their learning process. Although the dashboard suggested in this thesis was rated positively, we believe that we have just begun to explore the opportunities in this area. Hence, more research is required. In this regard, several issues must still be studied in-depth, e.g. what information is really useful to students (and teachers)? How should that information be displayed? More specific questions related to the work done could be asked too, e.g. could the data portraits of the students be used as mirrors and, therefore, be a part of the learning dashboard?

- **Visual interface**: as said in section 6.2.2.2, AdVisor gave priority to visual cues over text. A good example of this is the wide range of representations used in the workspace, i.e. Gantt chart, treeview, elastic list, etc. Given the potential of visual items for improving the teaching-learning process and the difficulty of achieving a minimalist design that displays a lot information, another field of research could be to investigate how to create learning tools whose interfaces are effective and usable. This research involves studying how to take advantage of InfoVis techniques and usability criteria (including LCD heuristics).

[1] Tecnologia Educativa: department which is in charge of the UOC campus.

- **FACRO**: the next step would be to test this educational monitoring tool in a real-world scenario or through user-based methods (e.g. think aloud). Likewise, it would be interesting to continue enhancing FACRO. Moreover, this should be integrated into some of the most popular open-source VLE, such as Moodle. As a result, educational community could use this tool.

In addition to InfoVis techniques, ***data mining*** (DM) may be an aspect to be included in learning dashboards and monitoring tools. Due to the complexity of the algorithms used in DM, these are able to suggest latent information with an explanation based on text, rules, clusters, etc. Such an information may complement the one extracted from the graphics by the students and teachers. In this regard, we have already done some research on the use of DM algorithms for educational applications. Specifically, we have modeled learners' participation profiles in online discussion forums (see articles 7 and 8 in Appendix H).

The use of data mining could also be used to ***create adaptive VLEs*** that, for instance, personalize the learning paths and recommend learning topics. Thanks to this adaptivity, a better guidance can be provided to the students.

With regard to instructional design, another extensions of this work could be:

- **Educational modeling language (EML)**: currently, the design of a course in AdVisor is defined by means of an XML file which is written by hand. Although this is a first step, the definition of a new EML or the modification of an existing one (like IMS LD) from the information structure proposed in this thesis may be a future field of research.

- **Course editor**: an aspect that could not be addressed in this dissertation was the design of a course authoring tool or, simply, a course editor. As a lot of teachers may have difficulty in designing online subjects, it can be stated that course editors may become key elements. In fact, the interviewees believed that a smart course editor could be a useful tool when designing their courses. In short, another possible field of research could be to study how course authoring tools should be.

As seen, because VLEs are tools that encompass a lot of aspects, there exist multiples and diverse fields of research. In this regard, this section has presented those which are closer to the research work carried out in this dissertation.

Appendices

A The Universitat Oberta de Catalunya (UOC)

Tis appendix introduces the reader to the Universitat Oberta de Catalunya (UOC), the university in which this thesis was carried out. For this purpose, the following topics are covered:

- The history of the university together with some figures (see section A.1).
- The main features which characterize the archetype of UOC student (see section A.2).
- The educational model that this university promotes (see section A.3).
- The assessment model which the UOC implements (see section A.4).
- The Virtual Campus (also known as UOC campus), which is the virtual learning environment of this university (see section A.5).

A.1 History and some figures

The Universitat Oberta de Catalunya (UOC) is a Spanish fully online university with headquarters in Barcelona which was founded by the Catalan government in 1994. The aim of this university was to meet the educational needs that society began to have at that moment, e.g. retraining, life-long learning, etc. To this end, the UOC has been using ICT so as to offer flexible courses that allow students to perform a completely online learning process, regardless of their residence, age, working hours and so on. In this regard, the UOC has had its own virtual campus since the beginning. This platform enables learners to do non-educational tasks (e.g. enrollment, payment, etc.) as well as accessing to the virtual classrooms. In other words, this platform is a replacement of the traditional campus where student life happens.

Over the years, the UOC has settled in other areas beyond the Catalonia. In 2000, it expanded to Spain and Latin America countries and, recently, it has begun to offer its courses in English and French-speaking countries. This expansion has contributed to the growth of this university. For example, ***the number of students has gone from 16000 in 2000 to over 60.000 in the 2010-2011 academic year*** (see Table A.1). Likewise, the UOC currently has ***a catalog of more than 850 academic qualifications*** that belong to seven areas: (1) economics and business studies, (2) IT, multimedia and telecommunication, (3) law and political sciences, (4) arts and humanities, (5) psychology and education sciences, (6) information and communication sciences, and (7) health sciences. These academic qualifications includes both official and UOC-specific degrees.

By way of example, in the 2010-2011 academic year, ***3385 virtual classrooms*** for Catalan (1642) and Spanish (1743) courses were used. The success of this academic year was possible thanks to a management staff of 490 and a teaching staff of 249 teachers and 3155 teaching collaborators[1].

Thanks to these figures, ***the UOC is one of the main Spanish online universities and***, according to Paulsen (2007), ***one of the 26 European megaproviders of e-learning***.

Official	Bachelor degree	EHEA degree	18062
		Non-EHEA degree	15345
		Diploma or foundation degree	10785
	Postgraduate	University master's degree	2906
	Doctoral	PhD	56
UOC-specific	Bachelor degree	Multimedia degree	136
	Postgraduate	Master's degree	781
		Postgraduate degree	1271
		Specialization course	1288
	Other	University athenaeum	3044
		Summer and winter open university	2897
		School of languages	2508
		Seminars, customized training, etc.	1797
		Total	**60876**

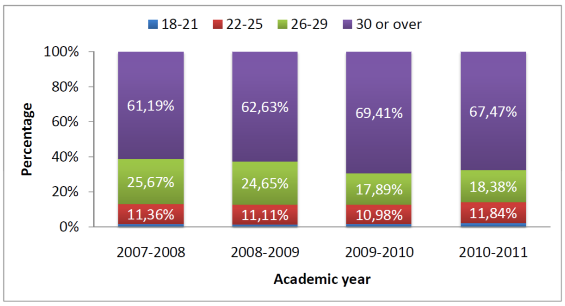
Table A.1: Breakdown of students at the UOC in the 2010-2011 academic year. ***Source***: (UOC, 2011).

[1] A *teacher* is responsible for the course and she is in charge of its design, whereas a *teaching collaborator* accompanies and guides the students during the learning process. So, *teachers* do managerial tasks and remain in the background, while *collaborators* are in touch with the learners and perform tasks such as grading, answering questions, etc.

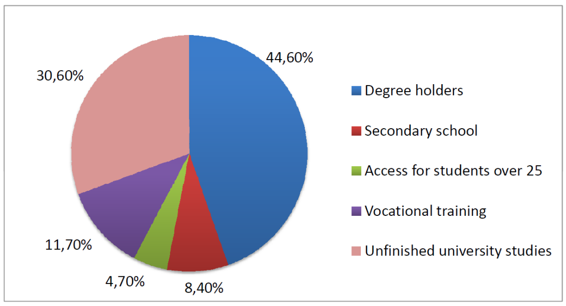
A.2 UOC students' profile

As shown in Figure A.1, UOC students match the typical profile of online learners (see section 2.4.1.1). Broadly speaking, they are:

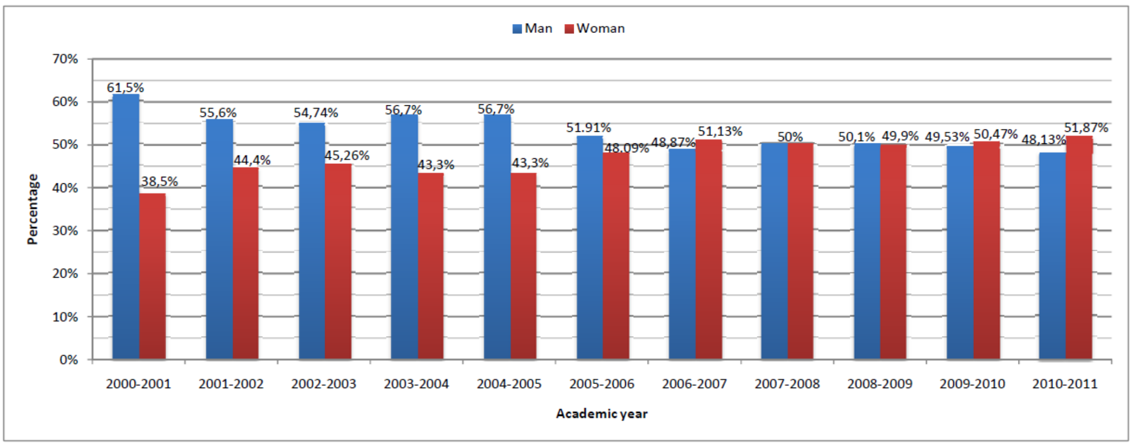
- **Adult**: more than 85% of the UOC students are over 25 years old (see Figure A.1a).
- **Employed**: most of them work. As proof of this, 94.8% worked during the 2002-2003 academic year and 95% had a full-time (89%) or part-time (6%) work in 2008-2009.
- **University experience**: a lot of students have university experience before enrolling in the UOC. More specifically, in the 2008-2009 academic year, 75% of students either held a degree (44.6%) or had not finished their university studies (30.6%) (see Figure A.1b).
- **The same number of men and women**: although the number of men enrolled in the UOC was greater initially, this figure has become practically equal to that of women since 2005 (see Figure A.1c).



(a) Breakdown of students by age from 2007 to 2011



(b) Students' academic profile prior to enrolling in the UOC in the 2008-2009 academic year



(c) Breakdown of students by gender from 2000 to 2011

Figure A.1: UOC students' profile. ***Sources***: (Lladós, 2009; UOC, 2011).

A.3 Educational model

As seen in Figure A.2, the UOC's educational model places the student's learning activity in the center of the teaching-learning process (Gros et al., 2009). This model also includes other three elements which revolve around the learning activity:

- **Resources**: any sort of item that is needed to perform a learning activity, e.g. document, audio, video, simulation, remote laboratory, etc. They can also be additional elements that allow students to increase their knowledge further than the scope of the course.

  All the subjects provide the learners with either lecture notes written by the teacher or a book at least. Likewise, most of them also give students short weekly guides which summarily indicate the sections of the book/lecture notes that should be read as well as the learning activities that should be done.

- **Accompaniment**: this consists of a group of actions that is carried out by the teaching collaborators. These actions are basically to track each student and guide her until attaining course and individual objectives. To do such actions, instructors resolve activities, help learners to plan their work, give students tailored feedback, etc. As it can be noticed, teaching collaborators are facilitators who guide and support the students. In other words, the UOC implements a student-centered learning. As seen, this is totally in accord with Constructivism (see section 2.4.2.1).

- **Collaboration**: the set of tools (e.g. forums, wikis, etc.) that encourages communication and teamwork among classmates. This type of tool enriches the learning process, since the help of the classmates complements the teaching collaborator's support. Thus, collaborative learning becomes essential in the UOC educational model. Furthermore, due to the idiosyncrasy of online students, the UOC mainly promotes asynchronous communication.

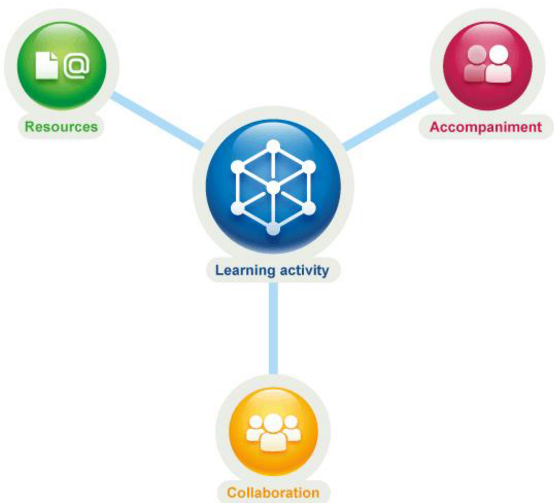


Figure A.2: UOC's educational model with the learning activity in the center. ***Source***: (Gros et al., 2009).

A.4 Assessment model

As far as the assessment model is concerned (see Figure A.3), ***the UOC promotes continuous assessment (CA) in all its subjects***. The CA is conceived as a mechanism that assesses the learners at different moments in the course of the semester and, at the same time, provides the students with feedback on their learning process. To this end, several assignments (usually four), called continuous assessment assignments (CAAs), are scheduled throughout the semester. Teaching collaborators grade the CAAs and give feedback to the learners. At the end of the subject, all the learners get a CA grade, which is the average of the grades obtained in all the CAAs.

As it can be observed, the fact that the UOC promotes the CA indicates that this university attaches great importance to the coursework. This matches the tenet of Constructivism which says that evaluating how students are progressing in the construction of knowledge is more important than the resulting product (see section 2.4.2.1). Likewise, the CAAs are used to guide learners through the course. At this point, it is worth emphasizing that the students are free to do the CAAs, except for those courses whose assessment model only has CA (Model 1 in Figure A.3). Nevertheless, all the teachers encourage their students to do CAAs, since the completion of the CAAs is a way of learning. Moreover, after more than 17 years, it has been proven that doing the CAAs helps the students to learn the new concepts and, hence, to pass their courses more easily.

Although there are a few subjects based on the Model 1 of the Figure A.3 (i.e. they only have CA), most of the courses follow the Model 2. This model forces the students who pass the CA to take a validation test on site at one of the UOC's centers at the end of the semester. This test tries to

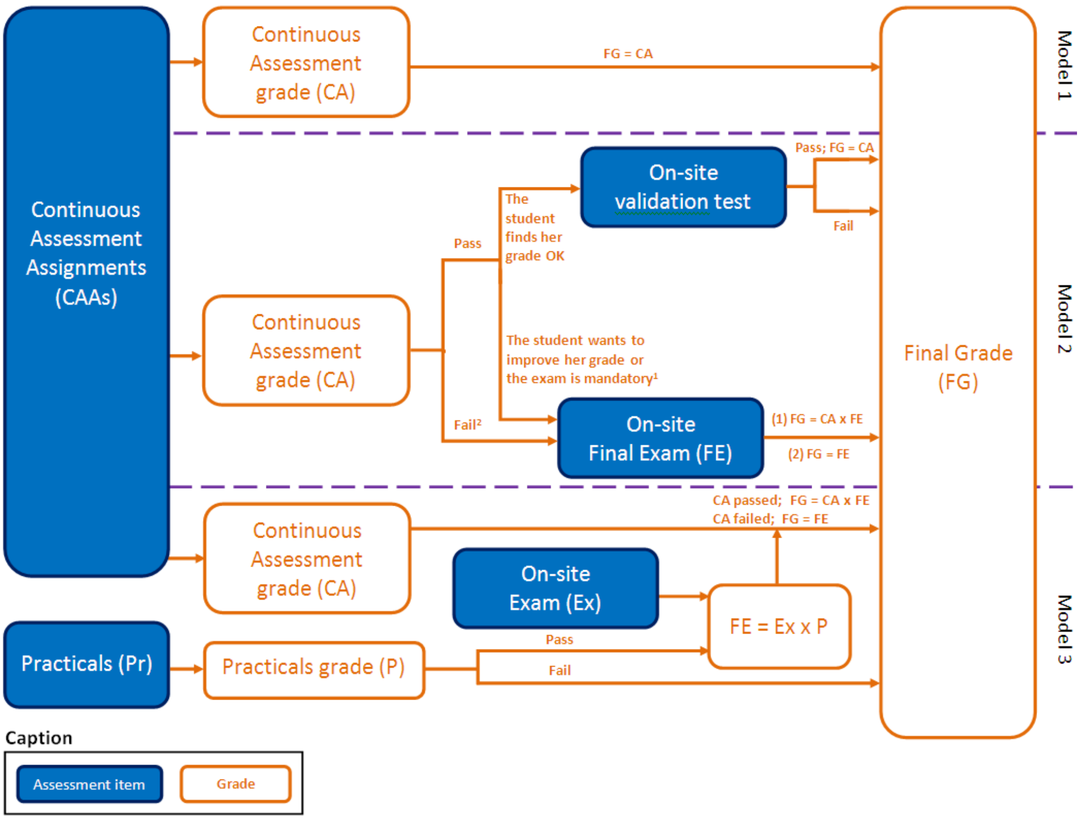


Figure A.3: The most common assessment models at the UOC.

check that the student was the person who really did the CAAs that she handed in. For this reason, the exercises of this test are based on those of the CAAs. If the student passes the validation test, then the final grade of the course is directly the CA grade. Otherwise, the student fails the subject.

If the student does not pass the CA or if she wants to improve the final grade that she would get from the CA grade, then the learner must take an on-site final exam. Unlike the validation test, the exam asks new exercises that are specially created for that occasion. In this case, the final grade of the course depends on the path that the student has followed: (1) when the student has passed the CA, then the final grade of the course is obtained by combining the grade of the final exam with the CA grade; (2) otherwise, the final grade of the subject is directly the grade of the final exam. At this point, it is worth saying that there are some courses that force their students to take a final exam. In such cases, the final exam tries to guarantee that the learners have achieved a minimum amount of competences in a harder way than that of the validation test.

Finally, there is a third model which includes practicals. Practicals are mandatory assignments that are usually more complex and longer than CAAs. Such assignments are very common in technical courses, such as those that belong to Telecommunications and Computer Science. In this third model, if the student does not pass the practicals, then she fails the course. When the student passes the practicals, the average grade of all them (P) is combined with the grade of the final exam. Next, the resulting grade (FE) is combined with the CA grade as long as the student has passed the CA. Otherwise, the final grade of the course is directly FE.

The previous three models are the most common. Nevertheless, there are other models such as the one based only on the combination of CAAs and practicals.

As seen, the assessment model do not require the students to attend F2F classes during the semester, except for the validation tests and the exams that are mandatory to be taken face-to-face at one of the UOC's centers at the end of the course.

A.5 Virtual campus

As VLEs were not very popular programs in 1994, an ad hoc VLE called *Virtual Campus* (or also known as *UOC campus*) was developed. This was designed as a web-based environment in which the life of the university community takes place. Just like an F2F university campus, the Virtual Campus allows the students to do administrative (e.g. enrollment, payment, etc.) as well as accessing to the virtual classrooms. In this regard, the rest of this section will be limited to the explanation of the classrooms, because the administrative tasks are out of the scope of this work.

The classrooms are learning spaces where a student meets the teacher and her classmates. Likewise, the classrooms include the learning content, activities and communication tools that are necessary to study (see Figure A.4). In this regard, each classroom is divided into four areas:

- **Communication**: there are three different communication spaces in an UOC classroom:
  - **Notice board**: this is a space where only teachers can write messages and learners are only permitted to read them. This is often used to put reminders and important notices.

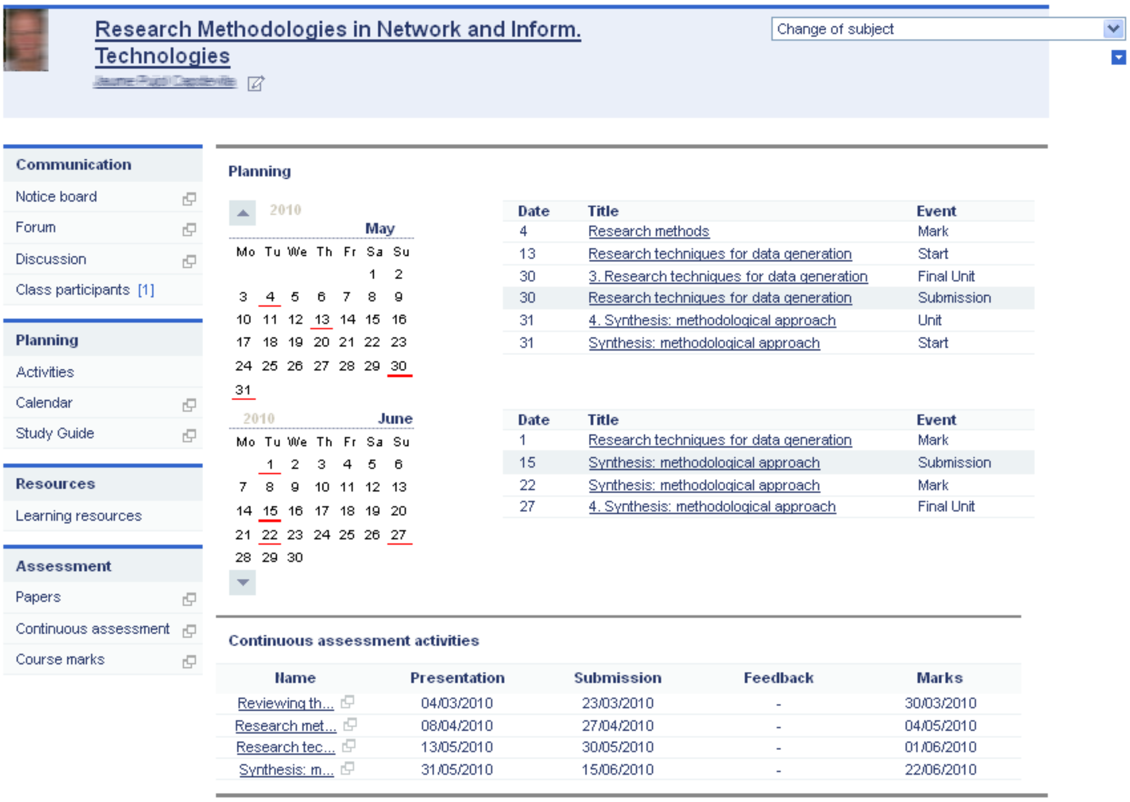


Figure A.4: UOC's virtual classroom.

- **Forum**: the main goal of this space is to allow the interaction between class members. Therefore, both students and lecturers can write and read messages. This is often used to ask and answer questions. The writing style is informal.
- **Discussion**: this is identical to the forum, but it is usually related to a learning activity. Hence, the quality of the messages is assessed. Thus, the writing style is often formal.

Besides the previous communication spaces, students can see those classmates who are on-line (i.e. *class participants*).

- **Planning**: in this area, the learner can read the syllabus (i.e. *study guide*). Moreover, there is a *calendar* in which shows the key events of the course, e.g. assignments' start and deadline dates. Mandatory assignments (i.e. CAAs) can also be found in a link called *activities*.
- **Resources**: thanks to this section, learners can access to the learning resources of the course in a digital format. In addition, other resources from the UOC's library can be consulted.
- **Assessment**: this space allows, on the one hand, the students to hand in their CAAs and, on the other, the instructors to assess them. Furthermore, learners can see their grades for each CAA as well as the overall CA grade.

In 2008, the Virtual Campus began to use of the standard OKI, which allows to integrate Moodle and Sakai tools/classrooms in the core of the campus easily. This was doubtless a turning point.

At present, the Virtual Campus continue to improve day by day.

B Sets of UCD and LCD heuristics

This appendix consists of the following two sections:

- The two main usability evaluation methods are described and compared (see section B.1).
- Heuristic evaluation is explained briefly (see section B.2). Next, the appendix focuses on the sets of heuristics that have been created from:
  - A user-centered design (UCD) approach (see section B.2.2).
  - A learner-centered design (LCD) approach (see section B.2.3).

B.1 Usability evaluation methods

Over the years, a variety of UCD methods for evaluating the usability of computer tools have been defined. In general, there are two commonly adopted approaches (Matera et al., 2002):

- User-based methods
- Usability inspection methods

They both are described below. Likewise, Table B.1 summarizes their main features.

B.1.1 User-based methods

The principal characteristic of these usability evaluation techniques can be summarized by means of the following definition:

User-based methods

These methods basically involve assessing various usability properties by observing how the system is used by a sample of real end-users.

The main advantage of these methods is that they provide ***the trustiest evaluation***, since the results are based on the observation of real users while they do real tasks. However, these techniques essentially have two problems:

- The cost is considerable due to the amount of time and effort that are needed to prepare the evaluation (Jeffries et al., 1991).
- The difficulty to reproduce the actual usage situation due to, among other issues, the Hawthorne effect, i.e. users modify their behavior because of the fact that they know they are being observed (Triacca et al., 2004).

Some techniques that belong to this category are: *think aloud* and *post-task walkthrough*.

B.1.2 Usability inspection methods

Unlike the user-based methods, this category is characterized by:

Usability inspection methods

These methods do not involve real end-users in the evaluation process. Instead, only expert inspectors assess the tool and provide judgments based on their knowledge.

	User-based methods	Usability inspection methods
Participants	Real end-users	Expert evaluators
Advantages	• Objective ⇒ trusty evaluation	• Good effectiveness-cost ratio • No special equipment, no real users
Disadvantages	• High cost • Hawthorne effect ⇒ difficulty in reproducing the real usage situation	• Dependence upon inspector's skills and knowledge ⇒ subjective results
Examples of techniques	• Think aloud • Post-task walkthrough	• Heuristics • Cognitive walkthrough

Table B.1: Main differences between user-based methods and usability inspection methods.

The techniques that belong to this category have ***a better effectiveness-cost ratio than user-based methods*** (Jeffries et al., 1991), since they do not need any special equipment, lab facilities nor real users (Ardito et al., 2004a). Nevertheless, ***the results are more subjective*** because they depend on the evaluators' experience and skills (Jeffries et al., 1991).

Despite the fact that there are different inspection techniques, ***the most popular one is heuristic evaluation***.

B.1.3 Which method is mainly used in learner-centered design (LCD)?

After reviewing the literature exhaustively, it can be concluded that although there are some studies which evaluate educational software by using user-based techniques, such as (UWG, 2010), the most common approach is the one that is based on usability inspection methods, more specifically, heuristics. For this reason, the rest of this appendix will be focused on heuristic evaluation.

B.2 Heuristic evaluation

First of all, this section defines what heuristic evaluation means and which is its principal advantage in comparison with other usability evaluation techniques.

Next, the evolution of the sets of heuristics based on a user-center design (UCD) approach is explained by means of three milestones, which are the three most popular sets: Shneiderman's, Norman's and Nielsen's sets. Moreover, each of these three sets is described in detail.

Finally, the section focuses on those heuristics that have been created from a learner-centered design (LCD) approach. More specifically, this appendix details seven of the most important sets of LCD heuristics that can be found in the literature.

B.2.1 What does heuristic evaluation mean?

Heuristic evaluation can be defined as follows:

Heuristic evaluation

It is a usability inspection method proposed by Nielsen and Molich (1990) whereby a small group of expert evaluators, guided by a set of usability principles (i.e. heuristics), determine whether a system conforms to these and identify specific usability problems.

(Ssemugabi and de Villiers, 2007)

Apart from being useful for evaluating and finding problems in existing tools, ***heuristics can also be used as guidelines during the design stage of a computer tool***. Thanks to its simplicity, heuristic evaluation can be used to find the usability problems in a user interface design so that they can be attended to as part of an iterative design process (Nielsen, 1994b). This possibility is an advantage compared to other techniques.

B.2.2 Sets of user-centered design heuristics

Even though the term *heuristic* was not used until 1990, some design guidelines which were proposed before the '90s have been considered as heuristics by a lot of researchers and practitioners. One of these sets of guidelines are the *eight golden rules* that were derived from experience by Shneiderman (1987, see section B.2.2.1). These rules have become widely used by designers because they are applicable in most interactive systems.

Similarly, Norman (1988) suggested seven principles that tried to facilitate the designer's task. These seven principles focus on transforming difficult tasks into simple ones. These are based on particular characterizations of the nature of human action (see section B.2.2.2).

In 1990, Nielsen and Molich proposed the heuristic evaluation and defined a set of usability principles, called heuristics, which was refined by Nielsen based on a factor analysis of 249 usability problems in 1994. The revised set (Nielsen, 1994a, see section B.2.2.3) consists of 10 heuristics which allow to evaluate software regardless of its purpose. Nowadays, ***these heuristics are probably the most used in the field of user-centered interface design***.

Next, the previous three sets of usability heuristics are described:

- Shneiderman's eight golden rules
- Norman's seven principles
- Nielsen's 10 usability heuristics

B.2.2.1 Shneiderman's eight golden rules of interface design

This section details the eight rules defined by Ben Shneiderman (1987) in the book *"Designing the user interface: strategies for effective human–computer interaction"*.

#	Rule
1	***Strive for consistency*** Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout.
2	***Enable frequent users to use shortcuts*** As the frequency of use increases, so do the user's desires to reduce the number of interactions and to increase the pace of interaction. Abbreviations, function keys, hidden commands, and macro facilities are very helpful to an expert user.
3	***Offer informative feedback*** For every operator action, there should be some system feedback. For frequent and minor actions, the response can be modest, while for infrequent and major actions, the response should be more substantial.
4	***Design dialog to yield closure*** Sequences of actions should be organized into groups with a beginning, middle, and end. The informative feedback at the completion of a group of actions gives the operators the satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans and options from their minds, and an indication that the way is clear to prepare for the next group of actions.
5	***Offer simple error handling*** As much as possible, design the system so that the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.
6	***Permit easy reversal of actions*** This feature relieves anxiety, since the user knows that errors can be undone; it thus encourages exploration of unfamiliar options. The units of reversibility may be a single action, a data entry, or a complete group of actions.
7	***Support internal locus of control*** Experienced operators strongly desire the sense that they are in charge of the system and that the system responds to their actions. Design the system to make users the initiators of actions rather than the responders.
8	***Reduce short-term memory load*** The limitation of human information processing in short-term memory requires that displays be kept simple, multiple page displays be consolidated, window-motion frequency be reduced, and sufficient training time be allotted for codes, mnemonics, and sequences of actions.

Table B.2: The eight golden rules defined by Shneiderman (1987).

B.2.2.2 Norman's seven principles

These seven principles provide a useful summary of Norman (1988)'s user-centered design philosophy. These were defined in the book *"The design of everyday things"* and are listed below.

#	Principle
1	***Use both knowledge in the world and knowledge in the head*** By building conceptual models, write manuals that are easily understood and that are written before the design is implemented.
2	***Simplify the structure of tasks*** Make sure not to overload the short-term memory, or the long-term memory of the user. On average, the user is able to remember five things at a time. Make sure the task is consistent and provide mental aids for easy retrieval of information from long-term memory. Make sure the user has control over the task.
3	***Make things visible*** Bridge the gulfs of execution and evaluation. The user should be able to figure out the use of an object by seeing the right buttons or devices for executing an operation.
4	***Get the mappings right*** One way to make things understandable is to use graphics.
5	***Exploit the power of constraints, both natural and artificial*** In order to give the user the feel that there is only one possible thing to do.
6	***Design for error*** Plan for any possible error that can be made, this way the user will be allowed the option of recovery from any possible error made.
7	***When all else fails, standardize*** Create an international standard if something cannot be designed without arbitrary mappings.

Table B.3: The seven principles defined by Norman (1988).

B.2.2.3 Nielsen's 10 usability heuristics

This section lists the 10 general heuristics for user interface design that Jakob Nielsen (1994a) defined. They can be found in Nielsen's website: www.useit.com/papers/heuristic/heuristic_list.html.

#	Heuristic
1	***Visibility of system status*** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
2	***Match between system and the real world*** The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
3	***User control and freedom*** Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialog. Support undo and redo.
4	***Consistency and standards*** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
5	***Error prevention*** Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
6	***Recognition rather than recall*** Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialog to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
7	***Flexibility and efficiency of use*** Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
8	***Aesthetic and minimalist design*** Dialogs should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialog competes with the relevant units of information and diminishes their relative visibility.
9	***Help users recognize, diagnose, and recover from errors*** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
10	***Help and documentation*** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Table B.4: The 10 usability heuristics defined by Nielsen (1994a).

B.2.3 Sets of learner-centered design heuristics

Despite its popularity, Nielsen's heuristics (and Shneiderman's and Norman's ones) are so general that can be insufficient or inadequate for some domains. This is the case of education, in which some researchers have argued that learning process modifies the UCD definitions of user and task. As a result, new heuristics based on a learner-centered design (LCD) have been defined. Broadly speaking, two types of heuristics for educational software can be distinguished:

Types of LCD heuristics

- The ones that are adaptations of Nielsen's heuristics to the educational context.
- Heuristics created from scratch by following an LCD approach.

The rest of this section describes, in chronological order, seven of the most relevant works that have been carried out in the field of the heuristics for educational software. Specifically, four of these seven sets are based on Nielsen's one to some extent, whereas the other three are totally new. Table B.5 displays the heuristics that will be described and highlights the main features.

Author	**Year**	**No. heuristics**	**Foundations**[1]
Quinn	1996	8	Cognitive Apprenticeship Anchored Instruction Problem-Based Learning Laurillard's model of technology-mediated learning
Squires and Preece	1999	8	Nielsen's heuristics Principles of Constructivism
Reeves et al.	2002	15	Nielsen's heuristics Instructional design principles
Ardito et al.	2004	39 heuristics for platforms	Authors' previous experience in usability evaluation Results of a user testing (think aloud + interviews)
Mehlenbacher et al.	2005	5 dimensions and 21 heuristics	HCI research Rhetorical theory Principles of e-learning design
Dringus and Cohen	2005	13 categories 161 heuristics	Nielsen's and Reeves et al.'s heuristics Authors' experience and evaluation of WebCT
Ssemugabi and de Villiers	2007	20	Nielsen's heuristics Specific heuristics for website design Learning theories, models and heuristics

[1] These foundations have been collected from the original papers.

Table B.5: Summary of the sets of LCD heuristics described in this appendix.

B.2.3.1 Quinn's heuristics

In a pioneering work, Quinn (1996) proposed the adaptation of the usability inspection methods for the purpose of evaluating the educational design of software. To this end, he looked for a convergent model which covered elements that were shared by the following theoretical perspectives on learning and instruction: Cognitive Apprenticeship, Anchored Instruction, Problem-Based Learning and Laurillard's model of technology-mediated learning.

According to Quinn (1996), he selected the aforementioned four approaches because, despite their differences, they implicitly or explicitly share an overall structure that includes two components: (1) to engage the learner in sequenced activities that match her abilities, and (2) guided reflection on learning where the students state their understanding and receive feedback. The resultant set consisted of eight heuristics (see Table B.6).

#	Heuristic
1	***Clear goals and objectives*** The software should make it clear to the learner what is to be accomplished and what will be gained form its use.
2	***Context meaningful to domain and learner*** The activities should be situated in practice and engaging to the learner.
3	***Content clearly and multiply represented, and multiply navigable*** The message should be unambiguous. The software should support different learner preferences and allow the student to find relevant information while engaged in an activity.
4	***Activities scaffolded*** Learner activities need to be supported to allow working within competence yet on meaningful chunks of knowledge
5	***Elicit learner understandings*** Learners need to articulate their conceptual understandings as the basis for feedback.
6	***Formative evaluation*** The software should provide learners with constructive feedback on their endeavors.
7	***Performance should be "criteria-referenced"*** The software should provide outcomes that are clear and measurable; likewise, competency-based evaluation should be a goal.
8	***Support for transference and acquiring "self-learning" skills*** The software should support transference of the skills beyond the learning environment, and this should also facilitate the learner to become able to self-improve.

Table B.6: Heuristics defined by Quinn (1996).

B.2.3.2 Squires and Preece's heuristics

Squires and Preece (1999) wanted to provide instructors with a predictive evaluation method that helped them to easily decide what software to use in class. To this end, Squires and Preece adapted the idea of heuristic evaluation to the educational context. First, they established possible relationships between Nielsen's heuristics and the principles of Social Constructivism. Based on that work, they finally developed a set of eight heuristics that took account of both usability and learning issues. These heuristics were called *learning with software heuristics* (see Table B.7).

#	Heuristic
1	***Match between designer and learner models*** There should not be significant differences between designer's and learner's model. Should this not be the case, the discrepancy could cause misconceptions in the learner. To avoid it, feedback should provide an understandable representation of the cognitive tasks which ensures that learner's model will be consistent with the designer's one.
2	***Navigational fidelity*** Interfaces should have a balance between complexity and simplicity. On the one hand, an excess of features may result in superficially complex interfaces which focus interaction on incidental navigation, rather than intended learning tasks and, on the other, a simplistic navigation may compromise the learning process.
3	***Appropriate levels of learner control*** A learner should have a sense of ownership of her learning within a supportive learning environment in which peers and teachers help her.
4	***Prevention of peripheral cognitive errors*** Usability errors should be anticipated and avoided, whereas cognitive errors are permissible when they are relevant to major learning issues.
5	***Understandable and meaningful symbolic representation*** The interface should demand a low cognitive load and the functionalities should be obvious. Symbols, icons and names should be consistent throughout the application.
6	***Support personally significant approaches to learning*** This is implemented by multiple representations, learner's support materials and metacognition. It should be clear what learning styles are supported and which aspects of the application relate to learning styles.
7	***Strategies for the cognitive error recognition, diagnosis and recovery cycle*** People learn by their mistakes. There should thus be strategies that promote this cycle, e.g. cognitive conflict, instructional scaffolding, etc.
8	***Match with the curriculum*** Educational tools should correspond, to some extent, to the curriculum of the course.

Table B.7: Heuristics defined by Squires and Preece (1999).

B.2.3.3 Reeves et al.'s heuristics

Reeves et al. (2002) wrote the results of the discussions that were carried out in a doctoral seminar held at the University of Georgia between August and December 2001. First of all, the traditional heuristic evaluation defined by Nielsen and Molich (1990) was modified so as to evaluate e-learning programs. These modifications also involved an expansion of Nielsen's heuristics in order to include instructional design principles. The final result was a set of 15 heuristics (see Table B.8) in which the first eight were based on Nielsen's ones (see section B.2.2.3).

#	Heuristic
1	***Visibility of system status*** (Nielsen's heuristic #1)
2	***Match between system and the real world*** (Nielsen's heuristic #2)
3	***Error recovery and exiting*** (Nielsen's heuristic #3)
4	***Consistency and standards*** (Nielsen's heuristic #4)
5	***Error prevention*** (Nielsen's heuristic #5)
6	***Navigation support*** (Nielsen's heuristic #6)
7	***Aesthetics*** (Nielsen's heuristic #8)
8	***Help and documentation*** (Nielsen's heuristic #10)
9	***Interactivity*** Providing content-related interactions and tasks that support meaningful learning.
10	***Message design*** Information should be presented in keeping with sound information-processing principles so that the information is presented correctly.
11	***Learning design*** Interactions should be designed in accord with the principles of a learning theory.
12	***Media integration*** The inclusion of media should serve clear pedagogical and/or motivational purposes. Any form of medium must thus be included to enrich the learning process.
13	***Instructional assessment*** If appropriate to the content, the program should provide assessment opportunities that are aligned with the program objectives and content.
14	***Resources*** The tool should provide access to all the resources necessary to support learning.
15	***Feedback*** The educational software should provide feedback that is contextual and relevant to the problem or task in which the learner is engaged.

Table B.8: Heuristics defined by Reeves et al. (2002).

B.2.3.4 Ardito et al.'s heuristics

Ardito et al. (2004b) aimed to define a methodology for evaluating e-learning applications which involved adapting the SUE methodology (Matera et al., 2002) to the e-learning domain. To this end, they developed a set of heuristics that is original in the sense that it explicitly distinguishes between the heuristics for e-learning platforms and those for content (or, as they call them, e-learning modules). As the scope of this thesis is the effective design of VLEs, this section will only pay attention to those heuristics that are related to e-learning platforms.

Ardito et al. (2004b) created their heuristics based on four dimensions:

- **Presentation**: this encompasses exterior features of the interface, i.e. all aspects related to visualization of tools and elements of the platform.
- **Hypermediality**: all features that enable to communicate through different channels (audio, video, textual, etc.) and even to organize lessons in a non-sequential way, allowing students to choose a logical path different from the one suggested.
- **Application proactivity**: ease of use of the tools so that students do not spend time on learning how the platform works, but they just make an effort to learn the course's learning domain. Likewise, it is also important to avoid potential problems through error prevention.
- **User's activity**: this is related to the needs of a student/lecturer which could arise during the user's interaction.

The choice of these dimensions was based on the researchers' previous experience in the domain of usability evaluation of hypermedia systems, stressing the importance of evaluating an application from different points of view so as to obtain more accurate results. For each dimension, Ardito et al. associated two general principles that contribute to characterize usability (ISO-9241, 1998): (1) effectiveness, and (2) efficiency. They each were divided into two criteria:

- **Effectiveness** (i.e. task completion by users)
  - **Supportiveness for learning/authoring**: this concerns the degree to which the tools provided by the platform allow to learn and prepare lessons and educational paths in an effective way.
  - **Supportiveness for communication, personalization and access**: how the provided tools satisfy these needs.
- **Efficiency** (i.e. task in time)
  - **Structure adequacy**: how efficiently the activities that the student usually performs are structured and visualized.
  - **Facilities and technology adequacy**: it concerns the efficiency of scaffolding and supplementary supports provided to the user. In other words, how the platform adapts to the technology used by the learner to access it.

Finally, Ardito et al. proposed, in the form of guidelines, a set of heuristics for each of criteria of each general principle of each dimension (see Table B.9). These guidelines were defined from a user testing in which 10 students were observed during their interaction with an educational tool.

Dimension	**General Principle**	**Criterion**	**Guideline**
Presentation	Effectiveness	Supportiveness for learning/authoring	For interface graphical aspects, the same UCD attributes hold
			Errors and cues to avoidance are highlighted
		Supportiveness for communication, personalization and access	It is possible to personalize interface graphics
	Efficiency	Structure adequacy	System state is clearly and constantly indicated
			Progress tracking is clearly visualized
			Possibilities and commands available are clearly visualized
			Course structure is clearly visualized
		Facilities and technology adequacy	Adaptation of the graphical aspect to the context of use is provided
Hypermediality	Effectiveness	Supportiveness for learning/authoring	The lecturer is supported in preparing multimedia material
			Easy movement among subjects is allowed by highlighting cross-references through state and course maps
		Supportiveness for communication, personalization and access	Communication is possible through different media channels
			A personalized access to learning contents is possible
	Efficiency	Structure adequacy	Both lecturer and student can access the repository
		Facilities and technology adequacy	It is possible to create contextualized bookmarks
			The platform can be used off-line, maintaining tools and learning context

Table B.9: Heuristics defined by Ardito et al. (2004b).

Dimensions	**General Principles**	**Criteria**	**Guidelines**
Application Proactivity	Effectiveness	Supportiveness for learning/authoring	Lecturers can access a scaffolding library to suggest winning models
			It is possible to insert assessment tests in various forms
			The platform automatically updates students' progress tracking
			The platform allows to insert learning domain tools
		Supportiveness for communication, personalization and access	Users profiles are managed
	Efficiency	Structure adequacy	Mechanisms exist to prevent usage errors
			Mechanisms exist for teaching-through-errors
			Lecturers and students access the repository in different modes
			Platform tools are easy to use
		Facilities and technology adequacy	It is possible to automatically and correctly attenuate scaffolding
			Adaptation of technology to the context of use is provided
			The date of last modification of documents is registered in order to facilitate updating
User's Activity	Effectiveness	Supportiveness for learning/authoring	Easy-to-use authoring tools are provided
			Assessment tests to check one's progress at any time are provided
			Reports are managed about attendance and usage of a course
			It is possible to use learning domain tools even when not scheduled
		Supportiveness for communication, personalization and access	It is possible to eliminate scaffolding or to personalize its attenuation
			Both synchronous and asynchronous communication tools are provided
			It is possible to communicate with both students and lecturers
			It is possible to make annotations
			It is possible to integrate the provided material
	Efficiency	Structure adequacy	Mechanisms are provided for search by key or natural language
		Facilities and technology adequacy	Authoring tools allow to create standard-compliant documents and tests (AICC, IMS, SCORM)
			Authoring tools facilitate documents update and assessment tests editing

Table B.9: Heuristics defined by Ardito et al. (2004b) (continued)

B.2.3.5 Mehlenbacher et al.'s heuristics

First of all, in order to identify common instructional situations, Mehlenbacher (2002) analyzed and compared ten models of instruction and learning that used technology. From that analysis, he proposed a conceptual framework that consisted of five interdependent dimensions which, according to him, were found in all (or everyday) instructional situations. These dimensions were: (1) learner background and knowledge, (2) learner tasks and activities, (3) social dynamics, (4) instructor activities, and (5) learning environment and tools. With his framework, Mehlenbacher wanted to provide researchers and practitioners with a useful instrument that allowed them to describe and evaluate any instructional situation.

Later, Mehlenbacher et al. (2005) connected the five dimensions to a set of heuristics for designers and evaluators of online learning environments (see Table B.10). These heuristics were influenced by a holistic approach based on HCI research, rhetorical theory and e-learning design. For each heuristic, they provided some questions that the designer or evaluator should ask herself while designing/evaluating an online learning environment. These questions can be founded in the paper (Mehlenbacher et al., 2005).

<table>
<tr><th colspan="2">Dimension of all instructional situations</th><th>Heuristic</th></tr>
<tr><td colspan="2" rowspan="5">Learner background and knowledge</td><td>Accessibility</td></tr>
<tr><td>Customizability and maintainability</td></tr>
<tr><td>Error support and feedback</td></tr>
<tr><td>Navigability and user movement</td></tr>
<tr><td>User control, error tolerance, and flexibility</td></tr>
<tr><td rowspan="8">Learner tasks and activities</td><td rowspan="4">Instructional content</td><td>Completeness</td></tr>
<tr><td>Examples and case studies</td></tr>
<tr><td>Readability and quality of writing</td></tr>
<tr><td>Relationship with real-world tasks</td></tr>
<tr><td rowspan="4">Interaction display</td><td>Aesthetic appeal</td></tr>
<tr><td>Consistency and layout</td></tr>
<tr><td>Typographic cues</td></tr>
<tr><td>Visibility of features and self-description</td></tr>
<tr><td colspan="2" rowspan="2">Social dynamics</td><td>Mutual goals and outcomes</td></tr>
<tr><td>Communication protocols</td></tr>
<tr><td colspan="2" rowspan="2">Instructor activities</td><td>Authority and authenticity</td></tr>
<tr><td>Intimacy and presence</td></tr>
<tr><td colspan="2" rowspan="4">Learning environment and tools</td><td>Help and support documentation</td></tr>
<tr><td>Metaphors and maps</td></tr>
<tr><td>Organization and information relevance</td></tr>
<tr><td>Reliability and functionality</td></tr>
</table>

Table B.10: Dimensions and heuristics defined by Mehlenbacher et al. (2005).

B.2.3.6 Dringus and Cohen's heuristics

Drawing on Nielsen (1994a) and Reeves et al. (2002)'s heuristics, Dringus and Cohen (2005) conducted a heuristic evaluation of WebCT from the perspectives of the learner and the instructor. As a result of this evaluation, they obtained a list of usability problems. Apart from this list, they made another one based on their teaching experience. They then merged the two problem lists into one comprehensive list. From the aggregated problem list, Dringus and Cohen identified 13 heuristic categories that included 161 specific heuristics (see Table B.11). In this regard, the specific heuristics were written in the form of questions so that inspectors could ask themselves during the evaluation.

In order not to overwhelm the reader with too many heuristics/questions, Table B.11 only shows some of them for each category.

#	Heuristic category
1	***Visibility*** • Does the user know where to start on the main page? • Is the intended functionality clear for each option or selection? • Are button labels meaningful? • Can the user visibly discriminate between information and activities arranged on the homepage?
2	***Functionality*** • How many actions/selections does the instructor have to do to complete one main task (e.g. establish an assignment)? • How intuitive are button functions without clicking on them first? • Are there sufficient shortcuts for navigating the activity, function or action?
3	***Aesthetics*** • Is there proper use of color or graphics that enhance navigation? • Are items or functions placed in meaningful order? • Are the screens pleasing to look at? • Is there too much course content or information on the screen?
4	***Feedback and Help*** • Is the user offered sufficient FAQs and human support to obtain necessary help? • Are system messages meaningful? • Is the user provided with sufficient information to know what the system status is and where in the system she is?
5	***Error Prevention*** • Does the use have control over the system? • Is "undo" an intuitive process? • Are errors avoided or minimized when possible?

Table B.11: Categories and some heuristics defined by Dringus and Cohen (2005).

6	***Memorability*** • Is information presented in organized chunks to support learnability and memorability? • Is cognitive load reduced by providing familiarity of items and action sequences?
7	***Course Management*** • Are files easy to upload? • Are files easy to organize according to sequence and timing desired by the designer? • Is attention paid to minimize redundant efforts?
8	***Interactivity*** • Can the user follow the progression or flow of discussion of one single topic or across multiple topics? • Are messages arranged in an effective threaded fashion? • Is it easy to compose a message? • Can activities be easily monitored by the instructor?
9	***Flexibility*** • To what extent can users customize their "view"? • Does the course support various learning styles? • Does the course support various modes of learning (i.e. asynchronous, synchronous, hybrid)?
10	***Consistency*** • Do all buttons/labels/texts/icons/etc. offer consistent and meaningful information? • Is there adequate integration of functionality and tasks, i.e. does the tool match the desired task? Does the tool match the learning objective? • Does the system operate consistently throughout the course?
11	***Efficiency*** • Does the organization match the mental model of the user and instructor? • Are modal operations reduced, where possible?
12	***Reducing Redundancy*** • Are items visible in multiple places and from multiple paths? • Can multiple but similar tasks be done easily?
13	***Accessibility*** • Does the system provide sufficient flexibility for multiple types of users? • Are alternative pathways to course content and activites available? • Is the text of sufficient viewable size? (this also belongs to the heuristic #1)

Table B.11: Categories and some heuristics defined by Dringus and Cohen (2005) (continued)

B.2.3.7 Ssemugabi and de Villiers's heuristics

The aim of Ssemugabi and de Villiers (2007) was to compare to what extent the findings of a heuristic evaluation conducted by experts corresponded with the findings of a survey evaluation filled out by learners. For this purpose, they developed a set of 20 heuristics for evaluating web-based learning environments. These 20 heuristics, in turn, were classified into three categories: (1) general interface usability criteria, (2) website-specific criteria for educational websites, and (3) learner-centered instructional design. The first category includes Nielsen (1994a)'s heuristics (see section B.2.2.3) adapted to the educational context. Even though this first class also applies to web-based applications, the second group contains heuristics that are more specific to websites. Finally, the last category identifies heuristics which are needed for online learner-centered education and that are grounded on current learning theories, models and other learning heuristics.

Table B.12 displays the three categories and, for each of them, the heuristics that belong to it. Furthermore, Ssemugabi and de Villiers provided guidelines (or sub-heuristics) for each heuristic, but only a small sample of them is shown for Categories 2 and 3.

#	Heuristic
	Category 1: General interface usability criteria (adaptation of Nielsen's heuristics to the educational context)
1	***Visibility of system status***
2	***Match between the system and the real world***
3	***Learner control and freedom***
4	***Consistency and adherence to standards***
5	***Error prevention***
6	***Recognition rather than recall***
7	***Flexibility and efficiency of use***
8	***Aesthetics and minimalism in design***
9	***Recognition, diagnosis and recovery from errors***
10	***Help and documentation***
	Category 2: Web-specific criteria for educational websites
11	***Simplicity of site navigation, organization and structure*** • Related information is placed together • There is a smooth flow of interaction with the application
12	***Relevance of site content to the learner and the learning process*** • Content is engaging, relevant, appropriate and clear to learners using the website • It is clear which materials are copyrighted and which are not

Table B.12: Categories and heuristics defined by Ssemugabi and de Villiers (2007).

#	Heuristic
	Category 3: Learner-centered instructional design
13	***Clarity of goals, objectives and outcomes*** • There are clear goals, objectives and outcomes for learning encounters • The reason for inclusion of each page or document on the site is clear
14	***Effectiveness of collaborative learning*** (where this is available) • Facilities and activities are available that encourage learner-learner and learner-teacher interactions.
15	***Level of learner control*** • Apart from controlling the interactions with the site, learners have some freedom to direct their learning, either individually or through collaborative experiences, and to have a sense of ownership of their learning • Where appropriate, learners take the initiative regarding the methods, time, place, content, and sequence of learning
16	***Support for personally significant approaches to learning*** • There are multiple representations and varying views of learning artefacts and tasks • Metacognition (the ability of a learner to plan, monitor and evaluate her own cognitive skills) is encouraged
17	***Cognitive error-recognition, diagnosis and recovery*** • Learners are permitted to learn by their mistakes and are provided with help to recover from cognitive errors
18	***Feedback, guidance and assessment*** • Learners are guided as they perform tasks • Quantitative feedback, e.g. grading of learners' activities is given, so that learners are aware of their level of performance
19	***Context meaningful to domain and learner*** • Knowledge is presented within a meaningful and authentic context that supports effective learning • The representations are understandable and meaningful, ensuring that symbols, icons and names used are intuitive within the context of the learning task
20	***Learner motivation, creativity and active learning*** • The site has content and interactive features that attract, motivate and retain learners, and that promote creativity on the part of learners

Table B.12: Categories and heuristics defined by Ssemugabi and de Villiers (2007) (continued)

C Quantitative data analysis

This appendix explains the concepts, assumptions and measures that have been taken into consideration when quantitative data have been analyzed statistically in this thesis. Likewise, it describes the statistic tests that have been used. More specifically, this appendix deals with the following topics:

- General concepts which are needed to understand the whole appendix (see section C.1).
- The scale of measurement called Likert scale, which has highly been used in this research work (see section C.2).
- The two disciplines that are part of the analysis of quantitative data and which have been used in this dissertation (see section C.3):
  - Descriptive statistics (see section C.3.1):
    - Frequency and percentage
    - Measures of central tendency
    - Measures of dispersion
    - Shape of the distribution
  - Inferential statistics (see section C.3.2):
    - Independent, dependent and extraneous variables
    - Hypotheses
    - Test statistic, p-value and level of significance
    - Kendall's coefficient of concordance
    - Spearman's rank correlation coefficient
    - Mann-Whitney U test

C.1 General concepts

This section explains some basic statistical concepts that are needed to understand this appendix:

- Population, individual, sample and variable
- Parameter and statistic
- Scales of measurements

C.1.1 Population, individual, sample and variable

A ***population*** is a finite or infinite collection of data which contains all subjects of interest whose properties are analyzed. Its size is denoted by *N* and every subject is called ***individual***.

However, researchers seldom have access to the whole population in which they are interested, but only have access to a limited part instead, i.e. a sample. Hence, a ***sample*** is a subset selected from the population. The size of a sample is denoted by the letter *n*.

A ***variable*** is a measurable attribute/property/feature that describes the individuals of the population/sample, e.g. gender, number of children, height, weight, etc. The value of a variable changes from one individual of the population/sample to another.

If we conducted a study of the educational background of the Spanish unemployed people, one variable could be *if the individual holds a university degree* (yes/no). Obviously, the Spanish unemployed would be the population (around $N = 5100000$). Because it would be very difficult to ask all people from the population, we could ask a sample that contained 700000 unemployed Spaniards. As it can be noticed, there are many possible samples which have $n = 700000$.

C.1.2 Parameter and statistic

A ***parameter*** is a measurable feature that characterizes a given population. Therefore, the parameter reports on the whole population. Regarding the ***statistic***, it is the same as the parameter but it refers to a sample. The *mean* and the *standard deviation* are examples of parameters/statistics.

As the same measure can be both a parameter and a statistic, different symbols are used to distinguish both cases. For example, μ and $\overline{x}$ are the mean of a population and a sample, respectively.

C.1.3 Scales of measurement

A variable can be measured with different scales. Because different statistical techniques are suitable for different kinds of data (Oates, 2006, Chapter 17, p. 246), it is essential to know what type of measurement scale one is using for each variable. Broadly speaking, there exist four categories of scales of measurement (Stevens, 1946): (1) nominal, (2) ordinal, (3) interval, and (4) ratio. Table C.1 summarizes some of the features of these categories, allowing to compare them.

Type	Characteristics of the scale			Statistical application	
	Properties	Permitted operations	Examples	Descriptive statistics	Inferential statistics
Nominal data (or categorical data)	• Categories without order	Count	Gender (i.e. male, female) Country (e.g. Spain, Italy, etc.) Color (e.g. red, green, blue, etc.)	Mode	Non-parametric
Ordinal data (or ranked data)	• Categorical data • The categories have an inherent order from smaller to larger • The differences/distances between categories anywhere on the scale cannot be assumed the same	Count and rank order	Grades at school (i.e. A, B, C+, etc.) Size (i.e. small, medium and large) Position (i.e. first, second, etc.)	Mode Median Range statistics	Non-parametric
Interval data	• Discrete and continuous numerical data • The scale is ordered • Each position in the scale is equidistant from one another • There is an arbitrary zero, not an absolute zero	Count, rank order, addition and subtraction	Temperature (-5^{o}C, 0^{o}C, 18^{o}C, etc.) pH	Mode, median, range statistics, mean, variance and standard deviation	Parametric
Ratio data	• Discrete and continuous numerical data • The scale is ordered • Each position in the scale is equidistant from one another • There exists proportion/ratio (i.e. 4 is twice as big as 2) • There is an absolute/natural zero (which means absence of the property)	Count, rank order, addition, subtraction, multiplication and division	Weight (e.g. 150kg., 500kg., etc.) Age (e.g. 3, 29, 34, 55, 67, 81, etc.) Height (e.g. 172cm, 181cm, etc.) Money (e.g. 0$, 100$, 1000$, etc.)	Mode, median, range statistics, mean, variance and standard deviation	Parametric

Table C.1: Scales of measurement.

C.2 Likert scale

C.2.1 Introduction

It is quite common for researchers to use questionnaires so as to inspect people's opinions on something (e.g. a new software, a course, etc.). Most of the questions in these questionnaires are usually on a Likert scale which ranges from *strongly disagree* to *strongly agree* (see Figure C.1). The use of this type of scale as a technique for measuring psychological attitudes was developed by and named after Rensis Likert (1932). This scale can be defined as follows:

Likert scale

A psychometric response scale primarily used in questionnaires to obtain participant's preferences or degree of agreement with a statement or set of statements.

(Bertram, 2007)

C.2.2 Variations

There are multiple versions of this scale. The most common variation is 5-point Likert scale. Other popular variants are 7-point and 9-point.

In addition to providing the respondents with the N points of the chosen variation, it is also frequent to give extra options such as *no response*. Furthermore, it is very common to code the categorical values with numbers, being *1* the lowest value (i.e. *strongly disagree*) and *5/7/9* the highest one (i.e. *strongly agree*).

Likert scale in this thesis

In this thesis, most of the questions in the questionnaires use a 5-point Likert scale. Each point is coded with a number, being *1* the most negative/lowest value and *5* the most positive/highest one. Likewise, the number *3* is a neutral value which can have the label *neither agree nor disagree* or *fair* depending on the question.

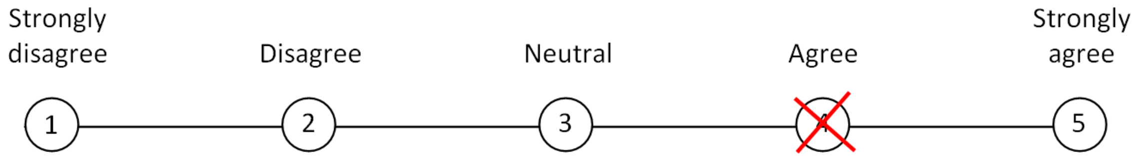


Figure C.1: Example of a 5-point Likert scale with the option *agree* checked.

C.2.3 What type of scale of measurement is a Likert scale?

In the literature, there exists an ongoing discussion on which category this scale belongs to. This discussion is due to the fact that a Likert scale can have both nominal (e.g. agree, disagree, etc.) and numerical values (e.g. 1, 2, etc.). Even though a lot of researchers tend to think this scale gives interval data, this assumption is wrong (Jamieson, 2004; Robertson, 2012). This is due to the fact that, although data is ranked and *strongly agree* (i.e. 5) is usually better than *agree* (i.e. 4), the researcher cannot be sure that the respondents consider the distance between *strongly agree* (i.e. 5) and *agree* (i.e. 4) is the same as *neutral* (i.e. 3) and *disagree* (i.e. 2), even though the difference is 1 in both cases. Consequently, a Likert scale is not an interval scale. This means that the numerical values that are often used only represent verbal statements and, therefore, these only provide information about the order of the items (i.e. the position) and nothing else.

Thesis assumption

Likert scale belongs to the category of ordinal scale because the nominal values of the scale can be ranked, but the distance between the scale points cannot be assumed to be equal. As a result, the variables measured with a Likert scale are ordinal.

C.2.4 Internal consistency

The internal consistency describes how well (or the degree of reliability in which) a set of variables/items/questions of a test measures a single, unidimensional, underlying (or latent) concept/construct. In this regard, one of the most common measures to calculate the internal consistency is the ***Cronbach's alpha coefficient*** (α).There are two ways to calculate it:

$$\alpha = \begin{cases} = \frac{k}{k-1} \cdot \left(1 - \frac{\sum_{i=1}^{n} s_i^2}{s_{sum}^2} \right) & \text{Variance of the items (the most commonly used)} \\ = \frac{n\rho}{1+\rho(n-1)} & \text{Correlation matrix} \end{cases} \tag{C.1}$$

where k and n are the number of items, s_i^2 is the variance of the component i for the current sample, s_{sum}^2 is the variance for the sum of all items, and ρ the average of the linear correlations among the items.

The value of α is a number between 0 and 1. The higher α is, the more reliable the scale is. According to the literature, it is generally accepted the threshold suggested by Nunnally (1978) which establishes that a value of α equals or greater than 0.7 is an indicator that the scale is internally consistent or reliable.

Despite using measures only suitable for interval and ratio data, such as the variance (see Table C.1), it is quite common to use the Cronbach's alpha coefficient when the variables/items/questions are based on a Likert scale (i.e. an ordinal measurement scale).

To understand how to calculate this measure from the first formula, let us imagine a shop that conducts a questionnaire with three questions ($k = 3$) to assess customer satisfaction. Each question measures a different aspect on a Likert scale (from 1 to 5). 10 customers participated.

Questions	Customers										s_i^2	
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10		
Question 1	5	4	2	4	3	4	4	3	4	5	.844	$\sum_{i=1}^{n} s_i^2 = 2.799$
Question 2	4	5	3	5	3	4	4	4	5	5	.622	
Question 3	5	5	2	5	3	5	4	3	5	3	1.333	
Sum	14	14	7	14	9	13	12	10	14	13	$s_{sum}^2 = 6.222$	

Table C.2: Example of Cronbach's alpha coefficient.

$$\alpha = \frac{k}{k-1} \cdot \left(1 - \frac{\sum_{i=1}^{n} s_i^2}{s_{sum}^2} \right) = \frac{3}{3-1} \cdot \left(1 - \frac{2.799}{6.222} \right) = 1.5 \cdot (1 - 0.4498) = 1.5 \cdot 0.55 = 0.825 \quad \text{(C.2)}$$

The result shows that the Cronbach's alpha is high: 0.825. The shop can trust that the three questions in the questionnaire reliably assess the same construct, i.e. customer satisfaction.

C.3 Statistical analysis

When data are collected from a population, these can mainly be analyzed by using:

- Descriptive statistics
- Inferential statistics

They both are explained below. As most of the data of this thesis come from a Likert scale, this appendix will especially focus on those measures, tests, etc., which are suitable for ordinal data.

C.3.1 Descriptive statistics

This discipline of statistics can be defined as follows:

Descriptive statistics

Discipline which focuses on quantitatively describing the main features of a collection of data. Hence, its goal is to summarize a dataset by using statistical measures.

Typically, there are four general types of statistical information that are used to describe data:

- Frequency and percentage
- Measures of central tendency
- Measures of dispersion
- Shape of the distribution

C.3.1.1 Frequency and percentage

Let X be the variable that is studied. Let $x_1, x_2, ..., x_n$ be a sample of size n and $v_1, v_2, ..., v_k$ the different possible values that the variable X can take. There are mainly four types of frequency:

- **Absolute frequency** (n_i): it is the number of times that the variable took a specific value (v_i) during the study/experiment. Thus, n_i denotes the absolute frequency of the value v_i.
- **Relative frequency** (f_i): it is the absolute frequency of a particular value (n_i) divided by the size of the sample, i.e. $f_i = \frac{n_i}{n}$. Thus, f_i denotes the relative frequency of the value v_i.
- **Cumulative absolute frequency** (N_i): for v_i, this frequency indicates the number of times that the variable was less than or equal to v_i during the experiment, i.e. $N_i = \sum_{r=1}^{i} n_r$.
- **Cumulative relative frequency** (F_i): it is the result of dividing each cumulative absolute frequency by the size of the sample, i.e. $F_i = \sum_{r=1}^{i} f_r = \dfrac{N_i}{n}$.

If the relative (f_i) and cumulative relative (F_i) frequencies are multiplied by 100, then the results are the percentage (p_i) and the cumulative percentage (P_i), respectively.

It is very usual to provide the information about frequencies and percentages by means of a frequency table (see Table C.3). The frequency tables of this thesis only show the colored columns of the Table C.3. However, some tables have an extra column denoted by p_i^* which shows the percentage of each option without considering the responses of the missing values (e.g. *no response*). In these cases, the column P_i is calculated from p_i^*.

v_i	n_i	f_i	p_i	N_i	F_i	P_i
1	2	2/20	10%	2	2/20	10%
2	1	1/20	5%	3	3/20	15%
3	6	6/20	30%	9	9/20	45%
4	7	7/20	35%	16	16/20	80%
5	4	4/20	20%	20	20/20	100%
	$n = 20$	$\sum f_i = 1$	$\sum p_i = 100\%$			

Table C.3: Example of frequency table: students' satisfaction with an online course (variable measured with a 5-point Likert scale).

C.3.1.2 Measures of central tendency

First of all, it is needed to define what a measure of central tendency is:

Measure of central tendency

A measure of central tendency is a single figure that represents the whole set of data (i.e. population/sample).

(Khan, 2008)

Hence, these measures reduce a large amount of data to a single, easily understood number (Healey, 2011). The three commonly used measures of central tendency are:

- Mode (Mo)
- Median (Mdn or Q_2)
- Mean (μ, $\overline{x}$)

Table C.4 summarizes the most significant features of these three measures. As seen, ***only the median and the mode can be used when a variable uses an ordinal scale of measurement***.

	Description	**Comments**	**Scales**
Mode (Mo)	This is the value that occurs most frequently in the population/sample. In other words, the most repeated score.	• A dataset can have one (unimodal) or more than one mode (multimodal). • The particular case in which the distribution has two modes is called bimodal. • If there are not values that occur most frequently, the distribution does not have mode. • It is not affected by extreme values.	Nominal Ordinal Interval Ratio
Median (Mdn or Q_2)	It is the value that is in the middle of the dataset.	• It always lies at the exact center of a distribution • Half of the values in the dataset lie below the median and half lie above the median. • Extreme values do not affect the median.	Ordinal Interval Ratio
Mean (μ, $\overline{x}$)	It is the average score of the distribution. $\mu = \frac{\sum_{i=1}^{N} X_i}{N} = \frac{\sum_{i=1}^{k} v_i n_i}{N}$ $\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{\sum_{i=1}^{k} v_i n_i}{n}$	• It is affected by extreme values (or outliers). • When the sample size is large and does not include outliers, the mean usually provides a better measure of central tendency.	Interval Ratio

Table C.4: Measures of central tendency.

C.3.1.3 Measures of dispersion

Just like the measures of central tendency, a definition of measure of dispersion is given first:

Measure of dispersion

The measures of dispersion inform about how similar a set of values are to each other. In other words, they describe the amount of variability or spread of the data around a central value.

By definition, the more similar the values are to each other, the lower the measure of dispersion will be, and the other way around. The most commonly used measures of dispersion are:

- Range (R)
- Interquartile range (IQR)
- Variance (σ^2, s^2)
- Standard deviation (σ, s)

Table C.5 summarizes the most important characteristics of each measure. As seen, ***the range and the interquartile range are the only measures that can be used with ordinal data***.

	Description	**Comments**	**Scales**
Range (R)	The difference between the largest and smallest values in the dataset, i.e. $R = X_{(n)} - X_{(1)}$	• This does not take all the items into account. • This is affected by extreme values. • This may not be representative of the population.	Ordinal Interval Ratio
Interquartile range (IQR)	The range of the middle 50% of the dataset, i.e. $IQR = Q_3 - Q_1$	• This does not take all the items into account. • This is often used with skewed data because IQR is insensitive to extreme values.	Ordinal Interval Ratio
Variance (σ^2, s^2)	$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(X_i - \mu)^2$ $s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2$	• The larger the variance is, the more the scores deviate, on average, away from the mean, and vice versa. • The units of variance are meaningless, since they are squared units of the original observations.	Interval Ratio
Standard deviation (σ, s)	$\sigma = \sqrt{\sigma^2}$ $s = \sqrt{s^2}$	• To avoid the problem of the squared units, it is usual to give the standard deviation instead of the variance. • Better than the previous three measures if the data are interval or ratio.	Interval Ratio

Table C.5: Measures of dispersion.

C.3.1.4 Shape of the distribution

Observing the shape of an ordered dataset, i.e. how the values of the dataset are distributed, can provide interesting information. For example, the *skewness*, which is an overall information that is related to the measures of central tendency and dispersion.

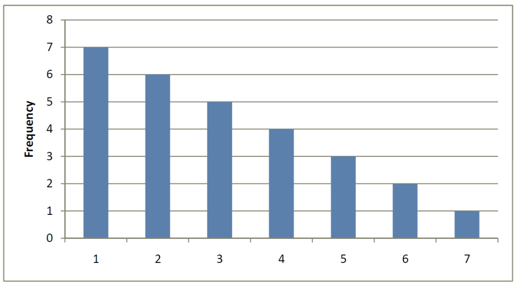
Skewness

Degree to which a statistical distribution is not in balance around the mean. In other words, degree and direction of asymmetry.

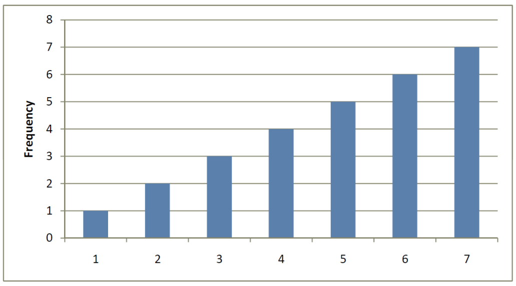
If the distribution is asymmetrical (i.e. this does not follows a normal distribution, $\overline{x} = Mdn_x = Mo_x$), then one of the following two kinds of skewness can be found (see Figure C.2):

- **Positive skewness (or right-skewed)**: the distribution has some extremely high values. Graphically, the right tail is longer and the mass of the distribution is concentrated on the left of the figure. For example, $X = \{1, 2, 3, 100\}$. In this case, usually $Mo_x < Mdn_x < \overline{x}$.
- **Negative skewness (or left-skewed)**: the distribution has some very low values. Graphically, the left tail is longer and the mass of the distribution is concentrated on the right of the figure. For example, $X = \{1, 100, 101, 102\}$. In this case, usually $\overline{x} < Mdn_x < Mo_x$.

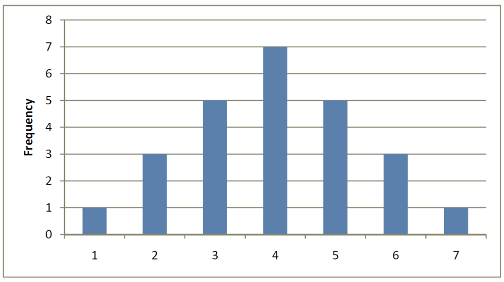
As seen in Figure C.2, one way of reporting on the shape of a distribution is by means of a bar chart. Likewise, a box plot is another graphical representation to display the shape of a distribution when the data are ordinal, interval or ratio (see Figure C.3).



(a) Positive skewness (or right-skewed distribution)

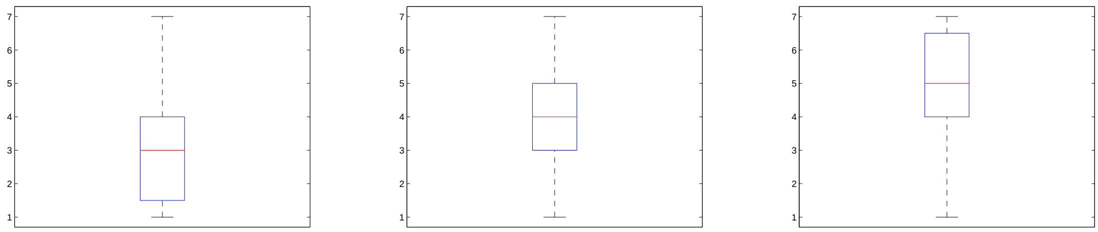


(b) Negative skewness (or left-skewed distribution)



(c) Symmetrical (normal distribution)

Figure C.2: Bar charts with different types of skewness.



(a) Positive skewness (or right-skewed) ***(b)*** Symmetrical (normal distribution) ***(c)*** Negative skewness (or left-skewed)

Figure C.3: Box plots which represent the same distributions of Figure C.2.

Box plot (or box-and-whisker plot)

It is a graphical representation that displays the five-number summary of a variable:

- The highest value (i.e. maximum)
- The quartile Q_3 (i.e. 75th percentile)
- The median or quartile Q_2 (i.e. 50th percentile)
- The quartile Q_1 (i.e. 25th percentile)
- The lowest value (i.e. minimum)

Each box plot has a blue box and two whiskers. On the blue box, there is a red line that represents the median (or Q_2). Likewise, the edges of the box are the 25th and 75th percentiles (i.e. Q_1 and Q_3, respectively). Therefore, the value of the height of the blue box is the same as the IQR (i.e. $Q_3 - Q_1$). As for the whiskers, they extend to the most extreme data points not considered outliers, whereas the outliers are plotted individually as a cross. In this thesis[1], a value is considered as an outlier if this is larger than $Q_3 + 1.5 \cdot \text{IQR}$, or smaller than $Q_1 - 1.5 \cdot \text{IQR}$.

Finally, the simplest way to display information on the distribution of a nominal variable is by using a pie chart (see Figure C.4). At this point, it is important to stress that the frequency tables as well as the bar and pie charts can contain *no response* answers, while the boxplots do not so.

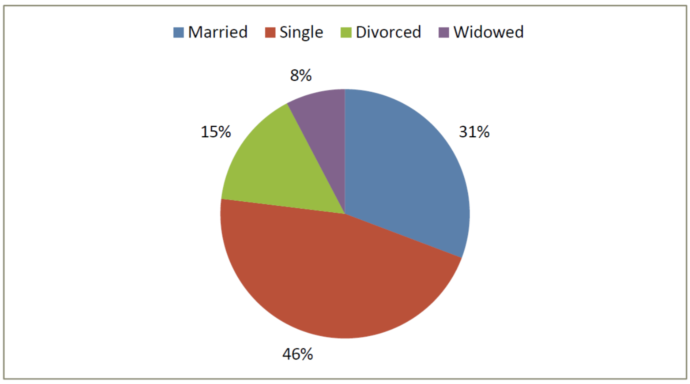


Figure C.4: Pie chart that displays the distribution of a nominal variable (i.e. marital status) in a sample.

[1] MATLAB® has been used to display the box plots of this thesis. The formulas of an outlier are those of this software.

C.3.1.5 Example

Finally, to understand most of the concepts that have been explained, let us use an example. Let X be a random variable that denotes the number of correct answers in a test with 5 questions. Let $x_1, x_2, ..., x_n$ be a sample of $n = 10$ students and $v_i = 0, 1, 2, 3, 4, 5$ the possible values that the variable X can take. The data obtained are: $X = \{3, 5, 4, 2, 4, 4, 3, 0, 4, 5\}$.

First of all, data should be organized. To this end, a frequency table is created (see Table C.6).

v_i	n_i	p_i	P_i
0	1	10%	10%
1	0	0%	10%
2	1	10%	20%
3	2	20%	40%
4	4	40%	80%
5	2	20%	100%
	$n = 10$	$\sum p_i = 100\%$	

Table C.6: Example – Frequency table.

As seen, the variable is measured with a ratio scale because the distance between the scores is equal, there is a meaningful and absolute zero and there exists a ratio/proportion (i.e. 4 correct answers are twice as much as 2 correct answers). Hence, the three measures of central tendency can be calculated, i.e. mode (Mo), median (Mdn) and mean ($\overline{x}$): Mo = 4, $Mdn = 4$ and $\overline{x} = 3.4$. Next, let us calculate the measures of dispersion, i.e. variance (s^2), standard deviation (s), range (R) and interquartile range (IQR): s_X^2 = 2.266, s_X = 1.505, R = 5 - 0 = 5, IQR = 4 - 3 = 1.

From the standard deviation and the IQR, one can conclude that the scores are quite close to each other. As shown in the bar chart and the box plot of Figure C.5, the distribution is left-skewed. This means that the mass of the scores is concentrated on the right hand (i.e. high scores). In this example, such skewness is a positive aspect. Moreover, if the box plot is observed, one can notice that the student who did not answer any question correctly (i.e. $v_i = 0$) may be considered an outlier (i.e. an exceptional case) because she is drawn with a red cross. As a result, this learner could be removed and then the mean and the standard deviation would be better, since this extreme value affects both measures.

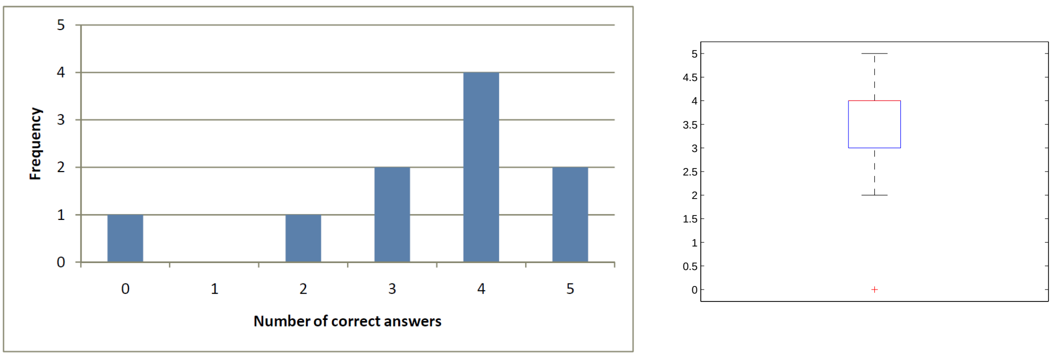


Figure C.5: Example – Bar chart and box plot.

C.3.2 Inferential statistics

As seen in section C.3.1, descriptive statistics only help to organize and describe datasets (e.g. to display patterns and general trends). In consequence, they do not enable to generalize to the whole population from a sample, but they only allow to make summations about the individuals that have really been measured (i.e. the ones that belong to the sample). Obviously, this is a limitation.

If one wants to use the data from a sample in order to infer the parameters of a population, then inferential statistics are needed. Inferential statistics can be defined as follows:

Inferential statistics

Discipline that encompasses techniques that allow to make inferences, decisions or predictions about a population based on sampled data.

C.3.2.1 Independent, dependent and extraneous variables

Before starting an experiment, two types of variables must be defined (Powell et al., 2008, p. 52):

- **Independent variable**: it is the aspect of an experiment that systematically varies across the different conditions. In other words, the independent variable is what is manipulated by the researcher in an experiment.
- **Dependent variable**: it is the aspect of an experiment that is permitted to vary freely to determine if it is affected by changes in the independent variable.

However, other variables, which are not the independent one, could affect the results of the dependent variable. These variables are known as ***extraneous or confounding variables***. In order to guarantee that the only variable that affects the dependent variable is the independent one, the researcher must control the extraneous variables as far as possible.

Let us imagine that a teacher conducted an experiment to check if the learners who take a mock exam get better final grades at the end of the term. In this example, the independent variable would be *taking a mock exam*, while the dependent one would be *the impact of the mock exam on the final grade*. One extraneous variable could be *the effect of the students who repeat the course*.

C.3.2.2 Hypotheses

To draw an inference about the parameters of a population from the sample data, a hypothesis test should be conducted. This needs to state two mutually exclusive hypotheses about the population:

- **Null hypothesis** (H_0): it states that there is no significant change or difference in the dependent variable as a result of the independent variable. Hence, this means *no difference/effect*.
- **Alternative hypothesis** (H_1): it is the opposite of the null hypothesis. Hence, it states that there is a significant change/difference as a result of the independent variable.

In the above example, the teacher could have two groups: one that took a mock exam (i.e. test group) and other that did not (i.e. control group). In this case, the null and alternative hypothesis would be:

H_0: There is no difference between the average final grades of the test group and the control group, i.e. $H_0 : \mu_{mock} = \mu_{no\_mock}$.

H_1: There is significant difference between the average final grades of the test group and the control group, i.e. $H_1 : \mu_{mock} \neq \mu_{no\_mock}$.

C.3.2.3 Deciding between the hypotheses: test statistic, p-value and level of significance

Before explaining how to decide if the null hypothesis has to be rejected in favor of the alternative hypothesis, it is worth indicating that a graphical example will be used in order to illustrate what is described below (see Figure C.6).

Once the null and alternative hypotheses are formulated, the next step is to calculate a data summary from the sample data, called ***test statistic***, which is used to evaluate both hypotheses (Utts and Heckard, 2011). ***The choice of the test statistic depends on the hypothesis to be tested*** (i.e. if this is based on the mean, median, etc.) ***and what is known about the population*** (e.g. if the population follows a normal distribution) (Leroy, 2011). Therefore, there exist different test statistics, e.g. Chi-square test, t-tests, Mann-Whitney U test, etc.

After getting the test statistic, this is located in the null distribution, i.e. the distribution of the test statistic when the null hypothesis is true. In the example of Figure C.6, the null distribution follows a normal distribution and the test statistic is $Z_{stat} = 2.56$. However, instead of using the test

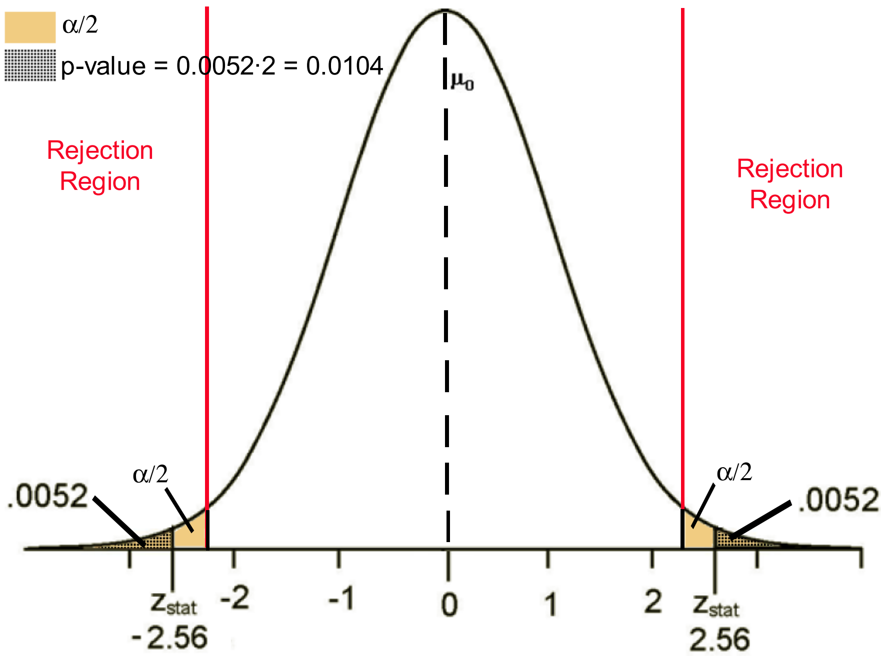


Figure C.6: Representation of the null distribution of a test statistic together with: the test statistic from the sample (Z_{stat}), the p-value, the level of significance (α) and the rejection region.

statistic directly, most statistical software programs, such as SPSS®, Minitab® or even MATLAB®, calculate the ***p-value*** from the test statistic. This value can be defined as follows:

p-value

It is the probability of observing a test statistic as extreme or more extreme than that observed if the null hypothesis is true.

(Gallin and Ognibene, 2012)

For a two-sided test like that of the Figure C.6, the p-value is the sum of the area to the right of the positive test statistic and the area to the left of the negative test statistic (i.e. the dotted areas in the Figure C.6). In the example, $p = 0.0104$. When the p-value is calculated, this is compared to a standard value called ***level of significance*** (α):

Level of significance (α)

This is a value chosen by the researcher to be the threshold from which the p-value is small enough to choose the alternative hypothesis over the null hypothesis (Utts and Heckard, 2011). In other words, the maximum probability of committing a type I error, i.e. to reject the null hypothesis, when this is true (Leroy, 2011).

Therefore,

$p > \alpha \quad \Rightarrow \quad H_0$ cannot be rejected (i.e. there is no enough evidence to reject the null hypothesis)

$p \leq \alpha \quad \Rightarrow \quad H_0$ is rejected and H_1 is accepted (i.e. the result is statistically significant)

Typical values of α are 0.05 and 0.01. ***In this thesis, α = 0.05***. Hence, by definition of p and α, if $p \leq 0.05$ (i.e. $\alpha = 0.05$), then there is only a 5% chance that the hypothesis null is incorrectly rejected, i.e. to make a type I error. In other words, at 5% level of significance (i.e. 95% confidence), the data provide enough evidence to reject H_0. In the example of Figure C.6, the chosen level of significance (α) is the sum of the colored areas. As it can be observed, $p < \alpha$, then H_0 is rejected.

Lastly, as there are different inferential statistics tests, the rest of the appendix will only focus on the ones that have been used in this thesis (non-parametric due to the use of Likert-type scales):

- Kendall's coefficient of concordance
- Spearman's rank correlation coefficient
- Mann-Whitney U test

These three statistics test were calculated by using the statistical program SPSS®.

C.3.2.4 Kendall's coefficient of concordance

This is a non-parametric statistic, also known as Kendall's W, which measures the degree of agreement between raters when they are asked to rank a list of items. In other words, Kendall's W measures the degree of similarity between k sets of ranks given to a same set of objects.

Assumptions of Kendall's W

- Variables are measured on an ordinal, interval or ratio scale.
- Variables do not need to be normally distributed.

To calculate Kendall's W, when there is no ties[2], the following formula should be used:

$$W = \frac{12 \sum_{i=1}^{k} \overline{R}_i^2 - 3k(k+1)^2}{k(k^2-1)} \tag{C.3}$$

where k is the number of items to be evaluated and $\overline{R}$ is the average of the ranks obtained by each item.

Kendall's W ranges from 0 to 1. The value 1 refers to the complete agreement between the raters, whereas the value 0 indicates that there is no overall trend of agreement. According to Schmidt (1997), the value of W can be interpreted as follows:

$$\begin{cases} 0 \le W < 0.1 & \text{No agreement} \\ 0.1 \le W < 0.3 & \text{Very weak agreement} \\ 0.3 \le W < 0.5 & \text{Weak agreement} \\ 0.5 \le W < 0.7 & \text{Moderate agreement} \\ 0.7 \le W < 0.9 & \text{Strong agreement} \\ 0.9 \le W \le 1 & \text{Unusually strong agreement} \end{cases}$$

Besides W, the p-value should also be calculated to know if the value of W is significant. If W is significant, then it is possible to make an inference from the sample to the population that the sample represents. In this regard, the null and alternative hypotheses are:

H_0: There is no agreement among raters, i.e. $W = 0$, where W is the Kendall's coefficient of concordance.

H_1: There is agreement among raters, i.e. $W > 0$, where W is the Kendall's coefficient of concordance

Therefore, if the Kendall's coefficient is statistically significant ($p \le 0.05$), then the null hypothesis can be rejected and, consequently, it can be concluded that there is significant agreement among the raters/judges.

[2] Ties: one judge rates two or more items with the same score.

Courses	Students										$\overline{R}_i$
	1	2	3	4	5	6	7	8	9	10	
Maths	5	5	5	4	5	1	5	4	5	5	4.4
English	2	2	2	2	3	4	2	2	2	2	2.3
Foreign Language	3	1	3	3	2	5	3	3	3	3	2.9
Science	4	4	4	5	4	2	4	5	4	4	4
Art	1	3	1	1	1	3	1	1	1	1	1.4

Table C.7: Example of Kendall's W – Data.

In order to understand how to use the previous formula, let us image an example: the study of the agreement (concordance) between 10 students regarding their favorite subjects (see Table C.7). The ranks went from 1 (the most) to 5 (the least). Next, the formula C.3 is used, being $k = 5$:

$$\begin{aligned} W &= \frac{12 \sum_{i=1}^{k} \overline{R}_i^2 - 3k(k+1)^2}{k(k^2-1)} = \frac{12(4.4^2 + 2.3^2 + 2.9^2 + 4^2 + 1.4^2) - 3 \cdot 5(5+1)^2}{5(5+1)^2} = \\ &= \frac{12 \cdot 51.02 - 3 \cdot 5 \cdot 36}{5 \cdot 24} = \frac{612.24 - 540}{120} = 0.602 \end{aligned} \tag{C.4}$$

In this example, $p = 0$. Hence, W is statistically significant and there is a moderate agreement.

Kendall's W in this thesis

This statistic was used to assess the degree of agreement among teachers when they had ranked several items. In this regard, the term *rank* means that one instructor could not use the same score for two or more different items. Therefore, ties were not allowed.

C.3.2.5 Spearman's rank correlation coefficient

This is a non-parametric version of Pearson's correlation. Spearman's correlation measures the strength and direction of association that exists between two ranked variables (i.e. ordinal, interval or ratio). This does not indicate a cause-effect relationship, but it only points out that the two variables are related somehow.

Assumptions of Spearman's correlation

- Variables are measured on an ordinal, interval or ratio scale.
- Variables do not need to be normally distributed.
- The type of relationship that it measures is monotonic.

To run this measure, it is first needed to convert the values of the variables into ranks. Next, there are two possible formulas depending on whether data have or do not have tied ranks[3]:

$$\rho = \begin{cases} \frac{\sum_i (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_i (x_i - \overline{x})^2 \sum_i (y_i - \overline{y})^2}} & \text{if data have tied ranks} \\ \\ 1 - \frac{6\sum d^2}{n(n^2-1)} & \text{if data do not have tied ranks} \end{cases} \tag{C.5}$$

where x and y are the ranks of the individual for each variable, respectively; $\overline{x}$ and $\overline{y}$ are the average of the ranks; n is the number of individuals; d is the difference between the paired ranks.

As for ρ, this takes a value between -1 and 1. According to Cronk (2004), this value can be interpreted as follows:

$$\begin{cases} \rho = 0 & \text{No correlation} \\ 0 < |\rho| < 0.3 & \text{Weak correlation} \\ 0.3 \leq |\rho| < 0.7 & \text{Moderate correlation} \\ 0.7 \leq |\rho| \leq 1 & \text{Strong correlation} \end{cases}$$

If the sign is positive, this means that when one variable increases, the other also increases. By contrast, if the sign is negative, then when one variable increases, the other decreases.

In addition to the coefficient ρ, it is needed to calculate the p-value in order to know if the value of ρ is significant. If ρ is significant, then it is possible to make an inference from the sample to the population that the sample represents. In this regard, the null and alternative hypotheses are:

H_0: There is no association between the two variables in the population, i.e. $\rho = 0$, where ρ is the Spearman's population correlation coefficient.

H_1: There is association between the two variables in the population, i.e. $\rho \neq 0$, where ρ is the Spearman's population correlation coefficient.

Therefore, if the correlation coefficient is statistically significant ($p \leq 0.05$), then the null hypothesis can be rejected and it can be concluded that there exists an association between the two variables in the population.

Finally, an example is provided in order to explain how this measure works. Let us imagine that 10 undergraduates took a pre-test before taking an English course. For these students, the teacher has two variables: students' pre-test grade and the level of English that they obtained at the end of the higher school (see Table C.8). The teacher wants to know if there exists an association between both variables.

First of all, the two variables have to be ranked. Next, it is needed to decide which of the two formulas of the equation C.5 will be used. To know it, one should check if there are tied ranks or not. As shown in Table C.8, there are tied ranks, e.g. students 1 and 6 share the rank 1.5 for the first variable (i.e. pre-test grade). Thus, the first formula of the equation C.5 has to be used:

[3] Tied ranks or ties: observations with the same value.

Student	Pre-test grade (i) [1]	Level of English (j)[2]	x_i	y_j	$(x_i - \overline{x})$	$(y_j - \overline{y})$
1	D (2)	Beginner (1)	1.5	1.5	-4	-4
2	C (3)	Intermediate (2)	3.5	4.5	-2	-1
3	B (4)	Advanced (3)	6	8.5	0.5	3
4	A (5)	Intermediate (2)	9	4.5	3.5	-1
5	A (5)	Advanced (3)	9	8.5	3.5	3
6	D (2)	Beginner (1)	1.5	1.5	-4	-4
7	B (4)	Intermediate (2)	6	4.5	0.5	-1
8	C (3)	Intermediate (2)	3.5	4.5	-2	-1
9	A (5)	Advanced (3)	9	8.5	3.5	3
10	B (4)	Advanced (3)	6	8.5	0.5	3
			$\overline{x} = 5.5$	$\overline{y} = 5.5$		

[1] *The grade of the pre-test* can take the values *A* (=5), *B* (=4), *C* (=3), *D* (=2) and *E* (=1).

[2] *Level of English* can take the values *Beginner* (=1), *Intermediate* (=2) and *Advanced* (=3)

Table C.8: Example of Spearman's correlation.

$$\rho = \frac{\sum_i (x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_i (x_i - \overline{x})^2 \sum_i (y_i - \overline{y})^2}} = \frac{16 + 2 + 1.5 - 3.5 + 10.5 + 16 - 0.5 + 2 + 10.5 + 1.5}{\sqrt{77.5 \cdot 72}} =$$
$$= \frac{56}{\sqrt{5580}} = \frac{56}{74.7} = 0.7496 = 0.75 \tag{C.6}$$

From the value of ρ, it is possible to conclude that there exists a strong positive association between both variables. Moreover, if the value of ρ (i.e. 0.75) is looked up on the Spearman's significance table, then one can see that the correlation is statistically significant ($p = 0.013$).

C.3.2.6 Mann-Whitney U test

This is one of the most powerful non-parametric tests for comparing two independent groups. It is the non-parametric alternative to the unpaired t-test.

Assumptions of Mann-Whitney U test

- The dependent variable is either ordinal, interval or ratio.
- Samples do not need to be normally distributed.
- Random samples from the populations.
- The two samples are statistically independent.

The Mann-Whitney U test (hereafter MW test) is based on the median and has the following null and alternative hypotheses:

H_0: The two samples come from the same population, i.e. $Mdn_X = Mdn_Y$.

H_1: The two samples come from different populations, i.e. $Mdn_X \neq Mdn_Y$.

This test consists of the following steps:

1. Combine the data from the two samples into one.
2. Rank the combined sample in increasing order. Ties must be corrected. To do this, they are assigned the average rank of the tied observations.
3. Calculate W_1, also known as Wilcoxon value, which is the sum of the ranks of the first sample.
4. Calculate U for the first sample, i.e. U_1:
$$U_1 = W_1 - \frac{n(n+1)}{2} \tag{C.7}$$
5. Calculate U for the second sample (i.e. U_2) from the formula:
$$U_2 = n \cdot m - U_1 \tag{C.8}$$
6. Determine U statistic. Its calculation depends on the size of the samples:
   - Small samples (approx. $n < 20$)
   $$U = min(U_1, U_2) \tag{C.9}$$
   - Large samples (approx. $n \geq 20$), U approaches a normal distribution:
   $$Z = \frac{U - \frac{n \cdot m}{2}}{\sqrt{\frac{m \cdot n \cdot (m+n+1)}{12}}} \tag{C.10}$$
7. Determine if the null hypothesis can be rejected or not.
   - Small samples (approx. $n < 20$): compare the obtained U with the critical U of the table of the Mann-Whitney U test. If the obtained U is smaller than the critical U, then the null hypothesis can be rejected.
   - Large samples (approx. $n \geq 20$): the null hypothesis can be tested by a Z-test, i.e. the p-value is found by using the normal distribution table.

In order to explain how MW test is calculated, the following example will be used: let us suppose that a researcher has a sample X of n individuals/observations, i.e. $X = \{x_1, x_2, \ldots, x_n\}$, and another sample Y of m individuals, i.e. $Y = \{y_1, y_2, \ldots, y_m\}$. In this example, X is a group in which all the members have studied by using books, whereas Y is a group that is exclusively made up of learners who have studied by using a laptop. The students from both groups have the same age and belong to the same school. For this experiment, the grade of a Mathematics test has been measured (see Table C.9). Therefore, the research question is: *is there a statistically significant difference between both groups regarding their grades in the test?*.

Group	**Students**							
	1	2	3	4	5	6	7	8
Book group (B)	1	5	2	4	3	4	1	2
Laptop group (L)	2	5	3	4	1	3	3	4

Table C.9: Example of Mann-Whitney U test – Data.

As said previously, the values of the individuals from the two samples should first be combined into one and then ranked in increasing order by taking the ties into consideration.

Group	B	B	L	B	B	L	B	L	L	L	B	B	L	L	B	L
Grade	1	1	1	2	2	2	3	3	3	3	4	4	4	4	5	5
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rank for ties	2	2	2	5	5	5	8.5	8.5	8.5	8.5	12.5	12.5	12.5	12.5	15.5	15.5

Table C.10: Example of Mann-Whitney U test – Combination and ranking.

Next, the sum of the ranks of the first sample (i.e. the book group) should be calculated, i.e. W_1:

$$W_1 = 2 + 2 + 5 + 5 + 8.5 + 12.5 + 12.5 + 15.5 = 63 \tag{C.11}$$

Now, U is calculated from U_1 and U_2. In this example, the normal approximation cannot be used, because the size of the samples is smaller than 20:

$$U_1 = W_1 - \frac{n(n+1)}{2} = 63 - \frac{8 \cdot (8+1)}{2} = 63 - 36 = 27 \tag{C.12}$$

$$U_2 = (n \cdot m) - U_1 = (8 \cdot 8) - 27 = 37 \tag{C.13}$$

$$U = min(U_1, U_2) = min(27, 37) = 27 \tag{C.14}$$

When the table of critical values of the MW test is used, the obtained U (i.e. 27) is bigger than the critical values of the table for $n = m = 8$, i.e. $p_{0.05}$ = 13 and $p_{0.01} = 7$. Therefore, the null hypothesis cannot be rejected. This means that there is not enough evidence to state that there is a significant difference in the grades of the Mathematics test between the students who use books and those who use laptops. In other words, according to the sample used in the MW test, both methods (i.e. books and laptops) lead the students to obtain similar grades.

Mann-Whitney U test in this thesis

In the present thesis, the Mann-Whitney U test was used to detect if there existed disagreement between two groups on a specific issue, being the independent variable the membership of a group and the dependent variable the opinion on the matter. Hence:

H_0 : The two groups have similar opinion.

H_1 : The two groups have different opinion.

If the null hypothesis could not be rejected, then the analysis of the two groups was conducted as if they were a single group. Otherwise, each group was analyzed individually in order to understand why they had different opinions.

Due to the idiosyncrasy of this research, it was desirable that the two groups of each test had the same opinion, since this meant that the opinion was the same regardless of the subject, the teacher, the classmates, the topic that was dealt with, etc. In other words, the more identical the opinion was, the more generalizable the results of the questionnaire were.

D AdVisor 0.0: questionnaire and results

This appendix contains the questionnaire used in the prototype AdVisor 0.0 as well as an exhaustive analysis of the responses collected. More specifically, the sections of this appendix are:

- Questionnaire (see section D.1)
- Results (see section D.2)

D.1 Questionnaire

All the questions with this symbol [*] were mandatory.

Section A – Respondent's profile

1. [$*$] Gender

   - Man
   - Woman

2. [$*$] Age

   - 17-20
   - 36-40
   - 21-25
   - 41-45
   - 26-30
   - 46-50
   - 31-35
   - Older than 50

Section B – Respondent's study habits

3. [$*$] Where do you usually study? (Select all that apply)

   - Home
   - Workplace
   - Public transport
   - Library
   - Other. Which? ___________

4. [$*$] When do you usually study?

   - Weekdays
   - On the weekend
   - Indistinctly, both weekdays and at the weekend

5. [$*$] How often do you study per week?

   - About 1 or 2 days per week item
   - About 3 or 4 days per week
   - About 5 or 6 days per week
   - Daily

6. [$*$] How long are your study sessions?

   - Less than 1 hour [0h,1h)
   - Between an hour and two hours [1h,2h)
   - Between an two hours and two hours and a half [2h,2:30h)
   - Between two hours and a half and three hours [2:30h,3h)
   - Between an three hours and three hours and a half [3h,3:30h)
   - Between an three hours and a half and four hours [3:30,4h)
   - 4 or more hours [4h,∞)

7. [∗] How often do you increase your study hours just before the CAAs' deadline?

   1 - Never 2 - Rarely 3 - Sometimes 4 - Usually 5 - Always

8. Related to the previous question, why do you do it like this?

Section C – Support for the guidance through the course

9. [∗] How useful did you find having the course divided into sessions?

   1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
   4 - Useful 5 - Very useful

10. [∗] How did you find the balance between the real and the estimated workload of a session?

    1 - The sessions were underloaded (i.e. real_workload<estimated_workload)
    2 - Well-balanced (i.e. real_workload=estimated_workload)
    3 - The sessions were overloaded (i.e. real_workload>estimated_workload)

11. [∗] In your opinion, how long should the workload of a session last?

    - 30 minutes
    - 1 hour
    - 1 hour and a half
    - 2 hours
    - 2 hours and a half
    - 3 hours
    - 3 hours and a half
    - 4 hours
    - More than 4 hours

Section D – Self-awareness

12. [∗] Rate the dashboard on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient 2 - Poor 3 - Fair 4 - Good 5 - Very good

13. If you have any suggestions, comments, etc. about the dashboard, please let us know below.

Section E – Self-regulation

14. [∗] To what extent did AdVisor help you to self-regulate your learning process?

    1 - Nothing 2 - Little 3 - Normal 4 - Quite a lot 5 - A great deal • No response

Section F – Multiple views

15. [∗] Which type of navigation/view did you find more useful?

    - The one based on the table of contents
    - The one based on the schedule
    - Indistinctly
    - No response

16. [∗] Rate the workspace as a whole on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient   2 - Poor   3 - Fair   4 - Good   5 - Very good

17. If you have any suggestions, comments, etc. about the workspace, please let us know below.

Section G – Usability

18. [∗] How usable did you find the double navigation?

    1 - Not at all usable   2 - Not very usable   3 - Neither usable nor unusable
    4 - Usable   5 - Very usable

19. [∗] Which manner of displaying a resource do you think is the best one?

    - Lightbox
    - New tab
    - New window
    - Embedded in the workspace
    - Other. Which? ___________
    - No response

Section H – Future improvements and suggestions

20. [∗] Choose the elements which you think that they should be improved or added: (Select all that apply)

    - Multimedia resources
    - Schedule
    - Information about assessment
    - Forums
    - Other. Which? ___________

21. If you have any suggestions, comments, etc. about any aspect of the platform that you find important, please let us know below.

D.2 Results

Next, the results of the questionnaire are shown and analyzed in detail. At this point, it is important to stress that the frequency tables as well as the bar and pie charts contain *no response* answers, while the box plots do not. Likewise, this section does not include the comments made by the teachers during the test. These are presented in Chapter 5 (see section 5.2.5).

D.2.1 Response rate

At the end of the evaluation of the second test (i.e. on August 8, 2010), 47 of 226 learners had filled out the questionnaire (see Table D.1). This meant a response rate of 20.8%. Given that the use of AdVisor was voluntary, ***this figure could be considered good***. More specifically, the response rate for Mathematics II was 17% (25 of 147 students), while Signals and Systems got 27.8% (22 of 79).

D.2.2 Respondents' profile

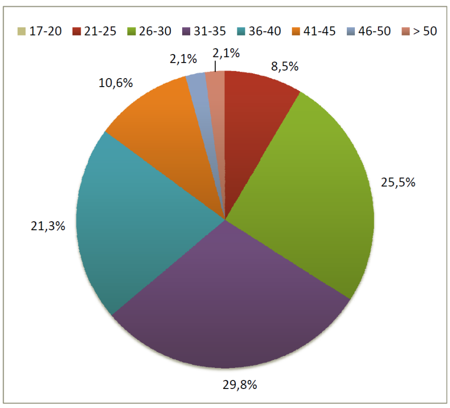
As shown in Table D.1, 89.4% of the respondents were men, a typical proportion in Engineering courses (Hill and Corbett, 2010). Moreover, 66% of the respondents were over 30 years old (see Figure D.1). The remainder 34% were divided into two age ranges: *21-25* (8.5%) and *26-30* (25.5%). Hence, over 91% were older than 25 years old. ***This result matches the average age of the archetype of online student*** which was defined by Gilbert (2000) (see section 2.4.1.1).

Course		**Mathematics II (.008)**	**Signals and Systems (.011)**	**Total**
Number of students in the tests	S-D 2009	89	31	120
	F-J 2010	58	48	106
	Total	147	79	226
Number of respondents	#Male	22	20	42 (89.4%)
	#Female	3	2	5 (10.6%)
	Total	25 (17%)	22 (27.8%)	47 (20.8%)

Table D.1: AdVisor 0.0 – Breakdown of the participants.

v_i	n_i	p_i	P_i
17-20	0	0%	0%
21-25	4	8.5%	8.5%
26-30	12	25.5%	34%
31-35	14	29.8%	63.8%
36-40	10	21.3%	85.1%
41-45	5	10.6%	95.7%
46-50	1	2.1%	97.8%
Older than 50	1	2.1%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Pie chart

Figure D.1: AdVisor 0.0 – Respondents' age ranges.

D.2.3 Reliability of the results

It was needed to be cautious about the significance of the results obtained from the questionnaire. The main reason was that the use of AdVisor 0.0 had been voluntary and, consequently, ***most of the respondents did not use AdVisor 0.0 all the time***. This meant that the responses, despite being useful, may have been based on an incomplete vision of the platform.

Likewise, although the response rate was acceptable and over 91% of the respondents were older than 25 (i.e. the average age of online students according to Gilbert (2000)), the sample was biased because, as said, all the individuals belonged to Engineering courses and 89.4% were men.

In short, the responses collected from this questionnaire could not be generalized to all online learners. Hence, ***the results only allowed to extract some trends*** of online students' opinions of the recommendations suggested in this work, rather than definitive conclusions.

D.2.4 Respondents' study habits

In order to improve the design of the courses and the learning tools so that they could adapt better to online learners, the respondents were asked about their study habits.

The first question asked about the place where they usually studied (multiple responses were permitted). As shown in Table D.2, ***46 of 47 respondents (97.9%) usually studied at home***. Among them, 34 (72.3%) only studied at home. Moreover, the only person who did not study at home studied at the *workplace*. This finding was really significant because it meant the option ***home stood out as preferred place to study***. The rest of options were ranked as follows: *workplace* (17%), *library* (6.4%), *public transport* (4.3%) and *other* (i.e. private academy, 2.1%). As a result, one could imagine what respondents' study place looked like: a dedicated study room with a desk, a comfortable chair, a computer/laptop/tablet (instead of a smartphone) and Internet access.

The respondents were also asked which type of day they preferred to study: *weekdays*, *weekend* or *indistinctly*. A priori, one could believe that the respondents, as online learners that they were, would have studied on the weekend, since many of them were workers and had less time on weekdays. However, ***70.2% studied any day indistinctly*** (see Figure D.2).

Likewise, they were asked how often they studied each week (see Figure D.3). The most chosen option was *about 3 or 4 days per week* (38.3%, median), followed by *5-6 days* (29.8%). Hence, ***the respondents had a constant studying pace***, i.e. around 4.5 days per week.

Study place	Home	Workplace	Library	Public transport	Other	Total
Home	34[1]	7	3	2	1[2]	46 (97.9%)[3]
No home	-	1	-	-	-	1
Total	34 (72.3%)	8 (17%)	3 (6.4%)	2 (4.3%)	1 (2.1%)	47

1 34 people chose *home* as the only option.

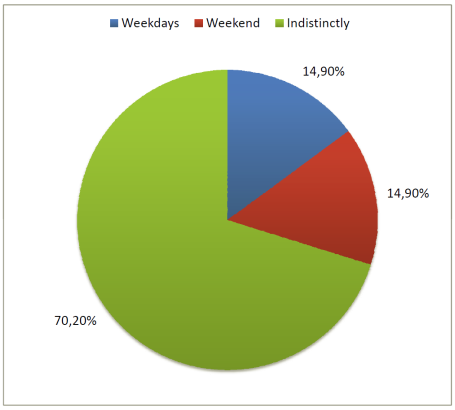
2 The respondent indicated that the *other* study place was a *private academy*.

3 12 people chose another option in addition to *home*. One of them checked two: *public transport* and *library*.

Table D.2: AdVisor 0.0 – Respondents' preferred study place.

v_i	n_i	p_i	P_i
Weekdays	7	14.9%	14.9%
Weekend	7	14.9%	29.8%
Indistinctly	33	70.2%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table

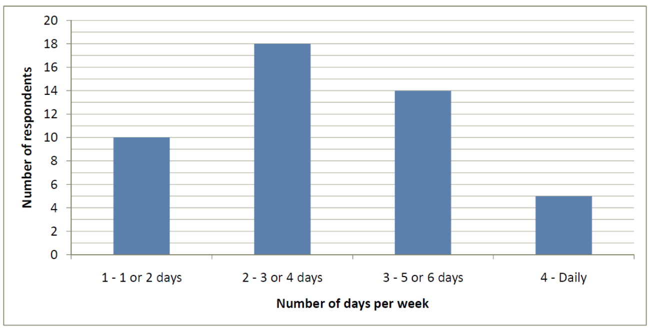


(b) Pie chart

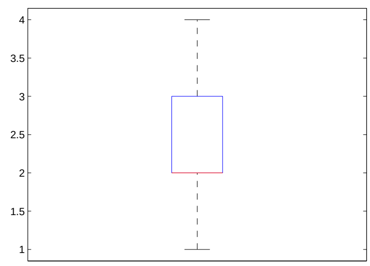
Figure D.2: AdVisor 0.0 – Respondents' preferred type of day to study.

v_i	n_i	p_i	P_i
1 - About 1 or 2 days	10	21.3%	21.3%
2 - About 3 or 4 days	18	38.3%	59.6%
3 - About 5 or 6 days	14	29.8%	89.4%
4 - Daily	5	10.6%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure D.3: AdVisor 0.0 – How often the respondents studied each week.

Likewise, 34% of those questioned answered that their study sessions lasted *1-2 hours*, while 25.5% said they studied in sessions of *2 hours to 2 hours and a half* (see Figure D.4). Therefore, ***the average duration would be about 1 hour and 45 minutes***.

The last question about the study habits asked: *"how often do you increase your study hours just before the continuous assessment assignments' (CAAs) deadline?"*. From the responses received, it may be concluded: ***42.6% of the respondents usually or always studied much more when the CAAs' deadline was close***. As evidenced by the bar chart of Figure D.5 (where the distribution is slightly left-skewed) and the mode (4, *usually*, 29.8%), there was a trend toward this study strategy. According to some comments from the respondents, they usually study like this because of the lack of time and the necessity of not forgetting any concept while solving a CAA. However, this study strategy also causes undesirable behaviors as a remark revealed: *"by studying how to solve the exercises of the CAAs, I learn and, what is more, I pass the course. The best method is learning by doing past CAAs"*. Such a study strategy may lead a lot of learners not to follow a constant study pace and only study when the CAAs' deadline is close. Actually, a Spearman's correlation was run to determine the relationship between how often the 47 respondents increased their study hours just before the CAAs' deadline and the number of days per week that they usually studied. The result indicated that there was a moderate negative correlation between both variables ($\rho = -0.324$), which was statistically significant ($p = 0.026$). Therefore, it seemed that there was some evidence to say that ***the more a learner increased her study time just before the CAAs' deadline, the less days she studied each week (or the less constant her study pace was)***.

As seen, CAAs may be a double-edged sword. On the one hand, they force learners to study the most important concepts prior to the validation tests and exams, but, on the other, a study method focused on the CAAs may lead some students not to learn all the concepts of a course, but only those that are necessary to pass the CAAs. Hence, because the main goal of any course should be that students acquire all the competences, ***both teachers and learning tools should encourage learners to follow a constant studying pace apart from doing mandatory assignments***.

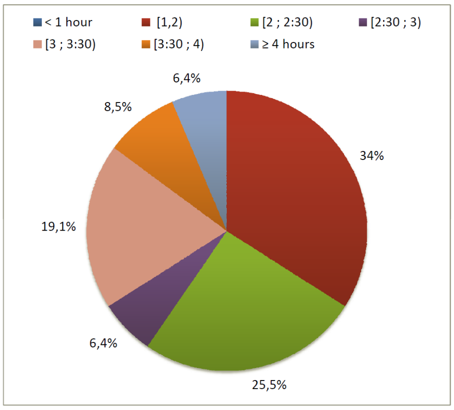
From the previous analysis, the respondents' study strategy can be characterized as follows:

Study strategy of the respondents

- **Preferred study place**: home
- **Preferred days to study**: indistinctly, i.e. both weekdays and on the weekend
- **Number of days per week in which the learner studies**: about 4.5 days
- **Average duration of a study session**: 1 hour and 45 minutes
- They often study much more when the CAAs' deadline is close

v_i	n_i	p_i	P_i
<1 hour	0	0%	0%
[1h,2h)	16	34%	34%
[2h,2:30h)	12	25.5%	59.6%
[2:30h,3h)	3	6.4%	66%
[3h,3:30h)	9	19.1%	85.1%
[3:30,4h)	4	8.5%	93.6%
[4h,∞)	3	6.4%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table

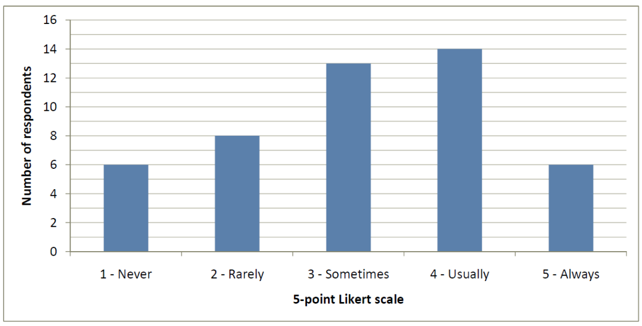


(b) Pie chart

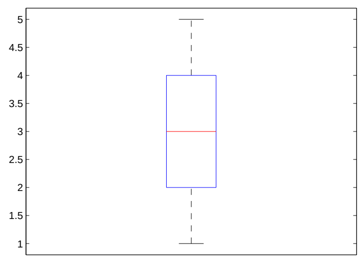
Figure D.4: AdVisor 0.0 – Average duration of the respondents' study session.

v_i	n_i	p_i	P_i
1 - Never	6	12.8%	12.8%
2 - Rarely	8	17%	29.8%
3 - Sometimes	13	27.7%	57.4%
4 - Usually	14	29.8%	87.2%
5 - Always	6	12.8%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure D.5: AdVisor 0.0 – How often the respondents increase their study hours just before the CAAs' deadline.

D.2.5 To guide students through the course (recommendation B)

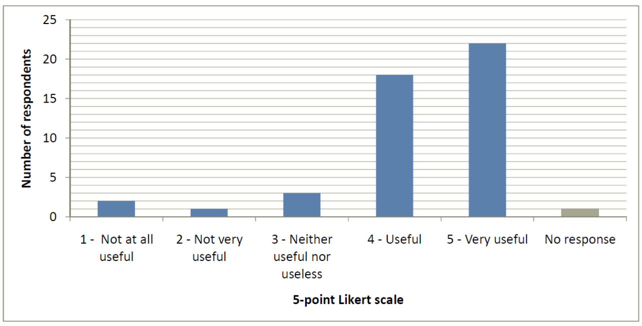
The principal element related to this recommendation was the session. In this regard, the respondents were first asked about the usefulness of having the course divided into sessions. According to the result of the Mann-Whitney U test (MW test), there was no evidence that supported that the two groups (i.e. Mathematics II and Signals and Systems) had different opinions of this item ($U = 261$, $Z = -.072$, $p = .942$). For that reason, the scores of both groups were analyzed together. As displayed in Figure D.6, 47.8% found sessions *very useful* (5, mode) and 39.1% considered them *useful* (4, median). This meant that ***86.9% thought that the sessions were helpful***. Actually, according to the box plot of Figure D.6, this result could have been considered better, since the respondents who rated it 1 (*not at all useful*, 4.3%) or 2 (*not very useful*, 2.2%) were outliers. Thus, it may be concluded that ***the organization based on sessions was really useful to the respondents***.

Although the sessions were similar to the short weekly guides of the UOC, these implied new tasks. For instance, the lecturers who participated in the test had to suggest an estimated duration/workload for each of the session as well as the ideal sequence of activities to follow, among other things. Due to this, one of the questions that arose was if the real workload of the session matched the estimated one (see Figure D.7). The two groups which participated in the test had similar opinions of this issue (MW test: $U = 216$, $Z = -.131$, $p = .896$). Specifically, 61.9% thought that the estimated workloads corresponded to the real ones. However, 26.2% believed that the sessions were overloaded. Finally, only 11.9% expressed that these were underloaded.

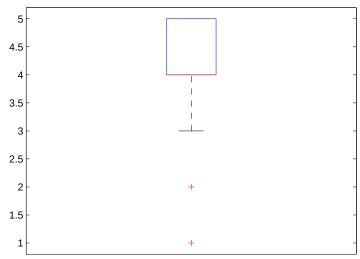
The fact that 26.2% found the sessions overloaded led us to think that the number of activities may have been very large and/or the estimated workloads may have been calculated at a guess. In any case, this was a proof that the teachers might have needed some kind of help when defining sessions.

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	2	4.3%	4.3%	4.3%
2 - Not very useful	1	2.1%	2.2%	6.5%
3 - Neither useful nor useless	3	6.4%	6.5%	13%
4 - Useful	18	38.3%	39.1%	52.2%
5 - Very useful	22	46.8%	47.8%	100%
No response	1	2.1%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart

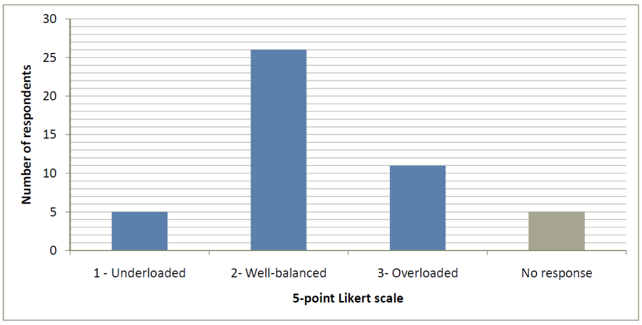


(c) Box plot

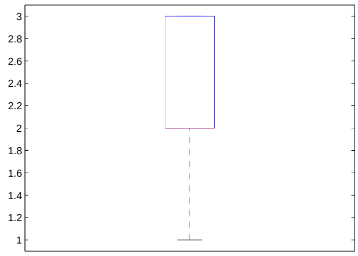
Figure D.6: AdVisor 0.0 – Usefulness of having the course divided into sessions.

v_i	n_i	p_i	p^*_i	P_i
1 - Underloaded (real_workload<estimated_workload)	5	10.6%	11.9%	11.9%
2 - Well-balanced (real_workload=estimated_workload)	26	55.3%	61.9%	73.8%
3 - Overloaded (real_workload>estimated_workload)	11	23.4%	26.2%	100%
No response	5	10.6%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p^*_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure D.7: AdVisor 0.0 – Balance between the real and the estimated workloads of a session.

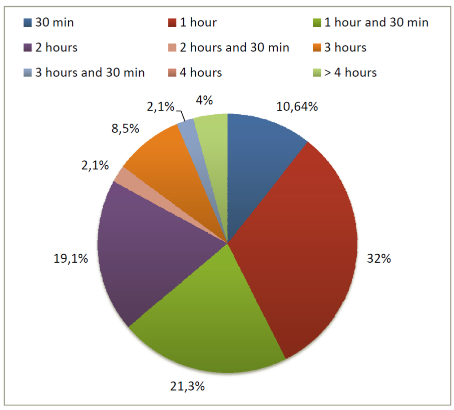
Related to the previous question, it was asked how long a session should last (see Figure D.8). 31.9% considered that *1 hour* would be the optimal duration/workload. Likewise, 21.3% and 19.1% chose *1:30* and *2 hours*, respectively. In accordance with ***72.3% of the respondents, the optimal workload of a session would be between 1 and 2 hours***. This range accorded closely with the average duration of the respondents' study sessions (i.e. 1 hour and 45 minutes, see section D.2.4).

Lastly, some learners said that the platform had made them feel a little stressed, since they had not sometimes been able to adapt their paces to AdVisor's one. To overcome this problem in next tests, it would be essential to stress that the studying pace proposed by AdVisor is only a suggestion and, therefore, following it is optional.

As the organization based on sessions had been found useful by most of the respondents, ***it was concluded that recommendation B seemed to be suitable***. However, some aspects, such as the balance between the estimated workload and the actual one, would have to be improved.

v_i	n_i	p_i	P_i
30 minutes	5	10.6%	10.6%
1 hour	15	31.9%	42.6%
1:30	10	21.3%	63.8%
2 hours	9	19.1%	83%
2:30h	1	2.1%	85.1%
3 hours	4	8.5%	93.6%
3:30	1	2.1%	95.7%
4 hours	0	0%	95.7%
> 4 hours	2	4.3%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Pie chart

Figure D.8: AdVisor 0.0 – Ideal workload of the sessions according to the respondents.

D.2.6 To provide self-awareness (recommendation C)

In order to evaluate the suitability of ***recommendation C***, AdVisor 0.0 used a dashboard, which displayed personalized information on the learning progress to each individual student.

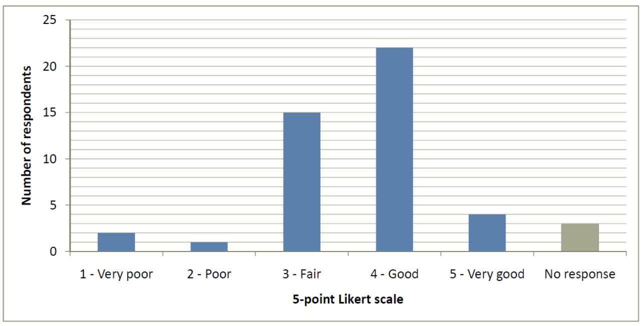
The questionnaire asked the respondents to evaluate AdVisor 0.0's dashboard by using a 5-point Likert scale. Both groups (i.e. Mathematics II and Signals and Systems II) were in agreement about this item (MW test: $U = 229$, $Z = -.334$, $p = .738$). As shown in Figure D.9, ***50% found it good*** (4, mode and median) and ***34.1% rated it 3*** (*fair*). Moreover, as displayed in the bar chart, the distribution was left-skewed. In fact, ***only 6.8% chose the option 1*** (*very poor*, 4.5%) ***or 2*** (*poor*, 2.3%). The evaluation of the dashboard was even better because the learners who checked the option *very poor* (score = 1) could have been considered outliers (see Figure D.9c).

Besides the scores of the Likert-type question, some comments supported the good evaluation of the dashboard. Some examples are: *"it has been really useful"*, *"it helps to follow the studying pace of the subject"*, *"it is quite useful and friendly"*, *"if it were used well, it could be very useful"*, *"it is very intuitive"*, *"it is right and enlightening"*, *"you know how you are compared to the course at a glance, it is perfect"*. Nonetheless, some complaints and improvements were written too, e.g. *"I think that some information is missing"*, *"I thought that it was not useful because it does not indicate what activities with finish date prior to the current date have not been complete yet"*.

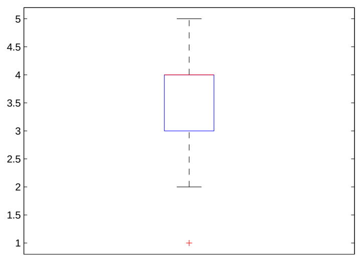
As seen, the results implied a large number of the respondents wanted to have personalized data about their learning progress. Therefore, ***recommendation C seemed to be appropriate for online education***. Furthermore, the dashboard seemed to be a good way to help students to be aware of their own learning processes at a glance. Hence, this would have to be in AdVisor 1.0.

v_i	n_i	p_i	p_i^*	P_i
1 - Very poor/Insufficient	2	4.3%	4.5%	4.5%
2 - Poor	1	2.1%	2.3%	6.8%
3 - Fair	15	31.9%	34.1%	40.9%
4 - Good	22	46.8%	50%	90.9%
5 - Very good	4	8.5%	9.1%	100%
No response	3	6.4%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure D.9: AdVisor 0.0 – Overall evaluation of the dashboard.

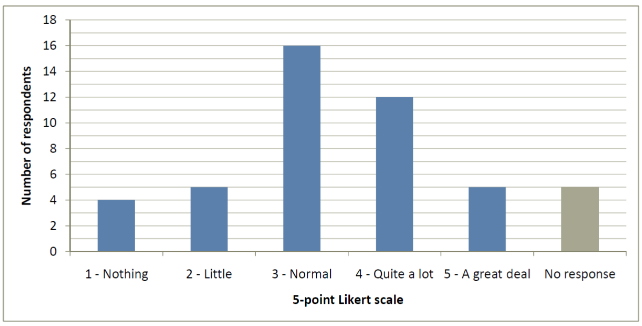
D.2.7 To provide tools that help students to be self-regulated (rec. B and C)

Recommendations B and C share an objective: to help students to be self-regulated. Therefore, regarding AdVisor 0.0, it would be to be expected that the usefulness of the session and that of the dashboard were correlated, i.e. if one is found useful, then the other should be considered equally useful. To know how these two items were correlated, Spearman's correlation coefficient was run. The result showed a highly statistically significant ($p = .006$) and moderate correlation ($\rho = .411$). Thus, there was some evidence that ***those learners who found the session useful also rated the dashboard positively***. In other words, it seemed that the guidance through the course and the self-awareness went hand in hand somehow. Several comments confirmed this fact: *"[AdVisor 0.0] is a very useful tool, even if you do not adapt to the proposed schedule, because you can be aware of the workload"*, *"it has been essential to follow the course pace, I cannot imagine this subject without this tool"*, *"[AdVisor 0.0] is a tool that is useful as a schedule and task planner"*, etc.

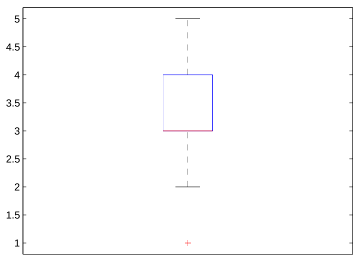
In addition to the session and the dashboard, AdVisor 0.0 had other items that tried to help students to be self-regulated, such as the Gantt and the option that enabled to mark an activity as complete (see section 5.2.2.3). To evaluate all these features as a whole, the next question was asked: *"to what extent did AdVisor help you to self-regulate your learning process?"* (see Figure D.10). The two classes had similar opinions (MW test: $U = 199.5$, $Z = -.551$, $p = .581$). In this regard, the option *normal* (3, 38.1%) was the mode and the median. However, ***40.5% thought that AdVisor had helped them in a significant way*** (score = 4 and 5), which was a high figure since: (1) the learners who rated 1 (*nothing*, 9.5%) could have been considered outliers (see Figure D.10c) and, (2) the optional use of AdVisor might have implied that some respondents did not realize the possibilities that the platform provided to regulate the learning process. Anyway, ***AdVisor 0.0 had apparently helped the students to self-regulate their learning process***.

v_i	n_i	p_i	p_i^*	P_i
1 - Nothing	4	8.5%	9.5%	9.5%
2 - Little	5	10.6%	11.9%	21.4%
3 - Normal	16	34%	38.1%	59.5%
4 - Quite a lot	12	25.5%	28.6%	88.1%
5 - A great deal	5	10.6%	11.9%	100%
No response	5	10.6%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure D.10: AdVisor 0.0 – To what extent AdVisor helped students to self-regulate their learning process.

D.2.8 To provide multiple views of the course (recommendation G)

AdVisor 0.0 proposed a new classroom by means of its workspace. This was characterized by the provision of two views of the same course simultaneously: (1) the table of contents (TOC), and (2) the schedule. As it can be read below, the workspace gained acceptance among the respondents.

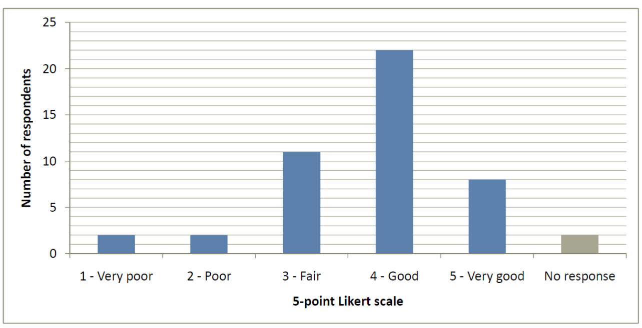
First, the respondents assessed the workspace on a 5-point Likert scale (see Figure D.11). According to the MW test ($U = 205$, $Z = -1.173$, $p = .241$), there was not evidence that allowed to state that both groups had different opinion. ***66.7% found the workspace good*** (4, 48.9%, mode and median) ***or very good*** (5, 17.8%). Consequently, the distribution was left-skewed, being ***only 8.9% of the responses equal to 1*** (*very poor*, 4.4%) ***and 2*** (*poor*, 4.4%). This result was better than it seemed, because those who rated it 1 (*very poor*) could have been labeled as outliers. In conclusion, ***the evaluation of the workspace was very good***.

Likewise, it was interesting to know which type of navigation/view was found more useful (see Figure D.12). In this regard, the most chosen answer was *equally useful* (38.5%), followed by the navigation based on the *Gantt chart/schedule* (33.3%) and the one based on the *TOC* (28.2%). ***This similarity between the two views indicated that they both had to stay in the platform***.

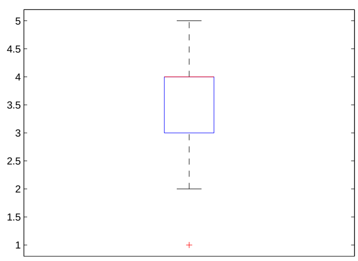
Given that the results of the workspace (i.e. multiple views) were positive, ***it could be concluded that the recommendation G made sense***. Thenceforth, the future prototypes of AdVisor would have to focus on the provision of different perspectives of the same course in order that the platform could better adapt to the students' preferences and needs. Actually, ***some comments demanded to include more views***. The most requested view was one that included the continuous assessment assignments (CAAs). The reason for that was described in section D.2.4, i.e. a lot of respondents organized their study time depending on the CAAs' deadline.

v_i	n_i	p_i	p_i^*	P_i
1 - Very poor/Insufficient	2	4.3%	4.4%	4.4%
2 - Poor	2	4.3%	4.4%	8.9%
3 - Fair	11	23.4%	24.4%	33.3%
4 - Good	22	46.8%	48.9%	82.2%
5 - Very good	8	17%	17.8%	100%
No response	2	4.3%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart

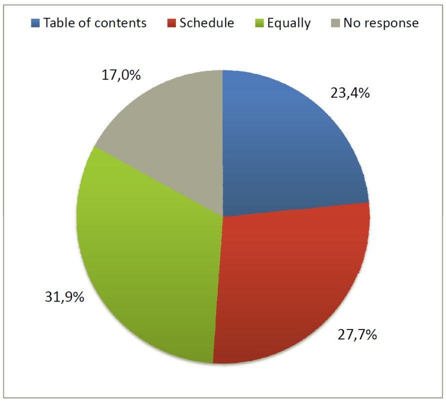


(c) Box plot

Figure D.11: AdVisor 0.0 – Overall evaluation of the workspace.

v_i	n_i	p_i	p_i^*	P_i
TOC	11	23.4%	28.2%	28.2%
Gantt chart/ Schedule	13	27.7%	33.3%	61.5%
Equally useful	15	31.9%	38.5%	100%
No response	8	17%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Pie chart

Figure D.12: AdVisor 0.0 – Which type of navigation/view the respondents found more useful.

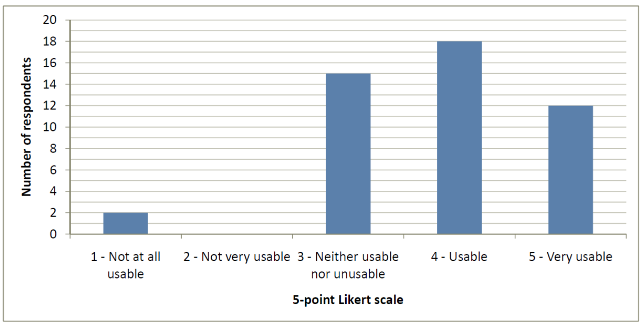
D.2.9 Usability (recommendations I-M)

In this test, the ***recommendations I-M*** were evaluated globally. In this regard, as the students were in the workspace most of the time, they were asked to rate the usability of the double navigation on a scale from 1 (*not at all usable*) to 5 (*very usable*). The two groups shared opinion (MW test: $U = 196$, $Z = -1.780$, $p = .075$). As shown in Figure D.13, 38.3% found it *usable* (4, mode and median). Likewise, 31.9% thought the platform was *neither usable nor unusable* (score = 3), while 25.5% *very usable* (score = 5). Hence, 95.7% of the respondents rated it 3 (*neither usable nor unusable*) or higher. Consequently, the distribution of the scores was clearly left-skewed (see Figure D.13c). In fact, ***only 4.3% found the double navigation unusable*** (score = 1).

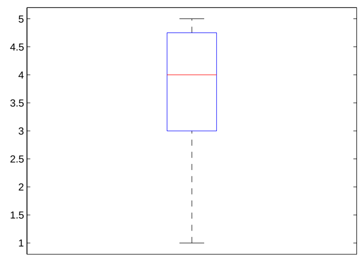
Considering the workspace was quite different to the UOC's classroom, it could be concluded that ***the evaluation of the usability of the double navigation was really good***.

v_i	n_i	p_i	P_i
1 - Not at all usable	2	4.3%	4.3%
2 - Not very usable	0	0%	4.3%
3 - Neither usable nor unusable	15	31.9%	36.2 %
4 - Usable	18	38.3%	74.5%
5 - Very usable	12	25.5%	100%
	$n = 47$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

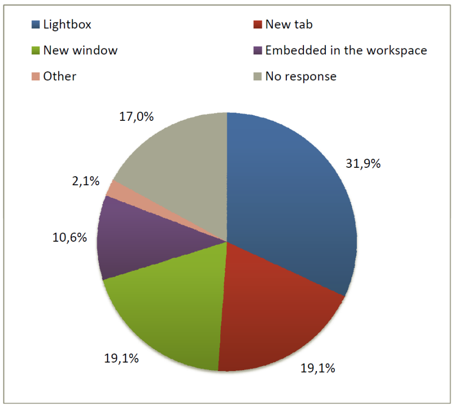


(c) Box plot

Figure D.13: AdVisor 0.0 – Evaluation of the usability of the double navigation.

v_i	n_i	p_i	p_i^*	P_i
Lightbox	15	31.9%	38.5%	38.5%
New tab	9	19.1%	23.1%	61.5%
New window	9	19.1%	23.1%	84.6%
Embedded	5	10.6%	12.8%	97.4%
Other	1	2.1%	2.6%	100%
No response	8	17%		
	$n = 47$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Pie chart

Figure D.14: AdVisor 0.0 – Preferred way to display activities.

Likewise, the questionnaire also included a question that attempted to check if the lightbox was the best way to display the activities or the respondents preferred another one (see Figure D.14). According to the respondents' opinion, the preferred way was the *lightbox* with 38.5% of the responses. Next, opening activities either in a *new browser tab* or in a *new browser window* were considered the best options by 23.1% each. 12.8% said that the activities could be shown just below the navigation area, i.e. *embedded* in the interface of the workspace. Finally, only one person marked the option *other* and suggested showing the activity both in a lightbox and in a new browser tab. Her reason was that if someone wanted to open two activities simultaneously, this was impossible (or less practical) with lightboxes.

Despite the fact that the ligthbox was the first option, it was considered that opening a new tab or a new window were very similar options (actually, this often depends on the web browser). As a result, their percentages were put together and the resultant value was 46.2%. As observed, this new percentage was higher than that of the lightbox. This, taken in conjunction with the advantage of being able to see several activities simultaneously, led us to think that opening a new tab or a new window could be better ways of displaying activities than the lightbox. Therefore, it was decided that ***AdVisor 1.0 would remove the lightbox and use tabs or windows*** depending on the web browser used by the student.

D.2.10 Future improvements

A list of elements to be added or improved was given to the students so that they chose as many items as they deemed appropriate (see Table D.3). *Adding more multimedia resources* was found necessary by 61.7% of the respondents. This may have been due to the fact that both courses mainly used PDF files. However, AdVisor 0.0 was able to show images, play videos and audios, etc. Hence, this was a course design issue which was the teachers' responsibility, not to AdVisor.

Regarding the rest of the choices, *adding information about assessment* was the second option (27.6%). This accorded with the request for a view based on CAAs made by the respondents (see section D.2.8). Next, 25.5% chose *to develop forums* and 19.1% chose *to improve aspects related to the schedule*. Finally, *other* (17%) alternatives were proposed too, e.g. *to enable students to*

	Multimedia resources	Info. about assessment	Forums	Schedule	Other
#Students	29 (61.7%)	13 (27.6%)	12 (25.5%)	9 (19.1%)	8 (17%)

Table D.3: AdVisor 0.0 – Improvements for the next prototypes.

communicate with the instructor, *to integrate AdVisor into the UOC campus*, etc. In addition to the previous responses, some comments suggested including information about CAAs in the schedule, since this was missing.

After gathering information about potential improvements, it could be concluded that ***the next prototypes of AdVisor would focus on assessment and forums***.

E AdVisor 1.0: questionnaire and results

This appendix contains the questionnaire used in the prototype AdVisor 1.0 as well as an exhaustive analysis of the responses collected. More specifically, the sections of this appendix are:

- Questionnaire (see section E.1)
- Results (see section E.2)

E.1 Questionnaire

All the questions with this symbol [*] were mandatory.

Section A – Respondent's profile

1. [∗] Gender
   - Man
   - Woman

2. [∗] Age
   - 17-20
   - 36-40
   - 21-25
   - 41-45
   - 26-30
   - 46-50
   - 31-35
   - Older than 50

3. [∗] How many semesters have you been enrolled at the UOC?
   - 1 semester
   - 2 semesters
   - 3 semesters
   - 4 or 5 semesters
   - More than 5 semesters

Section B – Support for the guidance through the course

4. [∗] Rate the usefulness of the following aspects on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

Organization based on sessions	1	2	3	4	5	• No response
To have all the activities detailed	1	2	3	4	5	• No response
Assessment letter / fill pattern	1	2	3	4	5	• No response

5. If you have any suggestions, comments, etc. about any of the previous aspects, please let us know below.

Section C – Self-awareness

6. [∗] Rate the usefulness of the status color on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

   1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
   4 - Useful 5 - Very useful

7. [∗] Rate the dashboard on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

   1 - Very poor/Insufficient 2 - Poor 3 - Fair 4 - Good 5 - Very good • No response

8. [∗] Rate the usefulness of each of the areas of the dashboard on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

Agenda	1	2	3	4	5	• No response
Pace	1	2	3	4	5	• No response
Assessment	1	2	3	4	5	• No response

9. What things would you change in order to improve the Advisor's dashboard? Please, let us know below.

Section D – Self-regulation

10. [∗] How useful was the option of marking an activity as complete for you?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful

11. [∗] To what extent did AdVisor help you to self-regulate your learning process?

    1 - Nothing 2 - Little 3 - Normal 4 - Quite a lot 5 - A great deal • No response

Section E – Multiple views

12. [∗] How useful did you find to know the relationship between the learning activities and each of the following course elements? Rate from 1 (*not at all useful*) useful to 5 (*very useful*).

Degree competences	1	2	3	4	5	• No response
Course objectives	1	2	3	4	5	• No response
Table of contents	1	2	3	4	5	• No response
Schedule/session	1	2	3	4	5	• No response
Continuous assessment assignment (CAA)	1	2	3	4	5	• No response

13. What other relationships do yo think that they would be useful for you? Please, let us know below.

14. [∗] How long did you use each view provided by AdVisor 1.0? Rate from 1 (*nothing*) to 5 (*a great deal*).

Gantt chart (i.e. schedule)	1	2	3	4	5	• No response
Treeview (i.e. TOC)	1	2	3	4	5	• No response
Elastic list (i.e. competences and objectives)	1	2	3	4	5	• No response
Simple list (i.e. activities, resources and CAAs)	1	2	3	4	5	• No response

15. If you have any suggestions, comments, etc. about the current views or you want to suggest a new one, please let us know below.

Section E – Usability

16. [∗] To what extent was each view easy to use? Rate from 1(*not at all usable*) to 5 (*very usable*).

Gantt chart (i.e. schedule)	1	2	3	4	5	• No response
Treeview (i.e. TOC)	1	2	3	4	5	• No response
Elastic list (i.e. competences and objectives)	1	2	3	4	5	• No response
Simple list (i.e. activities, resources and CAAs)	1	2	3	4	5	• No response

17. [∗] To what extent was each representation suitable for the information that it displayed? Rate from 1(*not at all suitable*) to 5 (*very suitable*).

Gantt chart (i.e. schedule)	1	2	3	4	5	• No response
Treeview (i.e. TOC)	1	2	3	4	5	• No response
Elastic list (i.e. competences and objectives)	1	2	3	4	5	• No response
Simple list (i.e. activities, resources and CAAs)	1	2	3	4	5	• No response

18. What things would you change in order to improve each view?

Section F – Overall evaluation and future improvements

19. [∗] Rate your overall experience with AdVisor 1.0 on a scale of 1-5, with 1 being *very bad* and 5 being *very good*:

    1 - Very bad 2 - Bad 3 - Fair 4 - Good 5 - Very good • No response

20. [∗] Would you like to use AdVisor in other courses?

    • Yes • No • No response

21. If you have any suggestions, comments, etc. about any aspect of the platform that you find important, please let us know below.

E.2 Results

This section analyzes the results of the previous questionnaire in detail. At this point, it is important to stress that the frequency tables as well as the bar and pie charts contain *no response* answers, while the box plots do not. Likewise, this section does not include the comments made by the teachers during the test. These are presented in Chapter 5 (see section 5.3.5).

E.2.1 Response rate

42 of 115 students filled out the questionnaire (see Table E.1). This meant a response rate of 36.5%, 15.7% more than that of AdVisor 0.0. For each course, the response rate was 41.9% for Electric Circuit Analysis and 33.3% for Mathematics II. Given that response rates tend to be lower for Internet questionnaires than for other delivery modes (Cook et al., 2000; Couper, 2000, cited by Dillman et al. (2009)), ***36.5% may be considered a good figure***. Actually, according to Nulty (2008), the average response rate for online surveys is about 33%, while that for paper-based surveys is 56%.

E.2.2 Respondents' profile

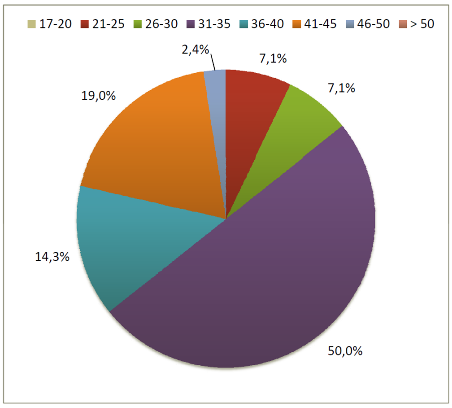
92.9% of the respondents were over 25 (see Figure E.1). In consequence, they probably worked and had family responsibilities. They could also be considered to be students with online learning experience, since 92.9% had been enrolled in the UOC at least *3 semesters* (see Figure E.2). Lastly, Table E.1 shows 95.2% were *men*, a usual fact in Engineering courses (Hill and Corbett, 2010). As seen, ***the respondents had, in general, the typical features of online students*** (see section 2.4.1.1).

Course		**Electric Circuit Analysis (.002)**			**Mathematics II (.008)**			**Total**
Language		Catalan (19)	Spanish (89)	Total	Catalan	Spanish	Total	
#Students in the test		33	10	43	51	21	72	115
Number of respondents	#Male	14	3	17	18	5	23	40 (95.2%)
	#Female	1	0	1	1	0	1	2 (4.8%)
	Total	15 (45.5%)	3 (30%)	18 (41.9%)	19 (37.3%)	5 (23.8%)	24 (33.3%)	42 (36.5%)

Table E.1: AdVisor 1.0 – Breakdown of the participants.

v_i	n_i	p_i	P_i
17-20	0	0%	0%
21-25	3	7.1%	7.1%
26-30	3	7.1%	14.2%
31-35	21	50%	50.2%
36-40	6	14.3%	78.5%
41-45	8	19%	97.5%
46-50	1	2.4%	100%
Older than 50	0	0%	100%
	$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table

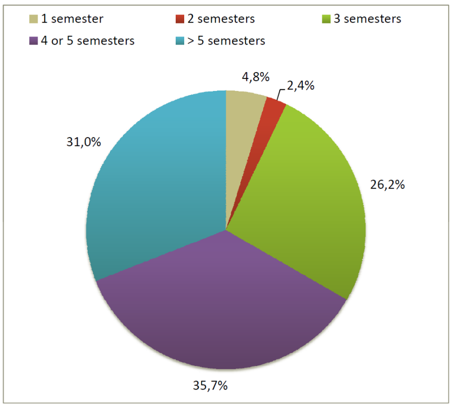


(b) Pie chart

Figure E.1: AdVisor 1.0 – Respondents' age ranges.

v_i	n_i	p_i	P_i
1 semester	2	4.8%	4.8%
2 semesters	1	2.4%	7.1%
3 semesters	11	26.2%	33.3%
4 or 5 semesters	15	35.7%	69%
More than 5 semesters	13	31%	100%
	$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Pie chart

Figure E.2: AdVisor 1.0 – Number of semesters that the respondents had been enrolled in the UOC.

E.2.3 Reliability of the results

Apart from stating that the response rate was good and the respondents' profile practically matched the archetype of online students (see sections E.2.1 and E.2.2), ***it could be ensured that all the respondents of this test had used the platform during the whole semester***. For all of these reasons, the results from the questionnaire were much more reliable than those of AdVisor 0.0.

Nevertheless, it was needed to be careful with the conclusions which were drawn. On the one hand, all the participants were enrolled in Engineering courses and most of them were men. On the other hand, ***a possible extraneous variable was detected***: a few of the respondents who belonged to Electric Circuit Analysis (.002) were annoyed for having to use two environments simultaneously, i.e. AdVisor and UOC classroom's forums. The reason for this may have been that the forums played a significant role in that subject (see section 5.1) and, as a result, learners had had to access to these communication tools a lot. Due to the aforesaid nuisance, some of the respondents from Electric Circuit Analysis filled out the questionnaire in less than 4 minutes and indiscriminately evaluated some aspects with low scores (i.e. 1 or 2). However, these students were not removed from the analysis since it was essential to collect all the opinions. Therefore, the results of Electric Circuit Analysis were, in general, slightly worse than those of Mathematics II.

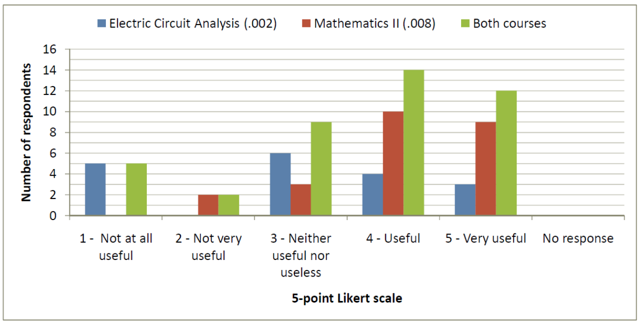
In conclusion, despite the aforesaid unexpected drawback, ***the results gave an insight into the suitability of the proposed recommendations*** as well as an interesting range of responses that could be used to extract trends, possible improvements, etc.

E.2.4 To guide students through the course (recommendation B)

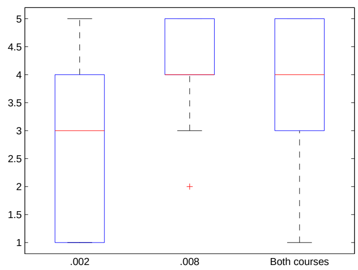
Besides the organization based on sessions, two more aspects related to this recommendation were evaluated by the respondents: (1) detailed activities, and (2) the assessment type of the tasks by means of a visual element (i.e. a letter or fill pattern). In this regard, the Cronbach's alpha coefficient for the three items was $\alpha = .90$, which gave evidence to prove that they three measured the same underlying construct: the usefulness of the guidance through the course (i.e. ***recommendation B***). Next, the results of each item are detailed.

v_i	Electric Circuit Analysis (.002)			Mathematics II (.008)			Both courses		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Not at all useful	5	27.8%	27.8%	0	0%	0%	5	11.9%	11.9%
2 - Not very useful	0	0%	27.8%	2	8.3%	8.3%	2	4.8%	16.7%
3 - Neither useful nor useless	6	33.3%	61.1%	3	12.5%	20.8%	9	21.4%	38.1%
4 - Useful	4	22.2%	83.3%	10	41.6%	62.4%	14	33.3%	71.4%
5 - Very useful	3	16.7%	100%	9	37.5%	100%	12	28.6%	100%
No response	0	0%	100%	0	0%	100%	0	0%	100%
	$n = 18$	$\sum p_i = 100\%$		$n = 24$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.3: AdVisor 1.0 – Usefulness of having the course divided into sessions.

As for the usefulness of organizing the courses in sessions (see Figure E.3), the Mann-Whitney (MW) test showed that there was enough evidence to reject the null hypothesis and say that the students from Electric Circuit Analysis (.002) and Mathematics II (.008) had different opinion ($U = 119.5$, $Z = -2.545$, $p = .011$). More specifically, this aspect was rated positively (median = mode = 4, 41.6%) in Mathematics II and worse (mode = median = 3, 33.3%) in Electric Circuit Analysis:

1. ***The opinion of the students from Mathematics II (.008) was very similar in AdVisor 0.0 and 1.0***: 83.3% and 79.1%, respectively, found the sessions *useful* (4) or *very useful* (5).

2. ***All the respondents who rated 1 were enrolled in Electric Circuit Analysis (.002)***. According to some comments, there may have been two possible reasons for this: (1) the teacher in charge of the subject had created too many sessions, and (2) the real and the estimated workloads were not well-balanced yet.

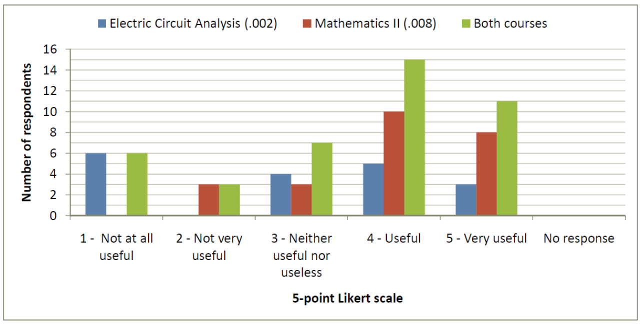
   Another reason might have been that the weekly short guides of Mathematics II were less complete than the lecture notes of Electric Circuit Analysis. Hence, the students from Mathematics II may have appreciated more the contributions of AdVisor linked to the guidance.

   Moreover, some students of Electric Circuit Analysis indiscriminately rated some aspects with low scores (i.e. 1 or 2) due to the inconvenience caused by the fact of having to use AdVisor 1.0 and UOC's forums simultaneously. In any case, the presence of too many 1's caused a large dispersion (IQR=3) in the distribution of scores of this course (see Figure E.3c).

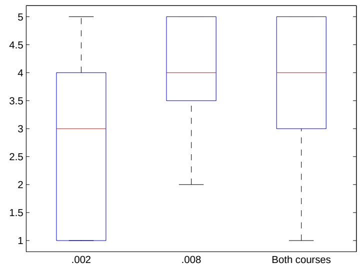
When both courses were analyzed together, it could be stated that ***about 62% found the organization based on sessions useful*** (4, 33.3%, mode and median) ***or very useful*** (5, 28.6%). The distribution was left-skewed or, in other words, ***only 16.7% of the respondents evaluated this aspect negatively*** (i.e. scores 1 and 2).

v_i	Electric Circuit Analysis (.002)			Mathematics II (.008)			Both courses		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Not at all useful	6	33.3%	33.3%	0	0%	0%	6	14.3%	14.3%
2 - Not very useful	0	0%	33.3%	3	12.5%	12.5%	3	7.1%	21.4%
3 - Neither useful nor useless	4	22.2%	55.5%	3	12.5%	25%	7	16.7%	38.1%
4 - Useful	5	27.8%	83.3%	10	41.7%	66.7%	15	35.7%	73.8%
5 - Very useful	3	16.7%	100%	8	33.3%	100%	11	26.2%	100%
No response	0	0%	0%	0	0%	0%	0	0%	0%
	$n = 18$	$\sum p_i = 100\%$		$n = 24$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.4: AdVisor 1.0 – Usefulness of having the activities detailed.

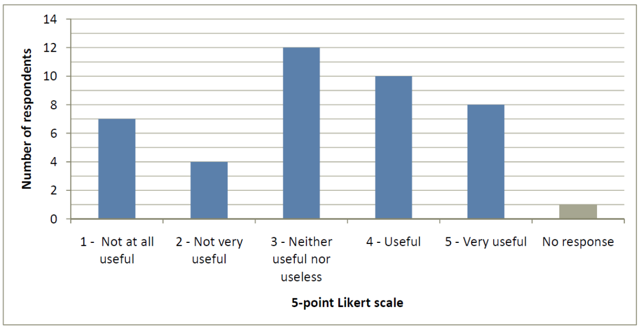
With regard to having the learning activities detailed, the responses were very similar to the previous aspect: ***around 62% rated it useful*** (4, 35.7%, mode and median) ***or very useful*** (5, 26.2%). Once again, there was enough evidence to state that the opinions of the two groups were different (MW test: $U = 133$, $Z = -2.189$, $p = .029$). Once more, all the students who rated *1* belonged to Electric Circuit Analysis (.002). The reasons for that may have been the same as the aforesaid ones. Actually, the similarity between these two aspects of AdVisor 1.0 was such that, according to Spearman's correlation coefficient, those learners who rated the organization based on sessions positively also found having a detailed schedule of the activities useful ($\rho = .786$, $p < .01$).

Finally, AdVisor 1.0 showed a letter (or fill pattern for the Gantt chart) which indicated the type of assessment of a particular item. In this occasion, there was not enough evidence to state that the two groups had a different opinion (MW test: $U = 151.5$, $Z = -1.427$, $p = .154$). ***About 44% found this visual element useful*** (4, 24.4%) ***or very useful*** (5, 19.5%). However, the most repeated value was 3 (*neither useful nor useless*, 29.3%), which coincided with the median (see Figure E.5). In fact, the distribution was practically symmetrical with IQR equal to 2. This result, together with the fact that assessment was important to the students (see section 5.2.5), may have meant this visual item had not been found really useful. One possible reason for this may have been that the information related to the activities that was conveyed by the letter/fill pattern already existed in the simple list view, where the CAAs were shown. In fact, each CAA displayed all the graded activities at a glance. Finally, although it is not shown in Figure E.5, the respondents from Electric Circuit Analysis (.002) were the ones who rated worse. Actually, 33.33% of them scored this item with 1 (*not at all useful*). From the questionnaire, it could not be drawn any conclusion about why this happened.

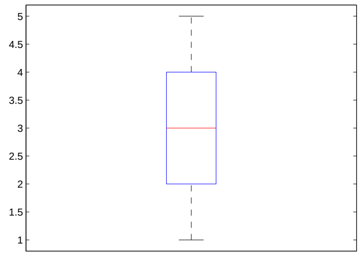
Although better results were expected, it could be stated that the three previous items had been accepted by the students and ***recommendation B seemed to be suitable for online education***.

v_i	Assessment letter / fill pattern			
	n_i	p_i	p_i^*	P_i
1 - Not at all useful	7	16.7%	17.1%	17.1%
2 - Not very useful	4	9.5%	9.8%	26.8%
3 - Neither useful nor useless	12	28.6%	29.3%	56.1%
4 - Useful	10	23.8%	24.4%	80.5%
5 - Very useful	8	19%	19.5%	100%
No response	1	2.4%		
	$n = 42$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.5: AdVisor 1.0 – Usefulness of the assessment letter/fill pattern.

E.2.5 To provide self-awareness (recommendation C)

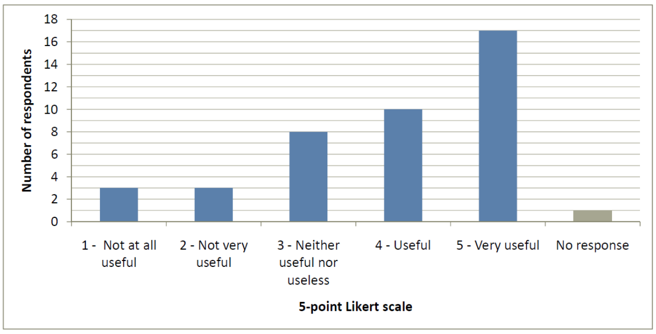
AdVisor 1.0 expanded the number of elements that aimed to provide students with awareness of their learning process. In addition to the dashboard as a whole, this prototype evaluated: (1) the status color, (2) the dashboard's agenda area, (3) the dashboard's pace area, and (4) the dashboard's assessment area. The Cronbach's alpha coefficient was $\alpha = .869$ and, hence, indicated that the previous five elements measured ***recommendation C***.

Regarding the status color, there was not enough evidence to reject the null hypothesis in the MW test ($U = 146.5$, $Z = -1.598$, $p = .11$). Therefore it was considered that the two groups (i.e. Electric Circuit Analysis and Mathematics II) had similar opinion. As shown in Figure E.6, ***41.5% found status color very useful*** (score = 5). Actually, this value was the mode, while the score 4 (*useful*, 24.4%) was the median. In consequence, the distribution was clearly left-skewed (see Figure E.6c). As observed, ***the status color was evaluated very positively, since 65.9% found this visual element useful or very useful***. Furthermore, the percentage of negative responses (score = 1 and 2) was equal to 14.6%.

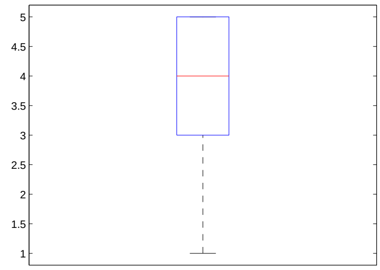
As in AdVisor 0.0, the dashboard was the main element that helped students to be aware of their learning process. Once again, the respondents were asked to evaluate it on a 5-point Likert scale. According to the MW test, there was not enough evidence to prove that the two groups thought about this tool differently ($U = 161.5$, $Z = -1.237$, $p = .216$). Moreover, as shown in the box plot of Figure E.7, the distribution was left-skewed with IQR equal to 1.25. This meant that the mass of the distribution was concentrated on the higher values. In fact, the most chosen score was *good* (4, 31.7%), which was also the median. As a result, ***56.1% of the respondents thought that the dashboard was a good*** (4, 31.7%) ***or very good*** (5, 24.4%) ***tool***. By contrast, only 17.1% chose

v_i	Status color			
	n_i	p_i	p_i^*	P_i
1 - Not at all useful	3	7.1%	7.3%	7.3%
2 - Not very useful	3	7.1%	7.3%	14.6%
3 - Neither useful nor useless	8	19%	19.5%	34.1%
4 - Useful	10	23.8%	24.4%	58.5%
5 - Good	17	40.5%	41.5%	100%
No response	1	2.4%		
	$n = 42$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.6: AdVisor 1.0 – Usefulness of the status color.

the options *poor* (2, 9.8%) or *very poor* (1, 7.3%). Although this result was good, this could have been considered even better, since the three respondents who rated 1 (*very poor*) were outliers (see Figure E.7c). As seen, the evaluation obtained by AdVisor 1.0's dashboard accorded with that of AdVisor 0.0's one (59.1% responses ≥ 4). ***This implied a reinforcement of the usefulness of the dashboard as a space that helps the student to be aware of her learning process***.

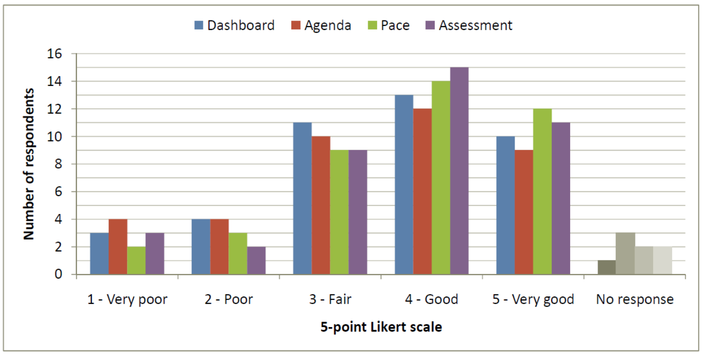
Apart from evaluating the dashboard as a whole, each information area was also evaluated individually in order to conduct a detailed analysis. Nevertheless, although the dashboard was made up of four areas, only three were used in the test due to technical problems with the feedback area. Consequently, the respondents were only asked to rate the agenda, the pace and the assessment areas (see Figure E.7). For these three areas, there was not enough evidence to state that the two groups had different opinion (MW test - agenda: $U = 141$, $Z = -1.266$, $p = .205$; MW test - pace: $U = 149.5$, $Z = -1.313$, $p = .189$; MW test - assessment: $U = 190$, $Z = -.157$, $p = .875$).

As for the agenda area, there was quite consensus (IQR = 1). ***79.4% of the respondents found it fair*** (i.e. score equal to 3) ***or better***, being *good* (4, 30.8%) the mode and the median. Although this result was good, this may have been considered better according to the box plot of Figure E.7, because the respondents who rated 1 (*very poor*, 10.3%) could have been labeled as outliers.

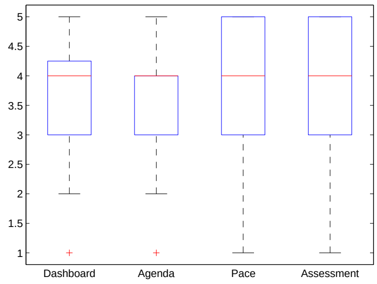
Regarding the pace area, this type of information was absolutely new to the students, since there was not a similar space in the UOC classroom. This area obtained the same mode and median as those of the agenda: 4 (*good*, 35%). In this regard, ***65% of the respondents rated it 4*** (*good*) ***or 5*** (*very good*, 30%). This figure reached 87.5% when the responses with score 3 (*fair*, 22.5%) were added. This excellent result was reaffirmed by means of the distribution of the scores, which had a negative skewness and was symmetrical between the quartiles Q_1 and Q_3 (i.e. the blue box). However, it had more dispersion (IQR = 2) than the agenda area (IQR = 1). Despite this, because

v_i	Dashboard			Agenda area			Pace area			Assessment area		
	n_i (p_i)	p_i^*	P_i	n_i (p_i)	p_i^*	P_i	n_i (p_i)	p_i^*	P_i	n_i (p_i)	p_i^*	P_i
1 - Very poor	3 (7.1%)	7.3%	7.3%	4 (9.5%)	10.3%	10.3%	2 (4.8%)	5%	5%	3 (7.1%)	7.5%	7.5%
2 - Poor	4 (9.5%)	9.8%	17.1%	4 (9.5%)	10.3%	20.6%	3 (7.1%)	7.5%	12.5%	2 (4.8%)	5%	12.5%
3 - Fair	11 (26.2%)	26.8%	43.9%	10 (23.8%)	25.6%	46.2%	9 (21.4%)	22.5%	35%	9 (21.4%)	22.5%	35%
4 - Good	13 (31%)	31.7%	75.6%	12 (28.6%)	30.8%	77%	14 (33.3%)	35%	70%	15 (35.7%)	37.5%	72.5%
5 - Very good	10 (23.8%)	24.4%	100%	9 (21.4%)	23.1%	100%	12 (28.6%)	30%	100%	11 (26.2%)	27.5%	100%
No response	1 (2.4%)			3 (7.1%)			2 (4.8%)			2 (4.8%)		
	$n = 42$	100%		$n = 42$	100%		$n = 42$	100%		$n = 42$	100%	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.7: AdVisor 1.0 – Evaluation of the dashboard and its information areas.

the upper whisker overlapped the third quartile, the last 25% of data only included the value 5 (*very good*). This meant that the overall rate of the pace area was shifted to 5 and, thus, was higher than that of the agenda area. Last but not least, the good evaluation of the status color, which was closely related to this information area, reinforced the usefulness of the dashboard's pace area.

With regard to the assessment area, it displayed, unlike the UOC classroom, learners' grades at a glance. The distribution of the scores was quite identical to that of the pace area: its median and mode were 4 (*good*, 37.5%) and its interquartile range (IQR) was 2 too. Likewise, ***87.5% found this area fair*** (3, 22.5%) ***or better***. But, in this case, 37.5% and 27.5% rated 4 (*useful*) and 5 (*very useful*), respectively. This meant that this area had been rated slightly worse than the pace area.

In addition to rating this tool, two people wrote a comment. One of them said the design would have to be improved. Specifically, s/he indicated that each information area had a small size, but there was too much room around the four boxes. Therefore, s/he suggested enlarging the box of each area. The other person requested that the feedback area was used next semester.

After analyzing the dashboard as whole and each of its information areas individually, it could be concluded that ***the dashboard was a useful tool that had helped the learners during the course***.

As seen, both the status color and the dashboard were evaluated very positively. Hence, the results seemed to indicate that providing online students with information that helps them be aware of their learning process is very important. In short, ***recommendation C was suitable***.

E.2.6 To provide tools that help students to be self-regulated (rec. B and C)

As said in section D.2.7, ***recommendations B and C*** pursue providing tools that help students to be self-regulated. The Cronbach's alpha coefficient of the items related to these two recommendations, $\alpha = .934$, confirmed that these elements, and consequently ***recommendations B and C***, measured the same construct: the usefulness of the items that support self-regulated learning.

In addition to the items of ***recommendations B and C***, two more questions related to self-regulated learning were asked: (1) *"how useful was the option of marking an activity as complete?"*, and (2) *"to what extent did AdVisor help you to self-regulate your learning process?"*. The previous Cronbach's alpha coefficient reached $\alpha = .95$ when these two new questions were added. Hence, there was evidence to state that the two new aspects were closely related to the items of ***recommendations B and C*** and, in consequence, also measured the aforesaid construct.

As for the feature of marking the completion of an activity (see Figure E.8), the MW test revealed that the difference between Electric Circuit Analysis (.002) and Mathematics II (.008) was statistically significant ($U = 113$, $Z = -2.732$, $p = .006$). Again, the students from Mathematics II scored better than the learners from Electric Circuit Analysis. For Mathematics II, the mode and the median were 5 (*very useful*, 50%) and 4.5 respectively, whereas the evaluation of the group of Electric Circuit Analysis had a mode of 1 (*not at all useful*, 38.9%) and a median of 3 (*neither useful nor useless*, 22.2%). At this point, it is worth emphasizing two facts:

- ***50% of the respondents from Mathematics II (.008) rated this functionality 5*** (*very useful*).

- ***All the respondents, except for one, who rated 1*** (*not at all useful*) ***were enrolled in Electric Circuit Analysis (.002).*** If the box plots of this group of Figures E.3, E.4 and E.8 are compared, one can notice they are identical. Thus, the reasons that led the respondents of this course to answer these three questions negatively may have been the same ones (see page 229).

Nevertheless, when the two groups were analyzed together, then it could be concluded that ***61.9% found marking the completion of an activity useful*** (4, 23.8%, median) ***or very useful*** (5, 38.1%, mode). Furthermore, as shown in Figure E.8c, the distribution was left-skewed.

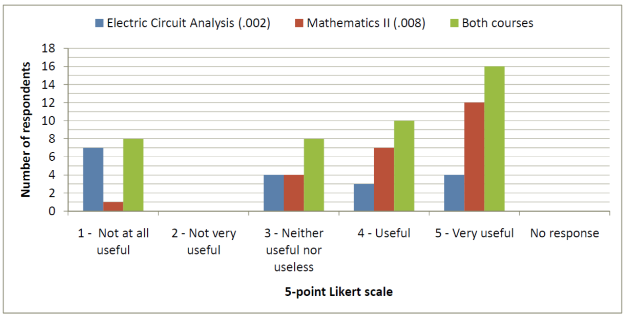
With regard to the question *"to what extent did AdVisor help you to self-regulate your learning process?"* (see Figure E.9), both groups, in general, had a similar opinion (MW test: $U = 167$, $Z = -1.273$, $p = .203$). Just like in AdVisor 0.0, ***over 40% found that AdVisor 1.0 had helped them in a significant way (i.e. scores 4 and 5).*** Likewise, the median and the mode were 3 (*normal*, 26.2%). However, in this occasion, the distribution was more disperse (IQR=2) than that of AdVisor 0.0 (IQR=1). Once again, it is important to emphasize that 6 of the 7 students who rated 1 (*nothing*, 16.7%) belonged to Electric Circuit Analysis (.002). This meant this question obtained a few more negative responses (i.e. 1 and 2) than when it was evaluated in the previous prototype. Despite this, the global result was good, since ***66.6% expressed that AdVisor 1.0 had helped them to be self-regulated in a normal*** (3, 26.2%) ***or significant way*** (scores 4 and 5, 40.4%).

As seen in sections E.2.4 and E.2.5 as well as in this one, most of those aspects of AdVisor 1.0 that were aligned with self-regulated learning attained good results. Hence, in general, ***there was evidence to say that AdVisor 1.0 had helped students to be self-regulated to some extent***.

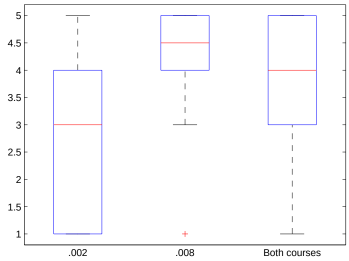
Lastly, it is worth saying that the evaluation of the extent of support of AdVisor for self-regulation had an either moderate or strong positive correlation with the rest of items (see Table E.2).

v_i	Electric Circuit Analysis (.002)			Mathematics II (.008)			Both courses		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Not at all useful	7	38.9%	38.9%	1	4.2%	4.2%	8	19%	19%
2 - Not very useful	0	0%	38.9%	0	0%	0%	0	0%	19%
3 - Neither useful nor useless	4	22.2%	61.1%	4	16.7%	20.9%	8	19%	38%
4 - Useful	3	16.7%	77.8%	7	29.2%	50.1%	10	23.8%	62%
5 - Very useful	4	22.2%	100%	12	50%	100%	16	38.1%	100%
No response	0	0%	0%	0	0%	0%	0	0%	0%
	$n = 18$	$\sum p_i = 100\%$		$n = 24$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

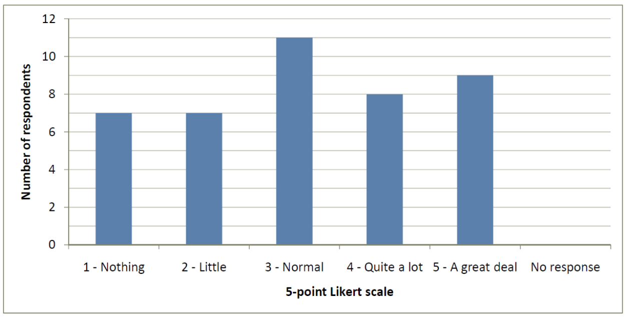


(c) Box plot

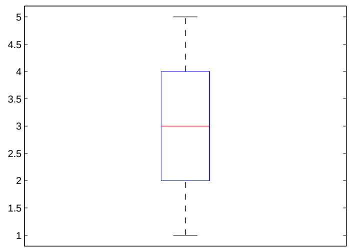
Figure E.8: AdVisor 1.0 – Usefulness of being able to mark an activity as complete.

v_i	n_i	p_i	P_i
1 - Nothing	7	16.7%	16.7%
2 - Little	7	16.7%	33.3%
3 - Normal	11	26.2%	59.5%
4 - Quite a lot	8	19%	78.6%
5 - A great deal	9	21.4%	100%
No response	0	0%	
	$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.9: AdVisor 1.0 – To what extent AdVisor helped to self-regulate the students' learning process.

	Session	**Detailed activities**	**Assessment letter**	**Status color**	**Dashboard**	**Marking completion**
AdVisor helped to self-regulate	$\rho = .683^{**}$ (Moderate)	$\rho = .710^{**}$ (Strong)	$\rho = .643^{**}$ (Moderate)	$\rho = .499^{**}$ (Moderate)	$\rho = .773^{**}$ (Strong)	$\rho = .712^{**}$ (Strong)

** Significant correlation at 1% level of significance.

Table E.2: AdVisor 1.0 - Spearman's correlation coefficient between the extent of support of the platform for self-regulation of the learning process and each of the features related to it.

E.2.7 To provide multiple views of the course (recommendations G and A)

This section focuses on the questions related to ***recommendation G*** or, in other words, the provision of multiple views of the same course. Furthermore, it indirectly deals with ***recommendation A***, i.e. to define competences and objectives clearly. In short, this section analyzes two aspects:

- Usefulness of the relationships between the activities and the rest of the course elements
- Use of each view

Next, the results of each issue are presented.

E.2.7.1 Usefulness of the relationships between the activities and the rest of the course elements

First of all, the questionnaire asked how useful was to know the relationship that existed between the activities and each of the course elements provided by AdVisor 1.0 during their learning process. According to the MW test, both groups seemed to have the same opinion for each of the relationships. From the results obtained from the questionnaire, the five relationships were ranked from the most to the least useful. Figure E.10 shows that ranking (from left to right).

The first position was clearly for the relationship between the activities and the continuous assessment assignments (CAAs) (MW test: $U = 204$, $Z = -.360$, $p = .719$), since 64.3% of the respondents chose the score 5 (*very useful*), ***becoming the mode and the median***. Likewise, the distribution was compact with IQR equal to 1. Furthermore, as it is shown in the box plot, the person who rated 2 (*not very useful*, 2.4%) could have been considered an outlier.

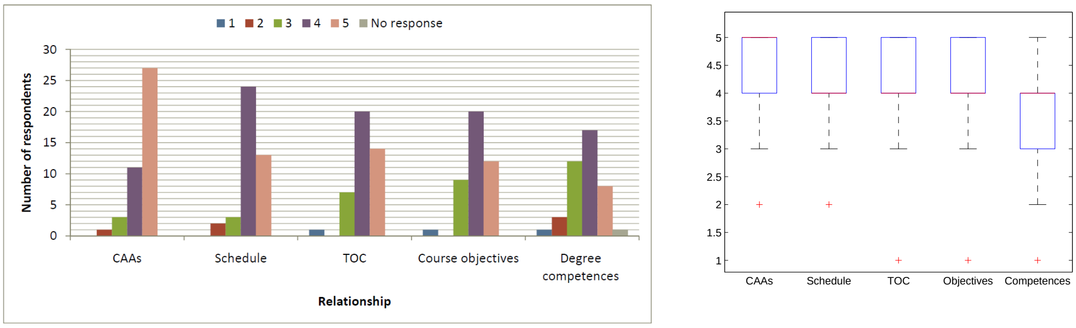
Next, the relationship with ***the schedule (or sessions) ranked second*** (MW test: $U = 204.5$, $Z = -.330, p = .741$), whereas ***the TOC and the objectives were third and fourth***, respectively (MW test-TOC: $U = 174.5$, $Z = -1.144$, $p = .253$; MW test-objectives: $U = 186$, $Z = -.823$, $p = .411$). The three relationships obtained very similar scores, being their modes and medians equal to 4 (*useful*). Moreover, the blue boxes of their box plots (i.e. the 50% of data) started in 4 and finished in 5, i.e. IQR equal to 1. Likewise, the scores which were lower than 3 (*neither useful nor useless*) could have been labeled as outliers in the three cases. However, the percentage of responses equal or greater than 4 was 88.1% for the schedule/session, whereas the TOC and the objectives obtained 80.9% and 76.2%, respectively. This is why the relationship with the schedule/sessions was second, the one with the TOC third, and the one with the course objectives fourth.

Finally, ***the relationship with the degree competences was the less useful*** (MW test: $U = 196$, $Z = -.305$, $p = .760$). Although its IQR was 1 and its mode and median were 4 (*useful*, 41.5%) like the three previous relationships, the blue box of its box plot went from 3 to 4 (i.e. it was more right-skewed). Hence, its evaluation was worse.

The order of preference of the relationships between the activities and the course elements

v_i	CAAs		Schedule/session		TOC		Course objectives		Degree competences		
	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	p_i^*	P_i
1 - Not at all useful	0 (0%)	0%	0 (0%)	0%	1 (2.4%)	2.4%	1 (2.4%)	2.4%	1 (2.4%)	2.4%	2.4%
2 - Not very useful	1 (2.4%)	2.4%	2 (4.8%)	4.8%	0 (0%)	2.4%	0 (0%)	2.4%	3 (7.1%)	7.3%	9.8%
3 - Neither useful nor useless	3 (7.1%)	9.5%	3 (7.1%)	11.9%	7 (16.7%)	19%	9 (21.4%)	23.8%	12 (28.6%)	28.3%	39%
4 - Useful	11 (26.2%)	35.7%	24 (57.1%)	69%	20 (47.6%)	66.7%	20 (47.6%)	71.4%	17 (40.5%)	41.5%	80.5%
5 - Very useful	27 (64.3%)	100%	13 (31%)	100%	14 (33.3%)	100%	12 (28.6%)	100%	8 (19%)	19.5%	100%
No response	0	0%	0	0%	0	0%	0	0%	1	2.4%	

(a) Frequency table



(b) Bar chart ***(c)*** Box plot

Figure E.10: AdVisor 1.0 – The usefulness of the relationships between the activities and different course elements.

was not surprising. The most useful relationship was the one that included the closest item to assessment, i.e. CAAs. After all, what any learner wants is to pass the subject. This result accorded with the requests for future improvements that were made by the respondents of AdVisor 0.0 (see section D.2.10). Likewise, the second position of the relationship with the schedule/sessions also made sense, since the respondents may have found it important to know what tasks they had to do. As seen, ***the preferred relationships were those that included the elements which were closer to the coursework***, i.e. what activities are part of the assessment and when they have to be performed. Actually, one respondent wrote that knowing the degree competences which one is developing is not relevant.

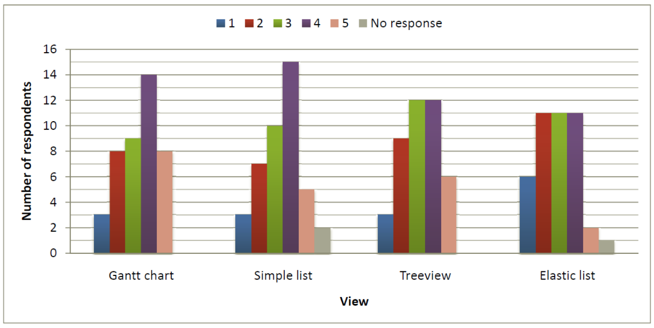
To find out other relationships that could be useful to students, an optional open question was included in the questionnaire. Only one person wrote a comment. She suggested linking the activities to the discussion forums. Thereby, each activity would have its own forum. This comment matched one of the requests of the respondents of AdVisor 0.0, who asked for including more information about assessment and developing forums (see section D.2.10). In this regard, AdVisor 1.0 focused on assessment, whereas ***AdVisor 2.0 would pay special attention to the forums***.

E.2.7.2 Use of each view

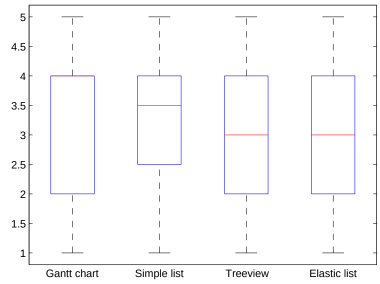
Related to the previous question, it was asked: *"how long did you use each view provided by AdVisor 1.0?"*. According to the MW test, the respondents from the two courses used all the views in a similar way. As shown in Figure E.11, ***the Gantt chart*** (linked to the schedule space) had a mode and a median of 4 (*quite a lot*, 33.3%), being ***the most used view*** (MW test: $U = 194.5$, $Z = -.564$, $p = .573$). This, along with the result of the dashboard's pace area, suggested that ***the students had found useful to have information about their studying pace and the course's schedule***. This also led one to think this view may have helped to the learners who studied in a constant way.

v_i	Gantt chart			Simple list				Treeview			Elastic list			
	n_i	p_i	P_i	n_i	p_i	p_i^*	P_i	n_i	p_i	P_i	n_i	p_i	p_i^*	P_i
1 - Nothing	3	7.1%	7.1%	3	7.1%	7.5%	7.5%	3	7.1%	7.1%	6	14.3%	14.6%	14.6%
2 - Little	8	19%	26.2%	7	16.7%	17.5%	25%	9	21.4%	28.6%	11	26.2%	26.8%	41.5%
3 - Normal	9	21.4%	47.6%	10	23.8%	25%	50%	12	28.6%	57.1%	11	26.2%	26.8%	68.2%
4 - Quite a lot	14	33.3%	81%	15	35.7%	37.5%	87.5%	12	28.6%	85.7%	11	26.2%	26.8%	95.1%
5 - A great deal	8	19%	100%	5	11.9%	12.5%	100%	6	14.3%	100%	2	4.8%	4.9%	100%
No response	0	0%		2	4.8%			0	0%		1	2.4%		
	$n = 42$	$\sum p_i = 100\%$		$n = 42$		$\sum p_i^* = 100\%$		$n = 42$	$\sum p_i = 100\%$		$n = 42$		$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.11: AdVisor 1.0 – Usage of each of the views provided.

The second position was for the simple list which included activities, sessions, resources and CAAs (MW test: $U = 184.5$, $Z = -.313$, $p = .754$). Its mode was 4 (*quite a lot*, 37.5%) and its median was 3.5. Although this view was ranked second in terms of use, one can notice that the scores of the Gantt chart and the simple list were very similar (see Figure E.11b). However, the Gantt chart was a little bit more left-skewed than the simple list. By contrast, the IQR of the simple list was more narrow (IQR=1.5) than that of the Gantt chart (IQR=2). In any case, the second position of the simple list may have meant that many students preferred knowing what activities they had to do during the semester, without considering the proposed dates. Another reason may have been that this view listed the CAAs (i.e. the mandatory activities) clearly and at a glance. Thus, this view could have been used by those learners who either were used to planning their learning process based on the CAAs or were only interested in passing the course by handing in the CAAs. As revealed in the questionnaire of AdVisor 0.0 (see section D.2.4), a significant proportion of UOC students match this profile, since most of them do not have enough time to perform all the activities. Actually, this accorded with the results of the previous question about the relationship between the activities and the course elements, which indicated that the assessment (or CAAs) was the most important aspect for the students.

Finally, both the treeview (related to the TOC) and the elastic list (linked to the competences and objectives) obtained similar scores (MW test-treeview: $U = 210$, $Z = -.157$, $p = .875$; MW-elastic list: $U = 186.5$, $Z = -.478$, $p = .633$). According to Figure E.11, their medians were 3 (*normal*) and their IQRs were 2. Nevertheless, the mode of the treeview was 3 (*normal*, 28.6%) and 4 (*quite a lot*%), whereas the elastic list's one was 2 (*little*, 26.8%), 3 (*normal*) and 4 (*quite a lot*). Moreover, the former obtained more 5's than the latter. As a result, ***the treeview was the third most used view and the elastic list was the fourth one***. The fact that the treeview was not directly related to either assessment or schedule, the two most important aspects for the students according to the previous question (see section E.2.7.1), may have been the reason for its third position. Despite being less important than the previous two views, ***the treeview might have been useful when the learners wanted to review a specific concept***.

As for the elastic list, its fourth position was expected, because, as seen in the previous question, competences and objectives, especially the former, were not considered essential by learners. The reason may have been that ***the current students may not yet be used to seeing a course from a perspective based on degree competences and course objectives***. Nevertheless, this view may be more important in the future, when the EHEA's degrees are deployed completely.

E.2.7.3 Conclusions

The previous analysis has shown that ***it seemed that the provision of multiple views (i.e. recommendation G) was accepted by all the respondents***. Actually, in addition to including discussion forums, two people suggested another view: one that displayed the relationship between one course and the rest of the subjects of the degree. In that view, the courses could be linked through the prerequisites, shared topics, etc. Moreover, the new information structure seemed to include the most important aspect of a course.

In contrast, as evidenced by the results of the previous two questions, ***the respondents did not find having the competences and the objectives clearly defined (i.e. recommendation A) useful***. This trend would have to be confirmed in the next prototype, but everything seemed to indicate that there was still a long way until the students got used to paying attention to degree competences and course objectives. For that reason, it would be important to promote the use of these two items with the support of the teachers in future.

E.2.8 Usability (recommendations I-M)

Each view of AdVisor 1.0 used a different type of visual representation, i.e. Gantt chart, treeview, elastic list and simple list. Each of them was evaluated by the respondents in terms of:

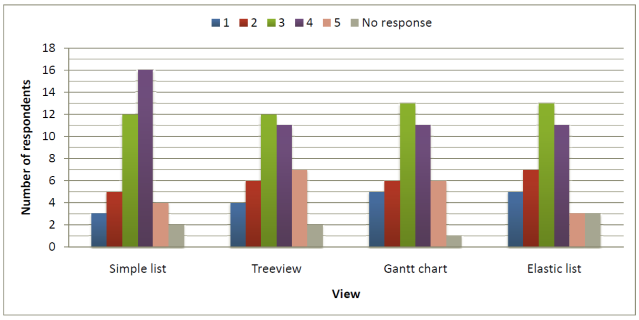
- Usability
- Suitability

The first aspect, i.e. usability, asked: *"to what extent was each view easy to use?"* (see Figure E.12). By contrast, the second issue focused on knowing to what extent each representation was suitable for the information that it displayed (see Figure E.13). To understand the difference between both concepts, let us imagine an example: a view that uses a calendar to show the schedule. This could be easy to use, but other representations could be more suitable, e.g. a Gantt chart.

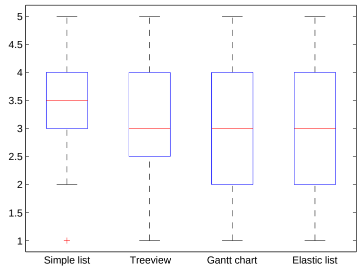
According to the results, the respondents from the two courses agreed that ***the simple list was the most usable view*** (MW test: $U = 172$, $Z = -.580$, $p = .562$). In fact, 50% found it *usable* (4, 40%, mode) or *very usable* (5, 10%), being the median equal to 3.5. This result was even better, since the three people who rated 1 (*not at all usable*, 7.5%) could be considered outliers (see Figure

v_i	Simple list			Treeview			Gantt chart			Elastic list		
	$n_i\ (p_i)$	p_i^*	P_i	$n_i\ (p_i)$	p_i^*	P_i	$n_i\ (p_i)$	p_i^*	P_i	$n_i\ (p_i)$	p_i^*	P_i
1 - Not at all usable	3 (7.1%)	7.5%	7.5%	4 (9.5%)	10%	10%	5 (11.9%)	12.2%	12.2%	5 (11.9%)	12.8%	12.8%
2 - Not very usable	5 (11.9%)	12.5%	20%	6 (14.3%)	15%	25%	6 (14.3%)	14.6%	26.8%	7 (16.7%)	17.9%	30.8%
3 - Neither usable nor unusable	12 (28.6%)	30%	50%	12 (28.6%)	30%	55%	13 (31%)	31.7%	58.5%	13 (31%)	33.3%	64.1%
4 - Usable	16 (38.1%)	40%	90%	11 (26.2%)	27.5%	82.5%	11 (26.2%)	26.8%	85.4%	11 (26.2%)	28.2%	92.3%
5 - Very usable	4 (9.5%)	10%	100%	7 (16.7%)	17.5%	100%	6 (14.3%)	14.6%	100%	3 (7.1%)	7.7%	100%
No response	2 (4.8%)			2 (4.8%)			1 (2.4%)			3 (7.1%)		
	$n = 42$	$\sum p_i^* = 100\%$		$n = 42$	$\sum p_i^* = 100\%$		$n = 42$	$\sum p_i^* = 100\%$		$n = 42$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.12: AdVisor 1.0 – Usability of each of the views provided.

E.12c). As for its suitability (MW test: $U = 195$, $Z = -.554$, $p = .580$), 45.2% thought the simple list was *suitable* (4, 26.2%) or *very suitable* (5, 19%). The option *normal* (3, 35.7%) was both the mode and the median. Hence, ***81% found the suitability of this view normal*** (3) ***or better***.

The treeview was ranked second. With consensus between the two courses (MW test: $U = 131.5$, $Z = -1.803$, $p = .071$), 45% found this representation *usable* (4, 27.5%) or *very usable* (5, 17.5%). In contrast to the simple list, the variability of the opinions was higher (IQR=1.5). Likewise, the mode and the median were 3 (*neither usable nor unusable*, 30%). As for its suitability, there was enough evidence to state that the two courses did not share the same opinion (MW test: $U = 125$, $Z = -2.242$, $p = .025$). In this regard, the students from Electric Circuit Analysis (.002) rated worse. Nevertheless, if the opinions of the two groups were analyzed together, then around 78% would consider the treeview as *normal* (3, 39%) or better, being 3 the mode and the median.

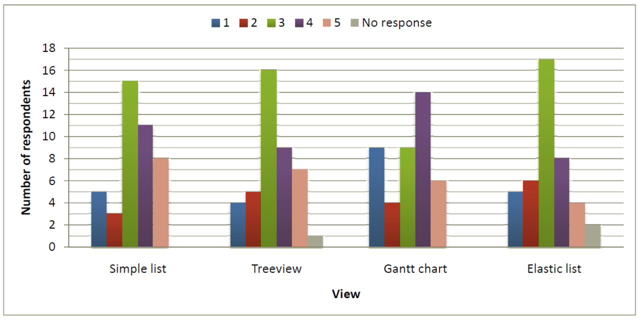
Finally, as shown in the box plots of Figures E.12 and E.13, both the Gantt chart and the elastic list had very similar distributions in terms of usability (median = mode = 3) and suitability (Gantt: mode = 4 and median = 3; Elastic list: mode = 3 and median = 3). However, ***the Gantt chart was slightly better than the elastic list*** due to several reasons:

- Although the median and the mode were 3 (*neither usable nor unusable*) in terms of usability for the two views, the respondents from the two courses had similar opinion about the Gantt chart (MW test: $U = 165$, $Z = -1.124$, $p = .261$), but not about the elastic list (MW test: $U = 109$, $Z = -2.287$, $p = .022$). The respondents from Electric Circuit Analysis (.002) evaluated the elastic list quite worse than the other group.

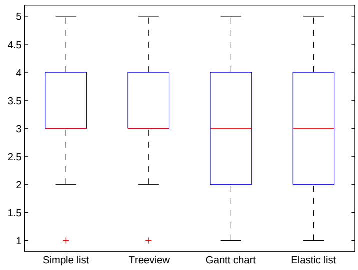
- Even though the two groups were in agreement about the suitability of both representations (MW test-Gantt chart: $U = 177$, $Z = -1.022$, $p = .307$; MW test-elastic list: $U = 155$, $Z = -1.226$, $p = .220$), the mode of the Gantt chart was 4 (*suitable*, 33.3%), whereas that of the elastic list was 3 (*normal*, 42.5%).

v_i	Simple list			Treeview			Gantt chart			Elastic list		
	n_i	p_i	P_i	n_i (p_i)	p_i^*	P_i	n_i	p_i	P_i	n_i (p_i)	p_i^*	P_i
1 - Not at all suitable	5	11.9%	11.9%	4 (9.5%)	9.8%	9.8%	9	21.4%	21.4%	5 (11.9%)	12.5%	12.5%
2 - Not very suitable	3	7.1%	19%	5 (11.9%)	12.2%	22%	4	9.5%	31%	6 (14.3%)	15%	27.5%
3 - Normal	15	35.7%	54.8%	16 (38.1%)	39%	61%	9	21.4%	52.4%	17 (40.5%)	42.5%	70%
4 - Suitable	11	26.2%	81%	9 (21.4%)	22%	82.9%	14	33.3%	85.7%	8 (19%)	20%	90%
5 - Very suitable	8	19%	100%	7 (16.7%)	17.1%	100%	6	14.3%	100%	4 (9.5%)	10%	100%
No response	0	0%		1	2.4%		0	0%		2 (4.8%)		
	$n = 42$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i^* = 100\%$		$n = 42$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure E.13: AdVisor 1.0 – Suitability of each of the views provided.

Despite the fact that the Gantt chart was slightly better than the elastic list, the results of suitability obtained by the Gantt chart were surprising. The reason was that 21.4% of the respondents thought that this representation was *not at all suitable* (score = 1). But, at the same time, this was the view that had more responses with high values (i.e. 4 and 5), 20 of 42, followed by the simple list with 19. Hence, there were extreme and opposite responses for the suitability of the Gantt chart. This fact caused certain confusion about if the Gantt chart was a suitable representation or not. In order to clear up this doubt, the open question *"what things would you change in order to improve each view?"* was used. None of the comments received for the Gantt chart suggested changing the representation. This, in conjunction with the fact that the Gantt chart had been the most used view (see section E.2.7.2) and thus the students had had more time to detect weak points, led us to think this visual representation was suitable but it would need to be enhanced a lot.

As seen, ***the simple list and the treeview were the best rated representations***. One reason for this may have been that they both are integrated in any operative system (OS). Therefore, the learners were used to utilizing both types of visual representations. By contrast, the Gantt chart and the elastic list required students to learn how they worked.

Considering AdVisor 1.0 was a prototype whose design mainly focused on aspects related to pedagogy and information structure, ***the evaluation of the usability (and suitability) could be considered good***. However, the whole platform would have to be improved in future as much as possible. Among the improvements that were suggested, it is worth stressing the following ones:

1. The Gantt chart would have to allow to select several activities or sessions and mark them as finished. AdVisor 1.0's Gantt chart only enabled to check activities as complete one by one.

2. The Gantt chart would have to show the current sessions by default. The Gantt chart of AdVisor 1.0 always showed the first sessions of the course regardless of the current date.

3. AdVisor's interface should have a look and feel more familiar to the students, e.g. UOC's style.

4. To attempt to make data more visible at a glance.

5. To reduce the amount of clicks needed until reaching the resources of an activity.

E.2.9 Overall experience

The respondents were asked about their overall experience with AdVisor 1.0 (see Figure E.14). When the two courses were analyzed together (MW test: $U = 193.5$, $Z = -.589$, $p = .556$), ***73.8% of the responses were 3*** (*normal*, 21.4%) ***or greater, being the score 4*** (*good*, 33.3%) ***the median and the mode***. Moreover, the distribution was left-skewed with IQR equals to 2. Therefore, in general, ***the respondents' experience was satisfactory***.

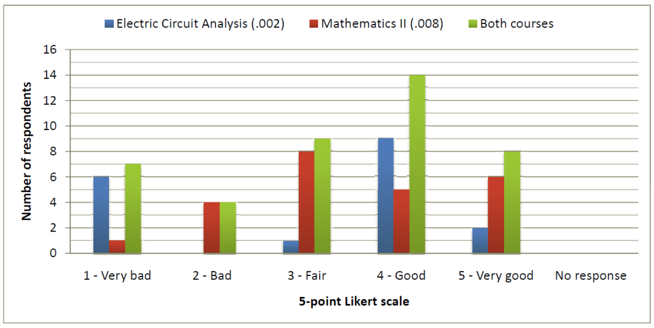
Nevertheless, when the overall experience was analyzed for each course individually, some latent issues emerged. As shown in Figure E.14, ***33.33% of respondents from Electric Circuit Analysis (.002) had had a very bad experience with the platform*** (score = 1). One of the reasons that they argued was that using two platforms simultaneously (i.e. AdVisor 1.0 and the UOC's forums) had been very annoying. According to some students, this situation had sometimes confused them. This may have led some respondents from .002 to indiscriminately rate several questions with 1 (*very bad*) and filled out the questionnaire quickly. Other reasons were explained in page 229. As a result, the distribution of the responses of Electric Circuit Analysis (.002) was less homogeneous than that of Mathematics II (.008), i.e. IQR_{002} = 3; IQR_{008} = 1.5 (see the box plots of Figure E.14). Even so, ***Electric Circuit Analysis (.002) paradoxically had a mode and a median of 4*** (*good*, 50%), ***whereas the mode and the median of Mathematics II (.008) were 3*** (*fair*, 33.3%).

Another question related to the overall experience was asked: *"would you like to use AdVisor in other courses?"* (see Figure E.15). This was asked without considering if they preferred AdVisor as a replacement of the UOC classroom or as a support tool. ***69% of the respondents expressed that they would use the platform again***. By contrast, 26.2% would not use it again and 4.8% did not know. At this point, it is important to emphasizing that there was enough evidence to state that the null hypothesis could be rejected and, therefore, the two groups had different opinion (MW test: $U = 137$, $Z = -2.144$, $p = .032$). As a result of this finding, the responses were analyzed for each course. Thanks to this, it was possible to observe that ***there was much more rejection in Electric Circuit Analysis (44.4%) than Mathematics II (12.5%)***. The main reasons for this difference may have been the same as the ones that have already been explained previously.

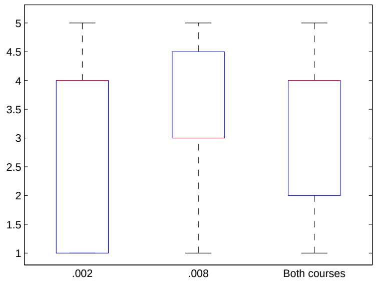
In conclusion, by taking all the evaluation of all the elements that were part of AdVisor 1.0 into consideration, ***it could be concluded that this prototype was favorably received by the respondents***. Despite this, the platform would have to be improved. One of those improvements would be to add discussion forums to AdVisor so that the students only had to use a single tool.

v_i	Electric Circuit Analysis (.002)			Mathematics II (.008)			Both courses		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Very bad	6	33.3%	33.3%	1	4.2%	4.2%	7	16.7%	16.7%
2 - Bad	0	0%	33.3%	4	16.7%	20.9%	4	9.5%	26.2%
3 - Fair	1	5.6%	38.9%	8	33.3%	54.2%	9	21.4%	47.6%
4 - Good	9	50%	88.9%	5	20.8%	75%	14	33.3%	81%
5 - Very good	2	11.1%	100%	6	25%	100%	8	19%	100%
No response	0	0%		0	0%		0	0%	
	$n = 18$	$\sum p_i = 100\%$		$n = 24$	$\sum p_i = 100\%$		$n = 42$	$\sum p_i = 100\%$	

(a) Frequency table

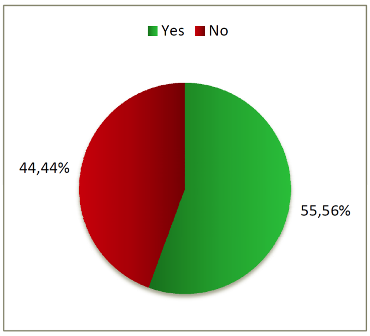


(b) Bar chart

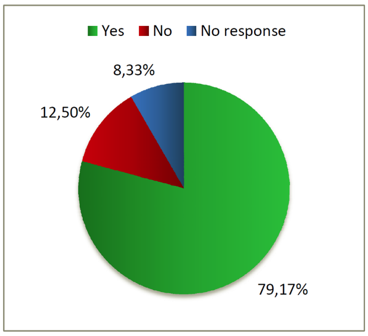


(c) Box plot

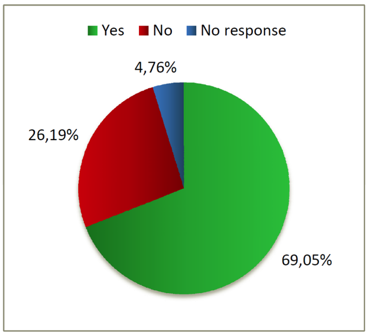
Figure E.14: AdVisor 1.0 – Overall experience.



(a) Circuit Analysis (.002)



(b) Mathematics II (.008)



(c) Both courses

Figure E.15: AdVisor 1.0 – *"Would you like to use AdVisor in other courses?".*

F AdVisor 2.0: questionnaire, interview and results

This appendix contains the questionnaire used in the prototype AdVisor 2.0 as well as the pre-determined set of questions of the interviews that were conducted. For each of them, an exhaustive analysis of the responses collected is provided. Therefore, the sections of this appendix are:

- Questionnaire (see section F.1)
  - Questions (see section F.1.1)
  - Results (see section F.1.2)
- Interview (see section F.2)
  - Set of questions (see section F.2.1)
  - Results (see section F.2.2)

F.1 Questionnaire

F.1.1 Questions

All the questions with this symbol [*] were mandatory.

Section A – Respondent's profile

1. [$*$] Gender
   - Man
   - Woman
2. [$*$] Age
   - 17-20
   - 21-25
   - 26-30
   - 31-35
   - 36-40
   - 41-45
   - 46-50
   - Older than 50
3. [$*$] How many semesters have you been enrolled at the UOC?
   - 1 semester
   - 2 semesters
   - 3 semesters
   - 4 or 5 semesters
   - More than 5 semesters
4. [$*$] Which type of job do you have currently?
   - Out of job
   - Part-time job (<20 hours/week)
   - Full-time job ($\geq$20 hours/week)

Section B – Support to the guidance through the course

5. [$*$] Rate the usefulness of the following aspects on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

Organization based on sessions	1	2	3	4	5	• No response
To have all the activities detailed	1	2	3	4	5	• No response
Assessment letter / fill pattern	1	2	3	4	5	• No response

6. If you have any suggestions, comments, etc. about any of the previous aspect related to self-regulation, please let us know below.

Section C – Self-awareness

7. [$*$] Rate the usefulness of the status color on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

   1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
   4 - Useful 5 - Very useful

8. [∗] Rate the dashboard on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

   1 - Very poor/Insufficient   2 - Poor   3 - Fair   4 - Good   5 - Very good   • No response

9. [∗] Rate the usefulness of each of the areas of the dashboard on a scale of 1-5, with 1 being *not at all usable* and 5 being *very usable*:

Agenda	1	2	3	4	5	• No response
Pace	1	2	3	4	5	• No response
Assessment	1	2	3	4	5	• No response
Forums	1	2	3	4	5	• No response

10. What things would you change in order to improve the Advisor's dashboard? Please, let us know below.

11. [∗] To what extent did AdVisor help you to be aware of your situation in the course?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

Section D – Self-regulation

12. [∗] How useful was the option of marking an activity as complete for you?

    1 - Not at all useful   2 - Not very useful   3 - Neither useful nor useless
    4 - Useful   5 - Very useful

13. [∗] To what extent did AdVisor help you to self-regulate your learning process?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

Section E – Multiple views

14. [∗] Rate the usefulness of the following aspects on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

To have multiple views of the course	1	2	3	4	5	• No response
The fact that all the views were related to the activities	1	2	3	4	5	• No response

15. [∗] To what extent did AdVisor help you to have an overview of the course beyond the activities and CAAs?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

16. [∗] How long did you use each view provided by AdVisor 1.0? Rank them from the *most used view* (1st) to *the least* (5th). You cannot repeat a position.

Gantt chart (i.e. schedule)	1st	2nd	3rd	4th	5th	6th
Treeview (i.e. TOC)	1st	2nd	3rd	4th	5th	6th
Elastic list (i.e. competences and objectives)	1st	2nd	3rd	4th	5th	6th
Activities and resources	1st	2nd	3rd	4th	5th	6th
Assessment	1st	2nd	3rd	4th	5th	6th
Forums	1st	2nd	3rd	4th	5th	6th

17. What things would you change in order to improve the AdVisor's views? Would you add or remove any view? Please, let us know below.

Section F – Social interaction

18. [∗] Rate the usefulness of the following aspects on a scale of 1-5, with 1 being *not at all useful* and 5 being *very useful*:

To have a forum per activity	1	2	3	4	5	• No response
To know what messages have liked to the classmates	1	2	3	4	5	• No response
To know the messages highlighted by the teacher	1	2	3	4	5	• No response

Section G – Usability

19. [∗] To what extent was each of the following elements useful? Rate from 1(*not at all usable*) to 5 (*very usable*).

Tooltips	1	2	3	4	5	• No response
To have the workspace divided into two parts (top: navigation and bottom: description)	1	2	3	4	5	• No response
Arrow button to show/hide the description area	1	2	3	4	5	• No response

20. [∗] To what extent was each view easy to use? Rate from 1(*not at all usable*) to 5 (*very usable*).

Gantt chart (i.e. schedule)	1	2	3	4	5	• No response
Treeview (i.e. TOC)	1	2	3	4	5	• No response
Elastic list (i.e. competences and objectives)	1	2	3	4	5	• No response
Activities and resources	1	2	3	4	5	• No response
Assessment	1	2	3	4	5	• No response
Forums	1	2	3	4	5	• No response

21. [∗] Give your opinion about the following statements related to the usability of AdVisor by ticking the appropriate option, being 1 *strongly disagree* and 5 *strongly agree*.

Learning to use the platform is fast	1	2	3	4	5
It is is easy to navigate without getting lost	1	2	3	4	5
You find what you are looking for fast	1	2	3	4	5
The design and the layout of the interface allow to see the important information at a glance	1	2	3	4	5
The visual style (i.e. font size, colors, icons, etc.) is suitable	1	2	3	4	5
Response time is good	1	2	3	4	5

22. What things would you change in order to improve the usability of each view?

Section H – Overall evaluation and future improvements

23. [∗] Rate your overall experience with AdVisor 1.0 on a scale of 1-5, with 1 being *very bad* and 5 being *very good*:

    1 - Very bad 2 - Bad 3 - Fair 4 - Good 5 - Very good • No response

24. [∗] Would you like to use AdVisor in other courses?

    • Yes • No • No response

25. [∗] What thing/s of AdVisor did you find more useful/interesting? Please let us know below.

26. [∗] What thing/s did you miss in AdVisor? Please let us know below.

27. If you have any suggestions, comments, etc. about any aspect of the platform that you find important, please let us know below.

F.1.2 Results

This section shows and analyzes the responses of the previous questionnaire in detail. Just like the appendices D and E, it is important to stress that the frequency tables and the bar and pie charts contain *no response* answers, while the box plots do not. Likewise, the comments made by the teachers during the test are not included. These are presented in Chapter 5 (see section 5.4.5).

F.1.2.1 Response rate

44 of 115 students completed the questionnaire (see Table F.1). This meant a ***response rate of 38.3%*** (1.8% higher than AdVisor 1.0). The response rate in Electric Circuit Analysis reached 39% (41.9% in AdVisor 1.0) and 37.5% in Mathematics II (33.3% in AdVisor 1.0). As it has already been argued in AdVisor 1.0 (see Appendix E.2.1), this response rate may be considered quite good.

F.1.2.2 Respondents' profile

88.6% of the respondents were over 25 years old (see Figure F.1) and, in consequence, the number of workers was high: 79.5% worked 20 or more hours, i.e. they had a full-time job (see Figure F.2). Likewise, 84.1% had been enrolled in the UOC for three or more semesters (see Figure F.3).

As the courses which participated in the test belonged to the Bachelor's Degree in Telecommunications, there were more men than women. Specifically, 86.4% of the respondents were men.

As seen, it can be stated that ***the respondents' profile matched that of typical online learners*** (see section 2.4.1.1), except for the difference in the number of males and females.

F.1.2.3 Reliability of the results

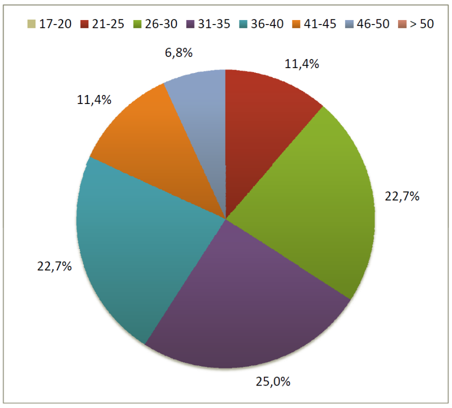
The use of AdVisor 2.0 was mandatory for all the students during the semester. This allowed to ensure that the respondents had used the platform in depth and, hence, their opinions were well-founded. However, this was not enough to state that the results were reliable. Apart from the compulsory use, the respondents had to be a representative sample of the potential end-users of the system. In this regard, one of the aspects that allows to achieve a high degree of representativeness is the size of the sample, i.e. the more respondents fill out the questionnaire, the more reliable the results will be. As for the test of AdVisor 2.0, 42 students filled out the questionnaire, which meant a good response rate (38.3%). However, the size per se does not guarantee that the

Course		**Electric Circuit Analysis (.002)**			**Mathematics II (.008)**			**Total**
Language		Catalan (19)	Spanish (89)	Total	Catalan	Spanish	Total	
#Students in the test		46	13	59	34	22	56	115
Number of respondents	#Male	14	8	22	9	7	16	38 (86.4%)
	#Female	1	0	1	2	2	5	6 (13.6%)
	Total	15 (32.6%)	8 (61.5%)	23 (39%)	12 (35.3%)	9 (41%)	21 (37.5%)	44 (38.3%)

Table F.1: AdVisor 2.0 – Breakdown of the participants.

v_i	n_i	p_i	P_i
17-20	0	0%	0%
21-25	5	11.4%	11.4%
26-30	10	22.7%	34.1%
31-35	11	25%	59.1%
36-40	10	22.7%	81.8%
41-45	5	11.4%	93.2%
46-50	3	6.8%	100%
Older than 50	0	0%	100%
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table

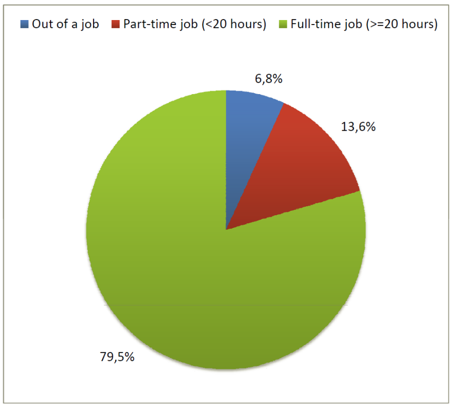


(b) Pie chart

Figure F.1: AdVisor 2.0 – Respondents' age ranges.

v_i	n_i	p_i	P_i
Out of a job	3	6.8%	6.8%
Part-time job (<20 hours)	6	13.6%	20.4%
Full-time job ($\geq$20 hours)	35	79.5%	100%
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table

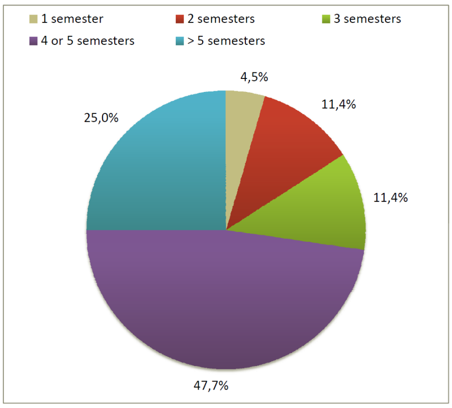


(b) Pie chart

Figure F.2: AdVisor 2.0 – Respondents' type of job.

v_i	n_i	p_i	P_i
1 semester	2	4.5%	4.5%
2 semesters	5	11.4%	15.9%
3 semesters	5	11.4%	27.3%
4 or 5 semesters	21	47.7%	75%
More than 5 semesters	11	25%	100%
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Pie chart

Figure F.3: AdVisor 2.0 – Number of semesters that the respondents had been enrolled in the UOC.

sample is able to represent a target population accurately. In addition to the size, it is also essential to select a sample which represents the target population in so far as it possesses all the features of the population. As seen in section F.1.2.2, ***the respondents' profile and the population's one were practically identical***, except for the fact that most of those questioned were men.

With regard to the variables that could have affected the reliability of the results, these were minimized as much as possible. For example, the inclusion of the discussion forums in this prototype enabled the students to carry out the whole learning process without using the UOC classroom. Students only had to use the UOC classroom in order to submit their solutions to the CAAs. This action was done five times in Electric Circuit Analysis and four times in Mathematics II. As a result, ***the extraneous variable of the test of AdVisor 1.0 was removed***.

Finally, it is worth stressing that the generalization of the results may have been affected by the fact that all the respondents were enrolled in courses which belonged to a technological degree.

In conclusion, despite the limitations of the sample, this was quite representative (and more reliable than that of AdVisor 1.0) to gain an insight into the suitability of the recommendations proposed in this thesis. Therefore, ***the results from AdVisor 2.0, along with those of AdVisor 1.0, provided a first validation of the suitability of the recommendations proposed in this thesis***. Likewise, these results laid the foundations for more research on this field, e.g. new experiments with students from different degrees and universities.

F.1.2.4 To guide students through the course (recommendation B)

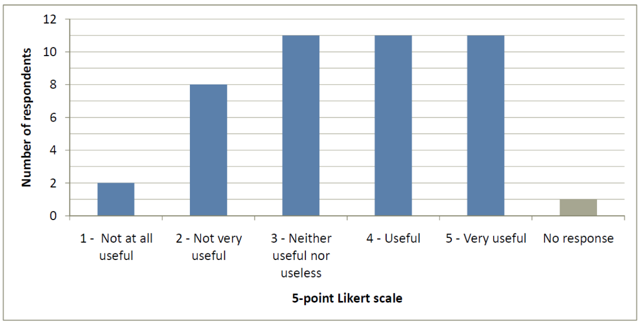
Recommendation B was evaluated by means of the same items as those of AdVisor 1.0: (1) organization based on sessions, (2) detailed activities, and (3) the assessment letter/fill pattern. In this occasion, the Cronbach's alpha coefficient was $\alpha = .673$, i.e. practically $\alpha = .70$. This result just matched up with the threshold from which a scale is considered reliable. For this reason, it was analyzed how much each of the three items affected the scale. The conclusion was that the inclusion of the assessment letter/fill pattern was detrimental to the reliability of the scale in such a way that if this item was removed, then the Cronbach's alpha coefficient reached $\alpha = .782$. Despite this, it could be considered that the three items measured the same construct, i.e. the usefulness of the guidance through the course (i.e. ***recommendation B***).

With regard to the usefulness of the sessions (see Figure F.4), the MW test indicated that, unlike AdVisor 1.0, there was not enough evidence to reject the null hypothesis and, hence, the two groups had similar opinions ($U = 216$, $Z = -.351$, $p = .726$). In that occasion, the distribution was multimodal (3, 4 and 5) and had the same median as AdVisor 1.0, i.e. 4 (*useful*). ***51.2% found the organization based on sessions useful*** (4, 25.6%) ***or very useful*** (5, 25.6%). This figure reached 76.7% when the score 3 (*neither useful nor useless*, 25.6%) was included.

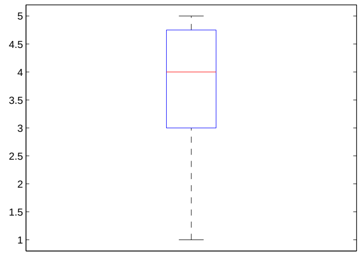
There was also agreement about the fact that the activities were detailed (MW test: $U = 187.5$, $Z = -1.067$, $p = .286$). As shown in Figure F.5, ***74.4% rated this feature with 3*** (*neither useful nor useless*, 18.6%) ***or higher***, being 55.8% of the responses 4 (*useful*, 30.2%) or 5 (*very useful*, 25.6%). Like in AdVisor 1.0, the median and the mode were 4 (*useful*, 30.2%).

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	2	4.5%	4.7%	4.7%
2 - Not very useful	8	18.2%	18.6%	23.3%
3 - Neither useful nor useless	11	25%	25.6%	48.8%
4 - Useful	11	25%	25.6%	74.4%
5 - Very useful	11	25%	25.6%	100%
No response	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart

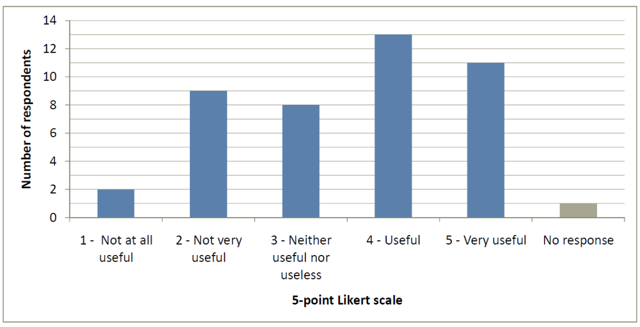


(c) Box plot

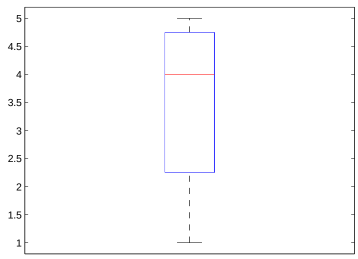
Figure F.4: AdVisor 2.0 – Usefulness of having the course divided into sessions.

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	2	4.5%	4.7%	4.7%
2 - Not very useful	9	20.5%	20.9%	25.6%
3 - Neither useful nor useless	8	18.2%	18.6%	44.2%
4 - Useful	13	29.5%	30.2%	74.4%
5 - Very useful	11	25%	25.6%	100%
No response	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

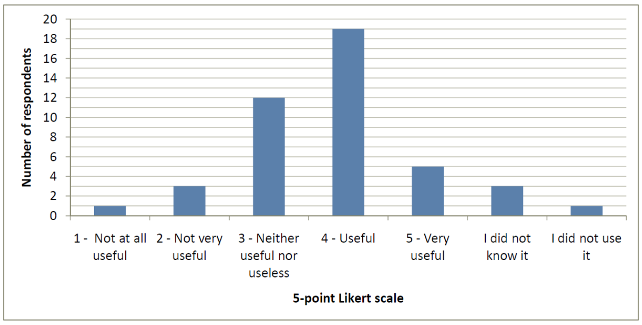


(c) Box plot

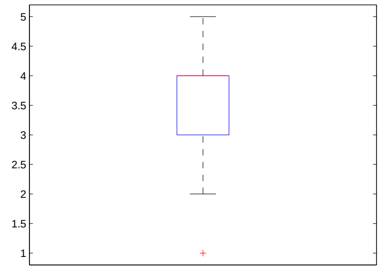
Figure F.5: AdVisor 2.0 – Usefulness of having the activities detailed.

v_i	Assessment letter / fill pattern			
	n_i	p_i	p_i^*	P_i
1 - Not at all useful	1	2.3%	2.5%	2.5%
2 - Not very useful	3	6.8%	7.5%	10%
3 - Neither useful nor useless	12	27.3%	30%	40%
4 - Useful	19	43.2%	47.5%	87.5%
5 - Very useful	5	11.4%	12.5%	100%
I did not know it	3	6.8%		
I did not use it	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.6: AdVisor 2.0 – Usefulness of the assessment letter/fill pattern.

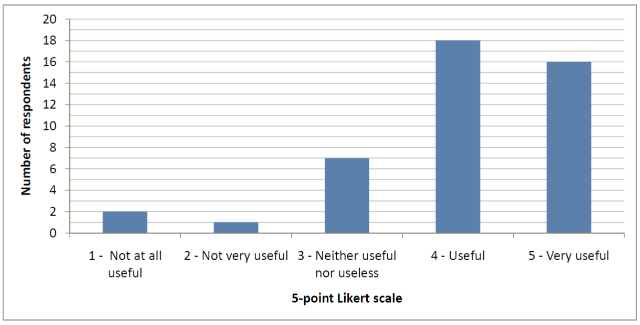
Although the overall rates of the previous two items were good, they were lower than those of AdVisor 1.0 (61.9% rated both features 4 or 5). A possible reason for this decrease was given by a comment of a student from Mathematics II. This remark said that the activities had been divided too much and, hence, the degree of detail had been excessive. Actually, according to this comment, the excess of detail had made the students get lost. This problem of instructional design may have affected the evaluation of both the session and the division of the activities. Likewise, it is important to take account of the fact that a significant proportion of online students organize their learning process based on CAAs (see section D.2.4) and, hence, sessions are not useful to them. Therefore, the percentage of respondents (around 25%) that found both items *not at all useful* (score = 1) or *not very useful* (score = 2) could be considered acceptable.

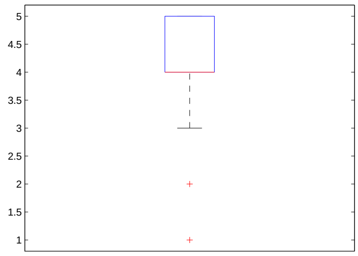
As for the assessment letter (fill pattern in the Gantt chart), there was consensus too (MW test: $U = 137.5$, $Z = -1.707$, $p = .088$). Moreover, this was evaluated better in AdVisor 2.0 than in AdVisor 1.0. As shown in Figure F.6, ***60%*** (16% better than AdVisor 1.0) ***thought that this item had been useful*** (4, 47.5%) ***or very useful*** (5, 12.5%). The median and the mode were 4 (*useful*), instead of 3 (*neither useful nor useless*). Moreover, the percentage of 1 (*not at all useful*, 2.5%) and 2 (*not very useful*, 7.5%) was 10% (AdVisor 1.0: 26.8%), being the score 1 an outlier value (see Figure F.6c).

In short, despite the aforesaid problem and the consequent results, ***it could be concluded that the guidance through the course (i.e. recommendation B) had been found useful by the respondents***. The main reason for this was that, for each item, the percentage of the responses equal or greater than 3 (*neither useful nor useless*) was: 76.7%, 74.4% and 90%, respectively, being at least 51% of the responses equal to 4 (*useful*) or 5 (*very useful*).

v_i	Status color		
	n_i	p_i	P_i
1 - Not at all useful	2	4.5%	4.5%
2 - Not very useful	1	2.3%	6.8%
3 - Neither useful nor useless	7	15.9%	22.7%
4 - Useful	18	40.9%	63.6%
5 - Very useful	16	36.4%	100%
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$

(a) Frequency table





(b) Bar chart ***(c)*** Box plot

Figure F.7: AdVisor 2.0 – Usefulness of the status color.

F.1.2.5 To provide self-awareness (recommendation C)

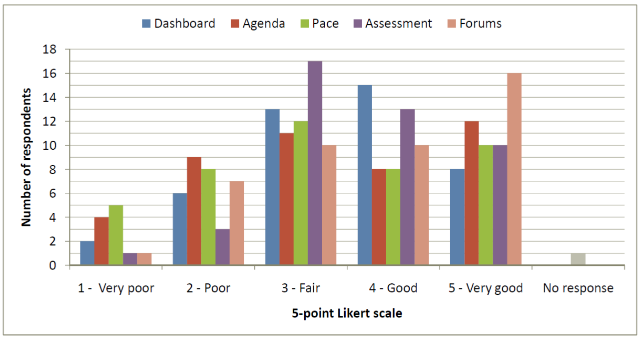
Recommendation C was measured by means of six items: (1) the status color, (2) the dashboard as a whole, (3) the dashboard's agenda area, (4) the dashboard's pace area, (5) the dashboard's assessment area, and (6) the dashboard's forums area. The Cronbach's alpha coefficient was $\alpha = .906$. This indicated that the previous six elements measured the usefulness of providing information that helps students to be aware of their learning process.

As for the status color, there was consensus between the two groups (MW test: $U = 182$, $Z = -1.491$, $p = .136$). Although the mode was lower than that of AdVisor 1.0, 4 (*useful*) instead of 5 (*very useful*), this feature was globally evaluated more positively in this prototype: ***77.3% of the respondents rated the status color useful*** (4, 40.9%) ***or very useful*** (5, 36.4%) compared to 66% of AdVisor 1.0. The median, in turn, was the same as that of the previous prototype, i.e. 4 (*useful*). This excellent result could even have been considered better due to two facts: (1) the 3 people (6.8%) who found the status color useless (i.e. scores 1 and 2) were outliers (see the box plot of Figure F.7), and (2) in addition to obtaining a high score, the opinion of the two groups was quite unanimous as evidenced by the IQR of the distribution, which was 1 (the IQR was 2 in AdVisor 1.0).

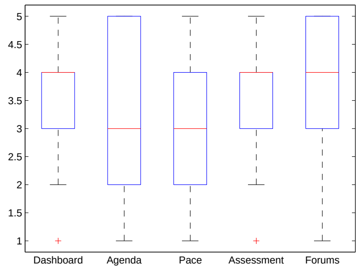
As seen in all the prototypes of AdVisor, the dashboard was the closest element to self-awareness (i.e. ***recommendation C***). For that reason, this was evaluated once again. First of all, the respondents were asked to evaluate the dashboard as a whole. In this regard, according to the MW test, there were not enough evidence to state that the two groups had a different opinion about this element ($U = 203$, $Z = -.940$, $p = .347$). As shown in the box plot of Figure F.8, the distribution of the responses was left-skewed, its variability was low (IQR=1) and the respondents who rated 1 (*not at all useful*) were outliers. Likewise, the frequency table and the bar chart show that ***81.8% of the respondents rated the dashboard 3*** (*fair*, 29.5%) ***or higher*** (AdVisor 1.0: 82.9%). Just like AdVisor 1.0, the mode and the median were 4 (*good*, 34.1%). As seen, the dashboard was evaluated in a

v_i	Dashboard		Agenda		Pace			Assessment		Forums	
	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	p_i^*	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i
1 - Very poor	2 (4.5%)	4.5%%	4 (9.1%)	9.1%	5 (11.4%)	11.6%	11.6%	1 (2.3%)	2.3%	1 (2.3%)	2.3%
2 - Poor	6 (13.6%)	18.2%	9 (20.5%)	29.5%	8 (18.2%)	18.6%	30.2%	3 (6.8%)	9.1%	7 (15.9%)	18.2%
3 - Fair	13 (29.5%)	47.7%	11 (25%)	54.5%	12 (27.3%)	27.9%	58.1%	17 (38.6%)	47.7%	10 (22.7%)	40.9%
4 - Good	15 (34.1%)	81.8%	8 (18.2%)	72.7%	8 (18.2%)	18.6%	76.7%	13 (29.5%)	77.3%	10 (22.7%)	63.6%
5 - Very good	8 (18.2%)	100%	12 (27.3%)	100%	10 (22.7%)	23.3%	100%	10 (22.7%)	100%	16 (36.4%)	100%
No response	0 (0%)		0 (0%)		1 (2.3%)		0	0%		0	0%
	$n = 44$	100%	$n = 44$	100%	$n = 44$	100%		$n = 44$	100%	$n = 44$	100%

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.8: AdVisor 2.0 – Evaluation of the dashboard and its information areas.

similar way in the three prototypes and very positively, which suggested that ***the dashboard had been really useful to the students***.

Besides evaluating the dashboard as a whole, each of its information areas were evaluated individually too (see Figure F.8). In this prototype, the four areas were assessed. In this regard, the opinion of the two groups was similar in each of the four information areas (MW test-agenda: $U = 213.5$, $Z = -.675$, $p = .500$; MW test-pace: $U = 175$, $Z = -1.395$, $p = .163$; MW test-assessment: $U = 188$, $Z = -1.321$, $p = .186$; MW test-forums: $U = 212.5$, $Z = -.709$, $p = .479$).

Regarding the agenda area, according to the box plot of Figure F.8c, the opinion of the respondents was very scattered, since the IQR was 3. Due to this variability, the median was 3 (*fair*, 25%) and the mode was 5 (*very good*, 27.3%). However, the result was good because ***70.5% of the respondents rated it 3*** (*fair*) ***or higher*** (AdVisor 1.0: 79.4%).

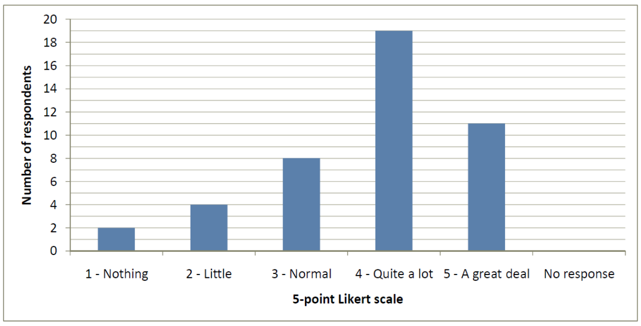
As for the pace area, the median and the mode were 3 (*fair*, 27.9%). The distribution of the responses was approximately symmetric. ***69.8% rated it 3*** (*fair*) ***or higher*** (AdVisor 1.0: 87.5%). As observed, the usefulness of the this area was surprisingly low in comparison with the previous prototype. From the questionnaire, no explanation could be found.

With regard to the assessment area, the variability was low (IQR=1). ***90.9% of the respondents found it fair*** (3, 38.6%) ***or better*** (AdVisor 1.0: 87.5%). The most chosen score was 3 (*fair*, 2.3%), whereas the median was 4 (*good*, 29.5%). Moreover, the responses with value 1 (*very poor*) were outliers (see Figure F.8c). This result proved that having information about the assessment was very important to the learners.

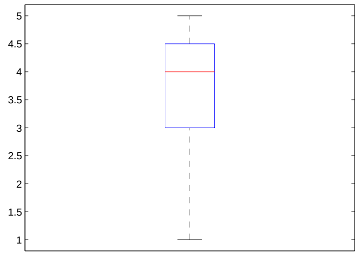
The fourth area, i.e. the one related to the discussion forums, obtained a mode equal to 5 (*very good*, 36.4%) and a median equal to 4 (*good*, 22.7%), being ***81.8% of the responses equal or greater than 3*** (*fair*, 22.7%). Nevertheless, it is needed to be cautious about this result because it is highly probable that the large number of forums that AdVisor 2.0 had (i.e. one forum per activity) may

v_i	n_i	p_i	P_i
1 - Nothing	2	4.5%	4.5%
2 - Little	4	9.1%	13.6%
3 - Normal	8	18.2%	31.8%
4 - Quite a lot	19	43.2%	75%
5 - A great deal	11	25%	100%
No response	0	0%	
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.9: AdVisor 2.0 – To what extent the platform helped the respondents to be aware of their situation in the course.

have implied the strong necessity (and usefulness) of having this information area.

Besides the evaluation, the respondents could write any comment to improve the dashboard. In this regard, some of the positive remarks were: *“I think that it is very visual and you can see all the information at a glance”* and *“it is perfect, above all, the pace area which encourages one to follow the proposed schedule”*. By contrast, some of the complaints were: *”I missed a summary which only indicated the graded activities”*, *“to highlight the current CAA and activity”* and *“to be able to go to the general forum though there are no messages to read”*. As for the potential improvements, the respondents suggested *“the possibility of choosing the content of each information area”* and *“to display the percentage of the table of contents that has been finished”*.

Finally, to guarantee the suitability of ***recommendation C*** (i.e. to provide self-awareness), the respondents were explicitly asked: *“to what extent did AdVisor help you to be aware of your situation in the course?”* (MW test: $U = 175.5$, $Z = -1.637$, $p = .102$). When this new question was added to the previous six items, the Cronbach's alpha coefficient reached $\alpha = .913$. As shown in Figure F.9, the mode was 4 (*quite a lot*, 43.2%), followed by the values 5 (*a great deal*, 25%) and 3 (*normal*, 18.2%). This meant that ***68.2% of the respondents stated that AdVisor 2.0 had helped them to be aware of their learning process significantly*** (i.e. scores equal 4 and 5). Or, in other words, only 13.6% of the respondents thought that AdVisor 2.0 had not helped them to be self-aware (i.e. values 1 and 2). Moreover, as shown in the box plot, the distribution of the responses was left-skewed with IQR and median equal to 1.5 and 4, respectively. This result, taken in conjunction with the previous ones of the status color and the dashboard, suggested that AdVisor 2.0 had helped the students to be aware of their own learning process and, consequently, ***it could be stated that recommendation C was suitable for online education***.

F.1.2.6 To provide tools that help students to be self-regulated (rec. B and C)

The Cronbach's alpha coefficient of the items related to ***recommendations B and C*** was $\alpha = .915$. This implied that all those items measured the same underlying construct: the usefulness of the elements that support self-regulation. In this regard, two more questions linked to this concept were asked: (1) *"how useful was the option of marking an activity as complete?"*, and (2) *"to what extent did AdVisor help you to self-regulate your learning process?"*. When these two aspects were taken into account, the previous Cronbach's alpha coefficient reached $\alpha = .932$.

As for the feature that enabled to mark the completion of an activity/session (see Figure F.10), the two groups, in contrast to AdVisor 1.0, shared the same opinion (MW test: $U = 222.5$, $Z = -.189$, $p = .850$). Moreover, the distribution of their responses was left-skewed. More specifically, 30.2% rated this feature 5 (*very useful*), becoming the mode. This score was followed by the value 4 (*useful*), which was the median with 27.9% of the responses. As a result, ***58.1% believed that this feature was useful*** (4, 27.9%) ***or very useful*** (5, 30.2%) (AdVisor 1.0: 61.9%). This figure reached 81.4% when the value 3 (*neither useful nor useless*, 23.3%) was included (AdVisor 1.0: 80.9%).

Likewise, as shown in Figure F.11 (MW test: $U = 227.5$, $Z = -.344$, $p = .731$), ***over 56% of the respondents found that the platform had helped them to be self-regulated in a significant way*** (scores 4 and 5). This figure meant an increase of the 16 percent in comparison to that of the previous prototypes. Unlike Advisor 0.0 and 1.0, in this occasion, the mode and the median were 4 (*quite a lot*, 40.9%), instead of 3 (*normal*). Moreover, although 22.8% of the respondents scored 1 (*nothing*) or 2 (*little*), all the responses with value 1 (*nothing*, 11.4%) could have been considered exceptional (see the box plot of Figure F.11). Likewise, the variability of the responses was low (IQR=1), which was the same value as that of AdVisor 0.0 and better than that of AdVisor 1.0. Hence, the result was good since around 77% of the responses were 3 (*normal*, 20.5%) or greater. Finally, all the items of ***recommendations B and C*** correlated moderately or strongly with the extent of support of AdVisor 2.0 for self-regulation of the learning process (see Table F.2).

As seen, most of the items linked to self-regulated learning were evaluated positively. Thus, ***it could be concluded that AdVisor 2.0 had helped the students to regulate their learning process***.

	Session	**Detailed activities**	**Assessment letter**	**Status color**	**Dashboard**	**Marking completion**
AdVisor helped to self-regulate	$\rho = .781^{**}$ (Strong)†	$\rho = .739^{**}$ (Strong)†	$\rho = .356^{*}$ (Weak moderate)	$\rho = .446^{**}$ (Moderate)	$\rho = .594^{**}$ (Moderate)	$\rho = .734^{**}$ (Strong)†

* Significant correlation at 5% level of significance.

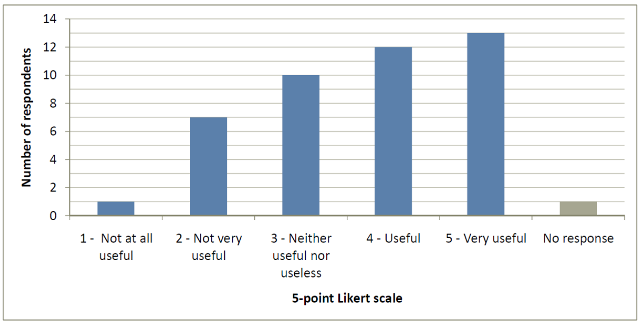
** Significant correlation at 1% level of significance.

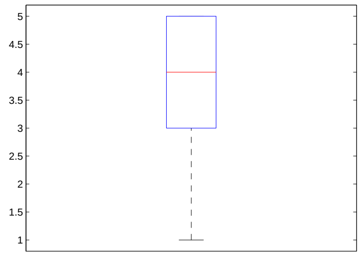
† Better result than that of AdVisor 1.0.

Table F.2: AdVisor 2.0 - Spearman's correlation coefficient between the extent of support of the platform for self-regulation of the learning process and each of the features related to it.

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	1	2.3%	2.3%	2.3%
2 - Not very useful	7	15.9%	16.3%	18.6%
3 - Neither useful nor useless	10	22.7%	23.3%	41.9%
4 - Useful	12	27.3%	27.9%	69.8%
5 - Very useful	13	29.5%	30.2%	100%
No response	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



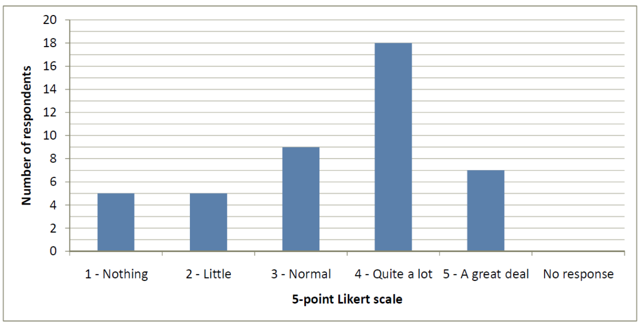


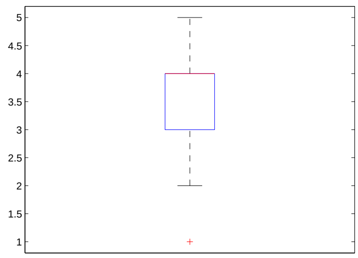
(b) Bar chart ***(c)*** Box plot

Figure F.10: AdVisor 2.0 – Usefulness of being able to mark an activity as complete.

v_i	n_i	p_i	P_i
1 - Nothing	5	11.4%	11.4%
2 - Little	5	11.4%	22.8%
3 - Normal	9	20.5%	43.2%
4 - Quite a lot	18	40.9%	84.1%
5 - A great deal	7	15.9%	100%
No response	0	0%	
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table





(b) Bar chart ***(c)*** Box plot

Figure F.11: AdVisor 2.0 – To what extent AdVisor helped to self-regulate the students' learning process.

F.1.2.7 To promote social interaction (recommendation D)

This section focuses on evaluating three of the features that the forums of AdVisor 2.0 had. The first question asked about the usefulness of having a discussion forum per activity (see Figure F.12). Regarding this question, there was no evidence to state that both groups had a different opinion (MW test: U = 164, Z = -1.658, $p = .097$). However, the IQR (= 2) indicated that there was variability in the opinions. Even so, the distribution was clearly left-skewed. More specifically, 79.1% of the respondents scored this organization of the forums with 3 (*neither useful nor useless*, 20.9%) or a greater value. In this regard, ***58.1% found the use of one forum per activity useful*** (4, 27.9%, median) ***or very useful*** (5, 30.2%, mode). This could be considered a very good result, since this organization of the forums was totally new to the students.

As a new forum was developed from scratch, two items were specially created for the students:

- **Like-it button**: each message had this button which allowed a student to express that she liked, enjoyed or supported the content of that message. When the learner clicked on the button, a counter increased and she could not click again. Thanks to this button, any student was able to know how many classmates liked that message.
- **Highlight**: the teacher could label a message as important so that their students saw a star beside the message. This meant that the learners had to pay attention to that message.

They both were evaluated in the questionnaire (see Figure F.13). In this regard, the respondents from Electric Circuit Analysis and Mathematics II had similar opinions regarding these two functionalities (MW test-like-it button: $U = 199.5$, $Z = -.257$, $p = .797$; MW test-highlight: $U = 163.5$, $Z = -.383$, $p = .702$). Before analyzing the responses, it is important to stress that these two items had not been used too much. Thus, the results had to be interpreted with prudence.

As for the like-it button, ***39% did not find it useful*** (i.e. scores 1 and 2). However, the mode was 4 (*useful*, 31.7%). This disparity in the opinions was reflected in the fact that the IQR was 2 and the median was 3 (*neither useful nor useless*, 20.5%). In consequence, the only conclusion that could be drawn was that this element would have to be studied in-depth in the future, because the result was not conclusive enough.

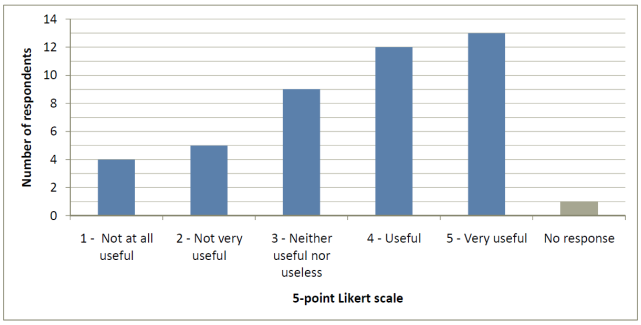
With regard to having the important messages highlighted, the respondents found this functionality much more useful than the like-it button. ***81.6% rated it 3*** (*neither useful nor useless*, 31.6%) ***or higher***. The distribution was multimodal (3 and 4) and its median was 3.5.

From the previous results, ***it could be concluded that the use of a forum per activity was useful to the respondents***. However, the two items related to social interaction obtained different results. On the one hand, the fact that the important messages had been highlighted by the teacher was found helpful. On the other hand, although the literature indicates that interaction between the classmates is a success factor in online education (see section 2.4.1.2), the like-it button did not have a good evaluation. This may have been due to the lack of promotion of this element during the test.

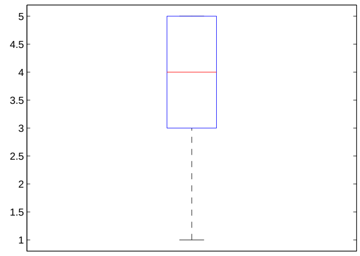
Given that the results, especially those of the two functionalities, were not conclusive enough, more research would have to be done in future so that well-founded conclusions could be drawn.

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	4	9.1%	9.3%	9.3%
2 - Not very useful	5	11.4%	11.6%	20.9%
3 - Neither useful nor useless	9	20.5%	20.9%	41.9%
4 - Useful	12	27.3%	27.9%	69.8%
5 - Very useful	13	29.5%	30.2%	100%
No response	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart

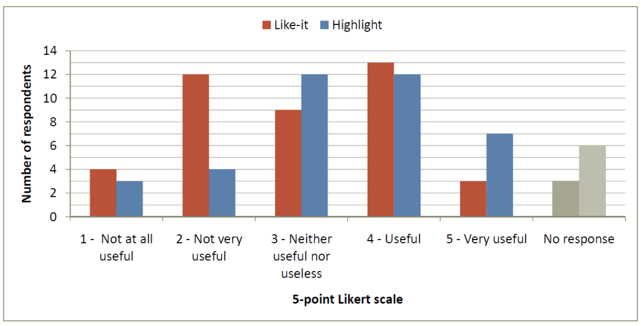


(c) Box plot

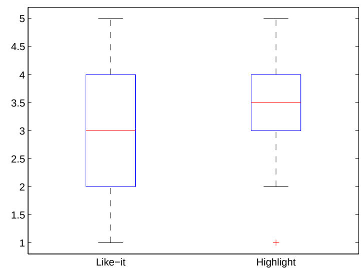
Figure F.12: AdVisor 2.0 – Usefulness of having a forum per activity.

v_i	Like-it				Highlight			
	n_i	p_i	p_i^*	P_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	4	9.1%	9.8%	9.8%	3	6.8%	7.9%	7.9%
2 - Not very useful	12	27.3%	29.3%	39%	4	9.1%	10.5%	18.4%
3 - Neither useful nor useless	9	20.5%	22%	61%	12	27.3%	31.6%	50%
4 - Useful	13	29.5%	31.7%	92.7%	12	27.3%	31.6%	81.6%
5 - Very useful	3	6.8%	7.3%	100%	7	15.9%	18.4%	100%
No response	3	6.8%			6	13.6%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$		$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.13: AdVisor 2.0 – Usefulness of the functionalities like-it and highlight.

F.1.2.8 To provide multiple views of the course (recommendations G and A)

Next, the results of all the questions related to ***recommendation G*** (i.e. provision of multiple views) are analyzed. Like in the previous test, the analysis is divided into two categories:

- Usefulness of having multiple views
- Use of each view

Next, the results of each category are presented.

Usefulness of having multiple views

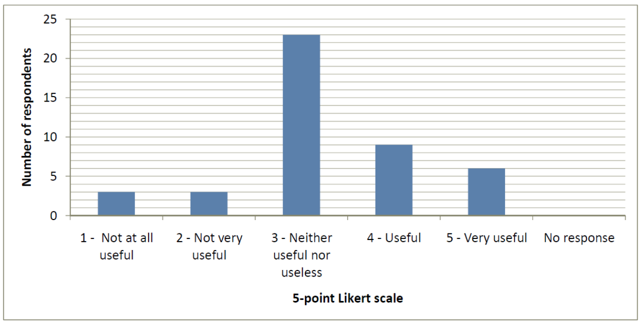
First of all, it was asked the respondents to evaluate the usefulness that AdVisor 2.0 had provided them with multiple views of the course (see Figure F.14). According to the MW test, there was consensus between the two groups ($U = 194.5$, $Z = -1.201$, $p = .230$) and, moreover, the opinion was quite unanimous (IQR=1). The questionnaire revealed that ***only 13.6% of the respondents found the provision of multiple views useless*** (i.e. scores 1 and 2), being those who answered with the value 1 (*not at all useful*, 6.8%) outliers (see Figure F.14c). By contrast, 34.1% stated that the organization of the course into multiple views was *useful* (4, 20.5%) or *very useful* (5, 13.6%). This meant that the score 3 (*neither useful nor useless*, 52.3%) was very high, becoming the mode and the median. Thus, ***it could be concluded that the evaluation of the provision of multiple views was neutral to good***.

Likewise, as seen in section 5.4.2.2, all the views of AdVisor 2.0 were linked to the learning activities. This way of structuring the information was evaluated too (see Figure F.15). The two groups agreed about this aspect (MW test: $U = 203$, $Z = -.680$, $p = .497$) with IQR equal to 1. ***81.3% rated it 3*** (*neither useful nor useless*, 30.2%) ***or higher***. The mode was 3 and the median was 4 (*useful*, 27.9%). Moreover, the respondents who chose the score 1 (*not at all useful*, 4.7%) were outliers. Hence, ***the connection between the information spaces through the learning activities was found suitable***.

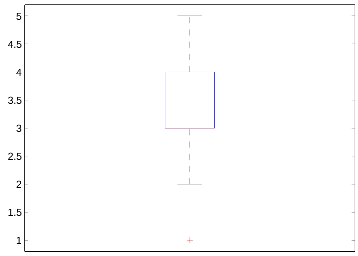
Finally, one of the goals of providing multiple views was to avoid that the students only paid attention to continuous assessment assignments (CAAs), i.e. the mandatory activities. For that reason, it was asked to what extent AdVisor 2.0 had helped the respondents to have an overview of the course beyond the learning activities and the CAAs (see Figure F.16). The respondents of the two groups agreed ($U = 183.5$, $Z = -1.425$, $p = .154$) and the variability of their responses was low (IQR=1). ***61.4% stated that AdVisor 2.0 had achieved this objective successfully*** (i.e. scores 4 and 5), being the mode and the median equal to 4 (*quite a lot*, 40.9%). Moreover, the score 1 (*nothing*, 9.1%) could have be considered an exceptional value (see the box plot of Figure F.16). These results were quite good, since a lot of learners usually study according to the deadlines of the CAAs (as an example, see the study habits of the respondents of AdVisor 0.0 in section D.2.4).

v_i	n_i	p_i	P_i
1 - Not at all useful	3	6.8%	6.8%
2 - Not very useful	3	6.8%	13.6%
3 - Neither useful nor useless	23	52.3%	65.9%
4 - Useful	9	20.5%	86.4%
5 - Very useful	6	13.6%	100%
No response	0	0%	
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

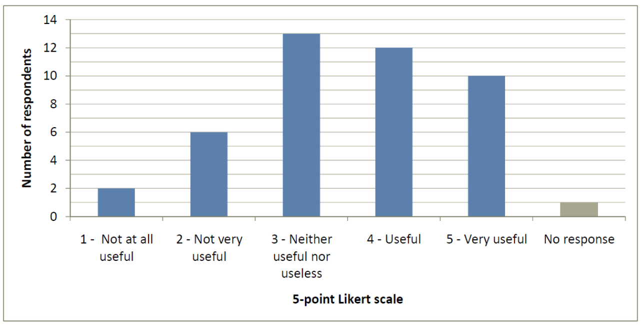


(c) Box plot

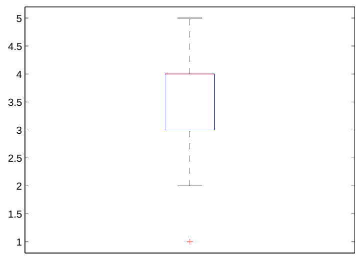
Figure F.14: AdVisor 2.0 – Usefulness of having multiple views of the course.

v_i	n_i	p_i	p_i^*	P_i
1 - Not at all useful	2	4.5%	4.7%	4.7%
2 - Not very useful	6	13.6%	14%	18.7%
3 - Neither useful nor useless	13	29.5%	30.2%	48.8%
4 - Useful	12	27.3%	27.9%	76.7%
5 - Very useful	10	22.7%	23.3%	100%
No response	1	2.3%		
	$n = 44$	$\sum p_i = 100\%$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart

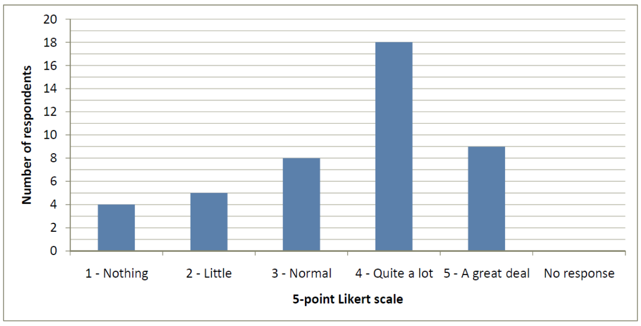


(c) Box plot

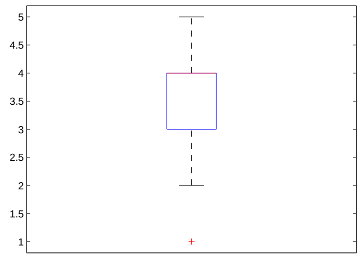
Figure F.15: AdVisor 2.0 – Usefulness of the fact that the information spaces were intertwined by means of the learning activity.

v_i	n_i	p_i	P_i
1 - Nothing	4	9.1%	9.1%
2 - Little	5	11.4%	20.5%
3 - Normal	8	18.2%	38.6%
4 - Quite a lot	18	40.9%	79.5%
5 - A great deal	9	20.5%	100%
No response	0	0%	
	$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.16: AdVisor 2.0 – To what extent AdVisor helped the respondents to have an overall overview of the course beyond the activities and CAAs.

Use of each view

Unlike AdVisor 1.0, the respondents of AdVisor 2.0 had to rank the views from the most used to the least. Thereby, it was possible to create a more exhaustive ranking. As seen in Figure F.17, ***the Gantt chart was the most used view*** as evidenced by the large number of respondents that chose the option *1st most used*, i.e. 50%. This view held the same position as that of AdVisor 1.0.

The second and third positions were for the list that contained activities and the resources (mode = *2nd* and *3rd*; median = *3rd*) ***and the view related to the assessment*** (mode = *2nd*; median = *3rd*), respectively. As said in section 5.4.2.3, the former simple list used in AdVisor 1.0 was divided into these two views. As the extinct simple list was the second most used view (see section E.2.7), the positions of the two new views accorded with the one of AdVisor 1.0's simple list.

As for ***the new view, the one linked to the forums, was the fourth most used*** (mode = median = *3rd*). This may have been due to the fact that forums are a key element in online learning.

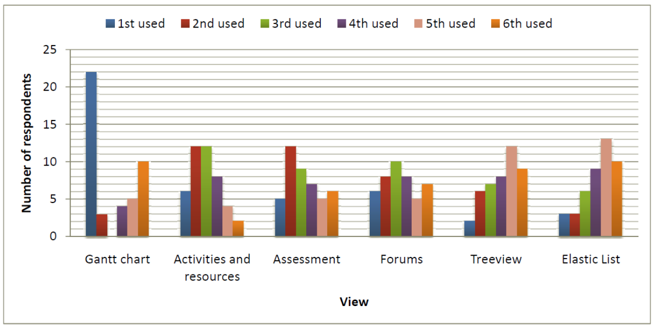
Finally, just like in AdVisor 1.0, ***the treeview and the elastic list were the least used views***, fifth and sixth respectively. Although both views obtained a mode of *5th*, the treeview had a median of *4rd* and the elastic list got a median of *5th*.

Conclusions

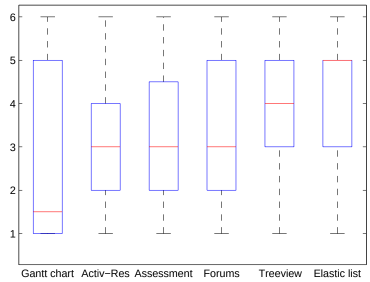
From the previous results, ***it was reaffirmed that recommendation G were suitable for online education***. Firstly, only less than 14% of the respondents did not find useful to have multiple views of a course. This suggested that this feature, which affects the information structure, was interesting for the online students. Moreover, the fact that the activities were the core of the structure and the

v_i	Gantt chart		Activities and resources		Assessment		Forums		Treeview		Elastic list	
	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i
The most used	22 (50%)	50%	6 (13.6%)	13.6%	5 (11.4%)	11.4%	6 (13.6%)	13.6%	2 (4.5%)	4.5%	3 (6.8%)	6.8%
2nd most used	3 (6.8%)	56.8%	12 (27.3%)	40.9%	12 (27.3%)	38.6%	8 (18.2%)	31.8%	6 (13.6%)	18.2%	3 (6.8%)	13.6%
3rd most used	0 (0%)	56.8%	12 (27.3%)	68.2%	9 (20.5%)	59.1%	10 (22.7%)	54.5%	7 (15.9%)	34.1%	6 (13.6%)	27.3%
4th most used	4 (9.1%)	65.9%	8 (18.2%)	86.4%	7 (15.9%)	75%	8 (18.2%)	72.7%	8 (18.2%)	52.3%	9 (20.5%)	47.7%
5th most used	5 (11.4%)	77.3%	4 (9.1%)	95.5%	5 (11.4%)	86.4%	5 (11.4%)	84.1%	12 (27.3%)	79.5%	13 (29.5%)	77.3%
The least used	10 (22.7%)	100%	2 (4.5%)	100%	6 (13.6%)	100%	7 (15.9%)	100%	9 (20.5%)	100%	10 (22.7%)	100%
	$n = 44$		$n = 44$		$n = 44$		$n = 44$		$n = 44$		$n = 44$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.17: AdVisor 2.0 – Usage of each of the views provided.

common item between the information spaces was also rated positively. Likewise, according to the respondents, the multiple views had helped, to some extent, to have an overview of the course beyond the activities and CAAs. Nevertheless, it could be observed that the respondents of AdVisor 1.0 and 2.0 had used the views in a similar way, being clearly the most used ones those which were linked to the schedule and the assessment.

Likewise, the fact that the forums view had been more used than the treeview and the elastic list confirmed what the literature states: social interaction is important in online education. In other words: ***forums are a key element in a VLE and, therefore, these platforms should promote social interaction (i.e. recommendation D)***.

By contrast, the elastic list (linked to the competences and objectives) had been the least used view again. Therefore, it could be concluded that ***recommendation A*** (i.e. to define competences and objectives clearly) ***did not accord with the habits/preferences of online students yet***.

Finally, ***the set of views offered by AdVisor 2.0 seemed to be quite complete***, since none of the learners suggested adding or removing some view.

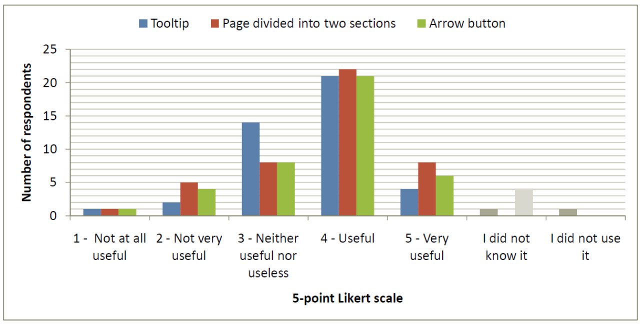
F.1.2.9 Usability (recommendations I-M)

Before detailing the results, it is important to stress that, although Chapter 4 recommended five usability recommendations, it was not carried out an individual evaluation for each. Instead, a global evaluation of the usability of AdVisor 2.0 was conducted. The results can be divided into:

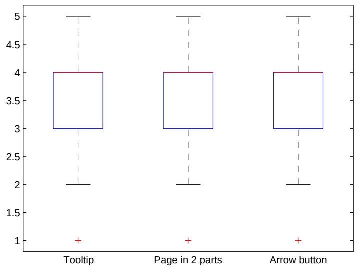
- Usefulness of different elements of the interface
- Ease of use of each view
- Usability of the whole platform

v_i	Tooltip			Page divided into two sections			Arrow button		
	n_i (p_i)	p_i^*	P_i	n_i	p_i	P_i	n_i (p_i)	p_i^*	P_i
1 - Not at all useful	1 (2.3%)	2.4%	2.4%	1	2.3%	2.3%	1 (2.3%)	2.5%	2.5%
2 - Not very useful	2 (4.5%)	4.8%	7.1%	5	11.4%	13.6%	4 (9.1%)	10%	12.5%
3 - Neither useful nor useless	14 (31.8%)	33.3%	40.5%	8	18.2%	31.8%	8 (18.2%)	20%	32.5%
4 - Useful	21 (47.7%)	50%	90.5%	22	50%	81.8%	21 (47.7%)	52.5%	85%
5 - Very useful	4 (9.1%)	9.5%	100%	8	18.2%	100%	6 (13.6%)	15%	100%
I did not know it	1 (2.3%)			0	0%		4 (9.1%)		
I did not use it	1 (2.3%)			0	0%		0 (0%)		
	$n = 44$	$\sum p_i^* = 100\%$		$n = 44$	$\sum p_i = 100\%$		$n = 44$	$\sum p_i^* = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.18: AdVisor 2.0 – Usefulness of the tooltip, the page divided into two sections and the arrow button for showing/hiding the description area.

Usefulness of different elements of the interface

Three elements of the interface were evaluated in terms of usefulness: (1) the tooltip, (2) the workspace divided into sections (i.e. navigation and activity areas), and (3) the arrow button that enabled to show/hide the activity area (see Figure F.18).

According to the MW test, there was not evidence to reject the null hypothesis and to prove that the respondents of the two groups had different opinions regarding these items (MW test-tooltip: $U = 216.5$, $Z = -.110$, $p = .912$; MW test-division: $U = 222$, $Z = -.494$, $p = .622$; MW test-arrow: $U = 173.5$, $Z = -.725$, $p = .468$). Moreover, as evidenced by the distribution shown in Figure F.18c, the evaluation of the three elements was quite similar. In fact, they three obtained the same mode and median, i.e. 4 (*useful*, around 50%). Likewise, the percentage of bad scores (i.e. 1 and 2) was low in the three cases: 7.1%, 13.6% and 12.5%, respectively. In addition to being low figures, the responses equal to 1 (*not at all useful*) were exceptional values in the three cases. As a result, ***it could be considered that the three elements had been suitable and helpful***.

Ease of use of each view

Like in AdVisor 1.0, the questionnaire asked the respondents to evaluate the usability of each view by using a 5-point Likert scale (see Figure F.19). From the results, a ranking was created.

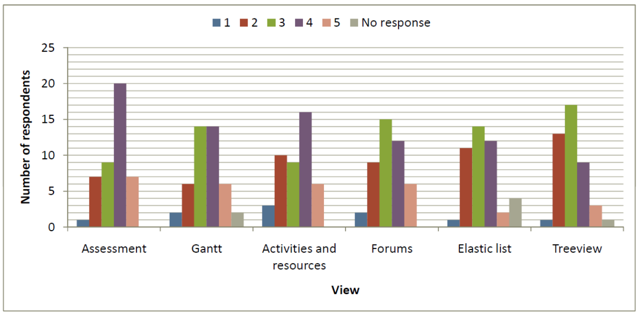
According to the respondents (MW test: $U = 192.5$, $Z = -1.22$, $p = .222$), the most usable view was the one that displayed the CAAs or, in other words, the view which was related to assessment. The median and the mode were 4 (*usable*, 45.5%), being the score 1 an exceptional value. ***81.8%***

v_i	Assessment		Gantt chart			Activities & resources	
	n_i (p_i)	P_i	n_i (p_i)	p_i^*	P_i	n_i (p_i)	P_i
1 - Not at all usable	1 (2.3%)	2.3%	2 (4.5%)	4.8%	4.8%	3 (6.8%)	6.8%
2 - Not very usable	7 (15.9%)	18.2%	6 (13.6%)	14.3%	19%	10 (22.7%)	29.5%
3 - Neither usable nor unusable	9 (20.5%)	38.6%	14 (31.8%)	33.3%	52.4%	9 (20.5%)	50%
4 - Usable	20 (45.5%)	84.1%	14 (31.8%)	33.3%	85.7%	16 (36.4%)	86.4%
5 - Very usable	7 (15.9%)	100%	6 (13.6%)	14.3%	100%	6 (13.6%)	100%
No response	0 (0%)		2 (4.5%)			0 (0%)	
	$n = 44$		$n = 44$			$n = 44$	

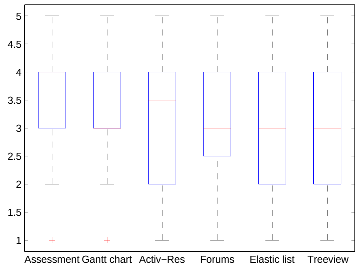
(a) Frequency table

v_i	Forums		Elastic list			Treeview		
	n_i (p_i)	P_i	n_i (p_i)	p_i^*	P_i	n_i (p_i)	p_i^*	P_i
1 - Not at all usable	2 (4.5%)	4.5%	1 (2.3%)	2.5%	2.5%	1 (2.3%)	2.3%	2.3%
2 - Not very usable	9 (20.5%)	25%	11 (25%)	27.5%	30%	13 (29.5%)	30.2%	32.6%
3 - Neither usable nor unusable	15 (34.1%)	59.1%	14 (31.8%)	35%	65%	17 (38.6%)	39.5%	72.1%
4 - Usable	12 (27.3%)	86.4%	12 (27.3%)	30%	95%	9 (20.5%)	20.9%	93%
5 - Very usable	6 (13.6%)	100%	2 (4.5%)	5%	100%	3 (6.8%)	7%	100%
No response	0 (0%)		4 (9.1%)			1 (2.3%)		
	$n = 44$		$n = 44$			$n = 44$		

(b) Frequency table (continued)



(c) Bar chart



(d) Box plot

Figure F.19: AdVisor 2.0 – Usability of each of the views provided.

rated the usability of this view neither usable nor unusable (3, 20.5%) ***or higher***.

Thanks to the improvements which were added to this prototype, the second most usable view was the Gantt chart (MW test: $U = 210.5$, $Z = -.211$, $p = .833$). The distribution was multimodal (3 and 4) and its median was 3 (*neither usable nor unusable*, 33.3%). Moreover, the box plot of Figure F.19 indicates that the two people who rated 1 (*not at all useful*, 4.8%) could have been considered outliers. In short, the evaluation of the usability of the Gantt chart was definitively better in AdVisor 2.0 than in AdVisor 1.0. Such was the case that ***80.9% found its usability 3*** (*neither usable nor unusable*) ***or better*** (AdVisor 1.0: 73.2%).

The respondents gave the third place to the view that showed activities and resources (MW test: $U = 205$, $Z = -.890$, $p = .374$). Its representation was the same as that of AdVisor 1.0's simple list (except for small improvements) and the results were practically identical (see section E.2.8): the median was 3.5, the mode was 4 (*usable*, 36.4%) and ***50% of the respondents found this view usable*** (4, 36.4%) ***or very usable*** (5, 13.6%). However, in this occasion, the dispersion of the responses (IQR=2) was higher than that of AdVisor 1.0 (IQR=1) and more responses equal to 2 (*not very usable*, 22.7%) were obtained. Even so, the usability of this view was acceptable.

The rest of the views (i.e. forums, elastic list and treeview) obtained the same median and mode: 3 (*neither usable nor unusable*). However, as evidenced by the box plot of Figure F.19d, the forums view (MW test: $U = 161.5$, $Z = -1.95$, $p = .051$) was scored better than the other two. To sum up, ***75% rated its usability 3*** (*neither usable nor unusable*, 34.1%) ***or higher***.

As for the elastic list ($U = 195$, $Z = -.128$, $p = .898$) and the treeview ($U = 196$, $Z = -.896$, $p = .370$), their box plots were identical (see Figure F.19d), being the responses of the elastic list slightly better. Compared to the results of AdVisor 1.0, the percentage of students that rated the elastic list 3 (*neither usable nor unusable*) or greater was practically identical (AdVisor 1.0: 69.2%; AdVisor 2.0: 70%), while that of the treeview was worse (AdVisor 1.0: 75%; AdVisor 2.0: 67.4%).

At this point, it is worth stressing that it was surprising that the treeview went from the second position in the previous prototype to the last one in this version. However, this did not have to be attributed to the worsening of the usability of the treeview, since this view was evaluated in AdVisor 1.0 and 2.0 in a similar way, but to the improvement of the rest of the views, specially the Gantt chart. One possible cause of this improvement may have been the use of elements which were found useful, such as the tooltip.

In conclusion, ***the usability of the views was, in general, considered acceptable. In some views, the appraisal of the usability was even better than in the previous prototype***.

Usability of the whole platform

Besides studying the usability of each of the views, it is also important to evaluate certain aspects that affect the usability of an application. In this regard, it was used a scale that was made up of six items and whose Cronbach's alpha was $\alpha = .841$ (see Figure F.20).

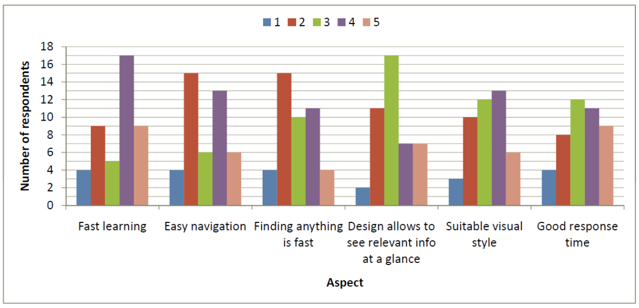
First of all, a short learning curve is one of the goals that any tool must have. In this regard, the questionnaire showed that ***59.1% of the respondents agreed*** (4, 38.6%) ***or strongly agreed*** (5, 20.5%) ***about the fact that AdVisor 2.0 had a quick learning curve*** (MW test: $U = 226.5$, $Z = -.367$, $p = .714$). This aspect actually obtained a median and a mode of 4 (*agree*, 38.6%). However, 29.6% expressed that learning to use AdVisor 2.0 had been hard (scores 1 and 2). Thus, the interface would have to be improved to be more intuitive and, consequently, faster to learn.

Likewise, the respondents were asked if the navigation through AdVisor had been so easy that it had been difficult to get lost. The two groups had similar opinions (MW test: $U = 183$, $Z = -1.426$, $p = .154$). However, there were a large number of responses in each of the ends of the scale. In fact, the mode was 2 (*disagree*, 34.1%), followed by the value 4 (*agree*, 29.5%). This variability is shown in Figure F.20c by means of the IQR, which was 2, and the median, which was 3 (*neutral*, 13.6%). More specifically, 43.2% indicated that the navigation had been complex (values 1 and 2), while 43.2% said this had been easy (scores 4 and 5). Given the aforesaid results, it could be concluded that ***the respondents found the navigation through the platform normal to difficult***.

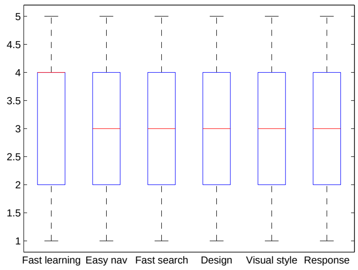
Related to the previous aspect, the respondents disagreed about if few clicks had been required to find something (MW test: $U = 147$, $Z = -2.3$, $p = .021$). In this occasion, more students from Mathematics II (57.1%) than from Electric Circuit Analysis (30.4%) pointed out that too many clicks had been needed to find a specific activity or information. In general, ***43.2% of the respondents***

Aspect	1 - Strongly disagree	2 - Disagree	3 - Neutral	4 - Agree	5 - Strongly agree
Learning to use the platform is fast	4 (9.1%)	9 (20.5%)	5 (11.5%)	17 (38.6%)	9 (20.5%)
It is is easy to navigate without getting lost	4 (9.1%)	15 (34.1%)	6 (13.6%)	13 (29.5%)	6 (13.6%)
You find what you are looking for fast	4 (9.1%)	15 (34.1%)	10 (22.7%)	11 (25%)	4 (9.1%)
The design and the layout allow to see the important information at a glance	2 (4.5%)	11 (25%)	17 (38.6%)	7 (15.9%)	7 (15.9%)
The visual style is suitable	3 (6.8%)	10 (22.7%)	12 (27.3%)	13 (29.5%)	6 (13.6%)
Response time is good	4 (9.1%)	8 (18.2%)	12 (27.3%)	11 (25%)	9 (20.5%)

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.20: AdVisor 2.0 – Usability of the whole platform.

considered that they had had to click a lot and, hence, finding something had not been a fast task. As a result, the interface would have to be simplified, e.g. by adding shortcuts to the platform.

The questionnaire also revealed that ***29.5% of those questioned*** (MW test: $U = 208$, $Z = -.821$, $p = .412$) ***believed that the design and the layout of the interface had not helped them to see important information at a glance*** (scores 1 and 2). Because the interface maybe wanted to convey too much information (e.g. type of assessment, activity status, etc.) simultaneously, the students may have been overwhelmed by the large number of colors, icons, etc. that were shown. In this regard, tooltips tried to minimize this problem, but they were enough. Even so, 38.6% did not consider the design and the layout of the interface detrimental to see the most important information at a glance (score = 3, mode and median) and 31.8% thought the interface had helped (scores 4 and 5). However, this did not mean the design and the layout would not have to be improved.

The aesthetic appearance of a platform is an important aspect that encompasses different elements: font size, background color, icons, etc. With regard to AdVisor 2.0's one, the two courses were in agreement (MW test: $U = 206.5$, $Z = -.848$, $p = .396$). More specifically, ***the suitability of the aesthetic of AdVisor 2.0 was rated 3 or higher by 70.5%*** of the respondents. The median was 3 (*normal*, 27.3%) and the mode was 4 (*suitable*, 29.5%). Nevertheless, around 30% expressed that the visual style of the platform would have to be improved (scores 1 and 2).

Finally, it was asked about the response time of the platform (MW test: $U = 172.5$, $Z = -1.664$, $p = .096$). ***72.7% stated that the response time was normal*** (3, 27.3%, mode and median) ***or fast*** (scores 4 and 5). This result was considered quite good, since, unlike the UOC campus which uses several distributed servers, AdVisor 2.0 only used one server. Moreover, the appreciation of the response time also depends on multiple factors: the server itself, the network traffic, user's ADSL speed and so on.

In conclusion, ***the overall score of the usability of AdVisor 2.0 could be considered acceptable***, since the following aspects should be taken into consideration:

- As said in section 5.1, the development of the three prototypes mainly focused on those aspects related to pedagogy and information structure (i.e. recommendations A-H).
- AdVisor 2.0 was not a stable platform, but a prototype. As a result, it was obvious that it was needed to spend more resources and time on its development, above all, in terms of usability.
- Users usually have a natural resistance to change and, in this case, most of the respondents was used to using the UOC classroom, as evidenced by the fact that 84.1% of them had been enrolled in the UOC for three or more semesters (see section D.2.2).

Despite the previous considerations, the usability of AdVisor should be improved in future, because usability is one of the cornerstones of any application, including VLEs (see section 3.3).

F.1.2.10 Overall experience

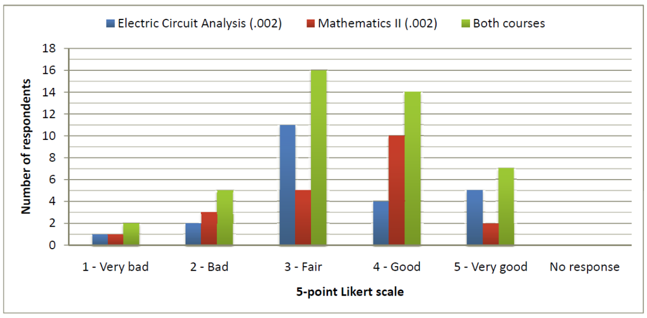
In addition to evaluating each aspect of the platform separately, it was also important to know the degree of satisfaction of the students with AdVisor 2.0 (see Figure F.21). In this regard, the respondents from the two courses agreed ($U = 233$, $Z = -.209$, $p = .835$). 47.7% of them stated that their overall experience had been *good* (4, 31.8%) or *very good* (5, 15.9%). The mode and the median were 3 (*fair*, 36.4%). Although the median and the mode were worse than those of AdVisor 1.0 (median = mode (33.3%) = 4 = *good*), ***only 15.9% of the respondents had had a bad*** (2, 11.4%) ***or very bad*** (1, 4.5%) ***experience***, being this figure lower than that of AdVisor 1.0 (26.2%). Moreover, the dispersion of the distribution was also lower (AdVisor 1.0: IQR=2; AdVisor 2.0: IQR=1) and the respondents who rated 1 (*bad*, 4.5%) were outliers. Therefore, ***the overall experience could be considered satisfactory and even better than that of AdVisor 1.0***.

Besides the global satisfaction of all the respondents, it was also important to know the results for each course. Unlike AdVisor 1.0, the score of the responses in each course was quite unanimous (IQR=1). Nevertheless, as evidenced by the medians shown in the box plots of Figure F.21, the respondents from Mathematics II (.008) had a better experience than those from Electric Circuit Analysis (.002). Actually, the responses of the group of Mathematics II were mostly 4 (*good*) or 5 (*very good*), whereas those of Electric Circuit Analysis were mainly 3 (*fair*). In conclusion, ***compared to AdVisor 1.0, the percentage of respondents that had had a bad or very bad experience was lower in each of the courses***. This was obviously a good result.

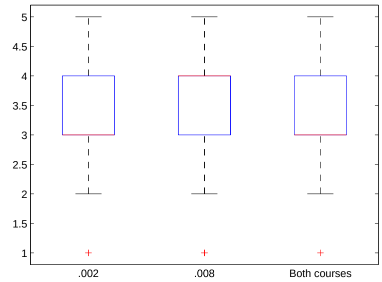
Finally, the questionnaire asked if the respondents would use AdVisor 2.0 in other courses. Regarding this question, there was consensus (MW test: $U = 142.5$, $Z = -1.327$, $p = .184$). In general, the result was worse than that of AdVisor 1.0, since the number of affirmative responses decreased 14.51%, i.e. from 69.05% in AdVisor 1.0 to 54.55% in AdVisor 2.0. But this did not mean a bad result, because 14.51% of the responses that stopped being affirmative mainly went to the *no response* option, which increased from 4.76% to 13.64% (+8.88%). The negative response, in turn, only increased 5.63%, i.e. from 26.19% to 31.82%. As seen, the negative responses did not increase

v_i	Electric Circuit Analysis (.002)			Mathematics II (.008)			Both courses		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Very bad	1	4.3%	4.3%	1	4.8%	4.8%	2	4.5%	4.5%
2 - Bad	2	8.7%	13%	3	14.3%	19.1%	5	11.4%	15.9%
3 - Fair	11	47.8%	60.8%	5	23.8%	42.9%	16	36.4%	52.3%
4 - Good	4	17.4%	78.2%	10	47.6%	90.5%	14	31.8%	84.1%
5 - Very good	5	21.7%	100%	2	9.5%	100%	7	15.9%	100%
No response	0	0%		0	0%		0	0%	
	$n = 23$	$\sum p_i = 100\%$		$n = 21$	$\sum p_i = 100\%$		$n = 44$	$\sum p_i = 100\%$	

(a) Frequency table

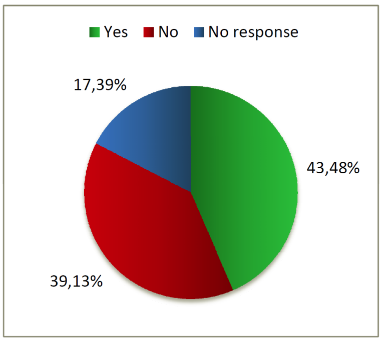


(b) Bar chart

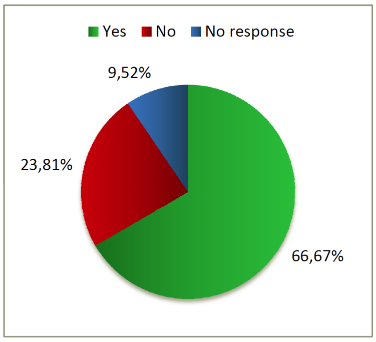


(c) Box plot

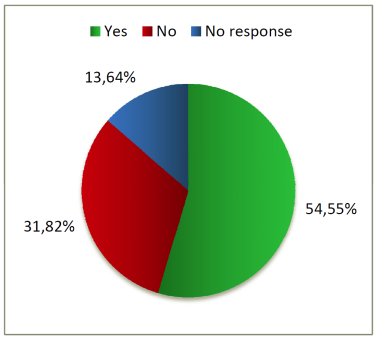
Figure F.21: AdVisor 2.0 – Overall experience.



(a) Circuit Analysis (.002)



(b) Mathematics II (.008)



(c) Both courses

Figure F.22: AdVisor 2.0 – *"Would you like to use AdVisor in other courses?".*

significantly, but there were more respondents who were undecided about if they would use or not the platform. Some possible reasons for the increase of the *no response* option may have been:

- **AdVisor was not within the UOC campus**: those respondents who were enrolled in other subjects had to use both AdVisor and the UOC classroom. In this regard, several comments requested for the integration of the platform into the UOC campus. This nuisance had already existed in AdVisor 1.0, but it seemed that this caused the students of AdVisor 2.0 more problems.

- **More indecision in Electric Circuit Analysis (.002)**: compared to AdVisor 1.0, less students of Electric Circuit Analysis said that they would not use AdVisor 2.0 in future. Instead, 17.39% of the respondents of AdVisor 2.0 ticked the option *no response* (nobody in AdVisor 1.0).

In short, ***the respondents' overall experience was good and over 50% would use AdVisor again***.

F.1.2.11 The most useful and missed aspects of AdVisor 2.0

The respondents were asked to say, with their own words, the most useful/interesting and the worst/missed things of AdVisor 2.0. The different snippets of the responses were tagged into one of the following five categories:

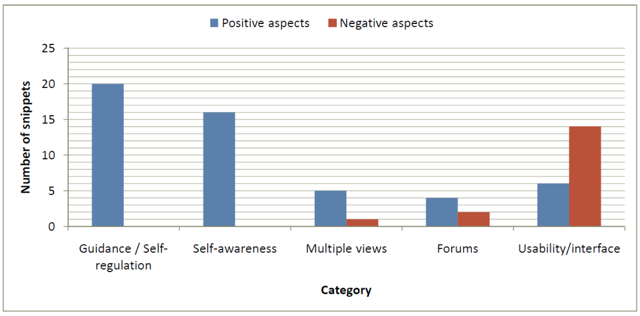
- Guidance/self-regulation (e.g. schedule, to mark activities as complete, etc.)
- Self-awareness (e.g. dashboard)
- Multiple views (e.g. organization)
- Social interaction (e.g. forums)
- Interface/Usability

68 snippets were categorized: 51 positive and 17 negative. As seen in Figure F.23, the most valuable items were the ones that were related to guidance/self-regulation (39.2%) and self-awareness (31.4%). The fact that the respondents highlighted the guidance and self-awareness as the most useful aspects was a clear indicator that ***recommendations B and C*** were suitable for the students and, at the same time, they were implemented in AdVisor 2.0 correctly. By contrast, 82.3% of the negative snippets were linked to the interface and its usability. This made evident the necessity of improving the interface in future if a stable version of the platform were developed.

Next, Tables F.3 and F.4 contain the responses of the Catalan and Spanish students from Electric Circuit Analysis (.002), respectively. Likewise, Tables F.5 and F.6 show the responses of the Catalan and Spanish learners from Mathematics II (.008), respectively. Some parts of the responses have been colored based on the recommendation/topic that they describe.

v_i	Useful/interesting things			Missed/Bad		
	n_i	p_i	P_i	n_i	p_i	P_i
Guidance/self-regulation	20	39.2%	39.2%	0	0%	0%
Self-awareness	16	31.4%	70.6%	0	0%	0%
Multiple views	5	9.8%	80.4%	1	5.9%	5.9%
Forums	4	7.8%	88.2%	2	11.8%	17.7%
Usability/Interface	6	11.8%	100%	14	82.3%	100%
	$n = 51$	$\sum p_i = 100\%$		$n = 17$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

Figure F.23: AdVisor 2.0 – Best and worst things.

ID	Useful/Interesting	Missed/Bad
1	It is a different way to follow the course.	Finding anything would have to be easier. In the beginning, it is a little bit confusing, but the usability improves when you use it day after day.
2	Ease of using and organization.	The forums did not have too many messages.
3	The resources (table of contents, learning materials and CAA) and the forum.	In my opinion, the visibility and the layout are not friendly in order to navigate through the platform.
4	It is very useful to organize/regulate the course.	No response.
5	*I do not like anything, I prefer the UOC's classroom.*	Nothing.
6	To be able to follow the assessment.	The fact that the courses that used AdVisor were separated from the rest of the subjects.
7	You have whatever you need in a friendly and fast environment.	A more attractive interface is needed.
8	The fact that AdVisor is a complete environment in which I have all the aspects related to the course.	It is necessary to improve the navigation and the response time. Maybe the forum is a little bit confusing.
9	The schedule and the monitoring of the course, because they have been very useful.	Nothing in particular. It may sometimes be difficult to find some specific message which you do not remember the activity to which it belonged.
10	The information provided.	No response.
11	The multiple views of the course, i.e. to have a forum per activity, a section which indicates the progress of the course, a section devoted to the schedule, etc.	To have to access from outside the UOC campus was annoying. Moreover, the activities were too segmented.
12	The connection between the activities and the resources required to perform them.	AdVisor is not cross-browser.
13	The schedule of the time.	The fact that the platform cannot be accessed from the UOC campus as the rest of the classrooms.
14	I did not use AdVisor too much, but I think that it was very useful the indicator of progress that one has done in the course.	The interface should be clearer. It was a little bit confusing in the beginning.
15	The forum and the schedule of the activities. The schedule of the activities is one of the things which can contribute value to this application compared to a regular classroom.	The interface is a little bit confusing and, hence, it would have to be more intuitive.

[1] In italics, negative things in the question that asked good things and vice versa.

Table F.3: Responses of the Catalan (19) class of Electric Circuit Analysis (.002).

ID	Useful/Interesting	Missed/Bad
1	The schedule of the units and activities as well as the indicators that warn that a graded activity was delayed or not.	In general, I think that AdVisor is a suitable tool that helps to follow the course a lot.
2	The control over the course in terms of time.	I think the visual style of the forums is ugly.
3	To be able to see both the grades and the new messages at a glance.	Nothing.
4	The schedule and the contents of the activities for each session.	The fact that AdVisor is outside the UOC campus.
5	To know my evolution regarding what is expected.	Better visualization.
6	The schedule of the different contents of the course. Or, in other words: to graphically see where you are.	To include the CAAs dropbox.
7	The idea is excellent, but *the fact that AdVisor was outside the UOC campus made me get confused.*	To integrate AdVisor with the rest of the UOC campus.
8	The functionality that allows to self-regulate your time and to see all the things at a glance. I liked it!	To balance the duration of the session better.

[1] In italics, negative things in the question that asked good things and vice versa.

Table F.4: Responses of the Spanish (89) class of Electric Circuit Analysis (.002).

ID	Useful/Interesting	Missed/Bad
1	The comparison between the proposed schedule and the personal pace.	It was not possible to export the information in other format in order to use it outside AdVisor.
2	*I think that the usability of the system would have to be improved*.	I missed having the activities ordered by date or by content in a single page.
3	The schedule.	To download the messages of the forums in a PDF.
4	To know the percentage that one has done.	More separation between sessions, they sometimes are confused.
5	The schedule and the self-regulation that one can carry out by marking which activities have been finished.	The fact that AdVisor is not integrated into UOC campus.
6	AdVisor is a good platform, but it is not complete. *Maybe, I am very conservative, but I prefer the UOC's classroom.*	The interface would have to be more intuitive, the schedule view would have to display all the items simultaneously, and the platform would have to cross-browser.
7	The schedule.	It would have to be more intuitive, because finding a specific activity or message was sometimes a difficult task.
8	Nothing in particular.	Nothing in particular.
9	No response.	No response.
10	The relationship between table of contents, progress, important dates, guidance, forums per activity, etc.	I missed the campus and the library.
11	The visual way in which one can see and mark their own progress.	The option for downloading the table of contents and the functionality that allows to write mathematical expression in the forums.
12	The progress bar.	To find the table of contents fast and easily.

[1] In italics, negative things in the question that asked good things and vice versa.

Table F.5: Responses of the Catalan (19) class of Mathematics II (.008).

ID	Useful/Interesting	Missed/Bad
1	The indicator of progress.	Using the forums was not easy.
2	No response.	No response.
3	The schedule and the overview.	The only thing was that one day before the exams, AdVisor was not available.
4	The schedule and the fact that the platform is easy to use.	Nothing.
5	The possibility of following the course/s from a single interface. The monitoring that one can carried out.	To be able to deliver my assignments through the platform.
6	Simplicity.	I missed having videos.
7	Schedule.	The interface would have to be more intuitive.
8	The monitoring and schedule.	The fact that AdVisor was not integrated into the UOC campus.
9	The schedule that the platform provides, if this is understood as a proposal of the teacher.	I would have both the AdVisor's and UOC classroom's schedule.

Table F.6: Responses of the Spanish (89) class of Mathematics II (.008).

F.2 Semi-structured interview

F.2.1 Set of questions

Section A – Interviewee's profile

1. In addition to being UOC teacher, have you ever been a teaching collaborator?

   - Yes
   - No

2. How long have you been working as a teacher/teaching collaborator at the UOC?

3. Have you ever been an online or blended teacher in any other institution?

   - Yes

     3.1. How long have you been working as a teacher in that institution?

   - No

4. Nowadays, which department do you belong to?

   - IT, multimedia and telecommunication
   - Economics and business studies
   - Law and political sciences
   - Arts and humanities
   - Psychology and education sciences
   - Information and communication sciences
   - Health sciences

5. As a teacher, how many subjects are you in charge of per semester?

6. And as a teaching collaborator?

7. Have you ever used a learning platform different to the UOC campus? For example: Moodle, Blackboard, D2L, an ad-hoc platform, etc.

   - Yes

     7.1. Which? ___________

   - No
   - No response

Section B – Course design

8. Rank the following aspects of a course according to their importance (1st = the most important), being the option *other* optional:

Degree competences	1st	2nd	3rd	4th	5th	6th	7th
Course objectives	1st	2nd	3rd	4th	5th	6th	7th
Table of contents	1st	2nd	3rd	4th	5th	6th	7th
CAAs and practicals	1st	2nd	3rd	4th	5th	6th	7th
Schedule	1st	2nd	3rd	4th	5th	6th	7th
Activities	1st	2nd	3rd	4th	5th	6th	7th
Other. Which?	1st	2nd	3rd	4th	5th	6th	7th

9. Why 1st and 2nd?

10. Why 5/6th and 6/7th?

11. When you design a course, which information do you usually use? In other words, do you usually design a course in the same order that the one that you have just defined in question 8?

12. Are you able to translate your design of a course from the paper to the UOC classroom?

    - Yes
    - No
      12.1. What things cannot you translate? What problems do you find?

13. How useful would a smart course editor (i.e. one that actively helped you to design your subjects) be to you?

1 - Not at all useful	2 - Not very useful	3 - Neither useful nor useless
4 - Useful	5 - Very useful	• No response

Section C – AdVisor

Section C.1 – Dashboard

14. *The interviewer shows the interviewee a photo of AdVisor's dashboard.* What do you think that this screenshot displays?

    - S/he knows
    - More or less
    - S/he does not know

15. *The interviewer explains what AdVisor's dashboard is.* How useful do you think that a dashboard like this could be to your students?

    1 - Not at all useful   2 - Not very useful   3 - Neither useful nor useless
    4 - Useful   5 - Very useful   • No response

16. How useful do you think that a dashboard like this could be to your teaching collaborators and you?

    1 - Not at all useful   2 - Not very useful   3 - Neither useful nor useless
    4 - Useful   5 - Very useful   • No response

17. Could you give your opinion about AdVisor's dashboard?

Section C.2 – Workspace

18. *The interviewer explains the foundations of AdVisor and its main features.* Do you think that the fact of having multiple views of the same course could provide you with more freedom/flexibility when you design your courses?

    - Yes

      18.1. In what way do you think that this would affect your design?

    - No
    - No response

19. To what extent do you think that having multiple views would enrich the vision that your students have of a course?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

20. Would you add or remove any view?

21. According to your opinion, rank the following views of AdVisor based on how often your students would use each of them (1st = the most used by your learners):

Gantt (i.e. schedule)	1st	2nd	3rd	4th	5th	6th
Treeview (i.e .table of contents)	1st	2nd	3rd	4th	5th	6th
Elastic list (i.e. competences and objectives)	1st	2nd	3rd	4th	5th	6th
Simple list (i.e. activities and resources)	1st	2nd	3rd	4th	5th	6th
Assessment (i.e. CAAs and practicals)	1st	2nd	3rd	4th	5th	6th
Forums	1st	2nd	3rd	4th	5th	6th

22. Why 1st and 2nd?

23. Why 5th and 6th?

24. Any comment about the multiple views?

25. How useful do you think that the detailed sessions would be for your students so that they could regulate their learning process?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful • No response

26. How useful do you think that both the possibility of marking an activity as complete and knowing the pending activities would be for your students?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful • No response

27. Any comment about the detailed schedule, sessions, etc. (vs. UOC's schedule)?

28. In general, how important are discussion forums in your courses?

    1 - Nothing 2 - Little 3 - Normal 4 - Quite a lot 5 - A great deal • No response

29. In general, rate UOC's forums according to their educational effectiveness on a scale of 1-5, with 1 being *very bad* and 5 being *very good*:

    1 - Very bad 2 - Bad 3 - Fair 4 - Good 5 - Very good • No response

30. What thing/s of UOC's forums do you find more useful/interesting? Please let us know below.

31. What thing/s do you miss in UOC's forums? Please let us know below.

32. *The interviewer explains the features of AdVisor's forums.* How suitable do you find the way of organizing the messages of a course?

    1 - Very bad 2 - Bad 3 - Fair 4 - Good 5 - Very good • No response

33. How useful do you think that the fact that your students were able to indicate if they like a message could be for them and you?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful • No response

34. How useful do you think that the fact that your teaching collaborators and you were able to highlight a message could be for you students?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful • No response

35. How useful do you think that your teaching collaborators and you were able to grade the students' message?

    1 - Not at all useful   2 - Not very useful   3 - Neither useful nor useless
    4 - Useful   5 - Very useful   • No response

36. Any comment about AdVisor's forums (vs. UOC's ones).

Section D – Monitoring

Section D.1 – Interviewee's student monitoring process

37. How important is continuous assessment for your students and you?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

38. How important do you think that monitoring students in an online course is?

    1 - Nothing   2 - Little   3 - Normal   4 - Quite a lot   5 - A great deal   • No response

39. Do you monitor/track your students beyond the CAAs?

    - Yes

      39.1. What items do you take into account when you monitor your students?

      39.2. How do you obtain those items?

      39.3. When you have all the information, how do you store/manage it?

      39.4. To what end do you use the information that you collect?

      39.5. Does the UOC campus provide you with all the information that you need?

      - Yes

      - No

      39.5.1 What information is missing?

    - No

      39.6. Why not?

40. Rate the amount of information that is provided by th eUOC campus on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient   2 - Poor   3 - Fair   4 - Good   5 - Very good   • No response

41. How easy is it to obtain the information that the UOC campus provides you?

    1 - Very difficult 2 - Difficult 3 - Fair 4 - Easy 5 - Very easy • No response

42. To what extent do you think that the UOC campus should provide a tool which helps you to monitor your students?

    1 - Unnecessary 2 - Not so necessary
      42.1. Why?

    3 - Indifferent • No response

    4 - Necessary 5 - Very necessary
      42.2. Why?
      42.3. What would that monitoring tool be like?

Section D.2 – FACRO

43. *The interviewer shows and explains FACRO, the proposed student monitoring tool.* Please, tell me your impression of this tool.

44. How useful do you think that this tool would be for you?

    1 - Not at all useful 2 - Not very useful 3 - Neither useful nor useless
    4 - Useful 5 - Very useful • No response

45. Would you use this tool in your courses?

    • Yes • No • No response

46. If this tool existed in your UOC classroom, to what extent would it positively affect the feedback that you and your teaching collaborators would give your students?

    1 - Nothing 2 - Little 3 - Normal 4 - Quite a lot 5 - A great deal • No response

47. Why?

48. What thing/s do you find more positive?

49. What thing/s do you find more negative (or miss)?

Section E – Overall evaluation

50. Rate the concept of dashboard on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient 2 - Poor 3 - Fair 4 - Good 5 - Very good • No response

51. Rate the concept of multiple views on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient 2 - Poor 3 - Fair 4 - Good 5 - Very good • No response

52. Rate AdVisor as a whole on a scale of 1-5, with 1 being *very poor* and 5 being *very good*:

    1 - Very poor/Insufficient 2 - Poor 3 - Fair 4 - Good 5 - Very good • No response

53. Would you use AdVisor in any of your courses?

    - Yes
      53.1. As a complement or as a replacement of the UOC classroom?

      53.2. Why would you use this platform?

    - No
      53.3 Why would not you use AdVisor?

    - No response

54. If you have any suggestions, comments, etc. about any aspect of the platform or the interview that you find important, please let me know.

F.2.2 Results

This section analyzes the semi-structured interviews conducted with eight UOC teachers. The questions tried to know the opinion of the instructors about different aspects that are related to the recommendations proposed in this thesis. At this point, it is worth indicating that each aspect was evaluated both quantitatively and qualitatively. On the one hand, interviewees were asked to rate each aspect on a scale (yes/no, Likert, etc.) and, on the other, they had to justify the score that they had chosen. In this regard, it is important to stress that the frequency tables, bar and pie charts which are shown below contain *no response* answers, while the box plots do not. Likewise, it will be given the most significant comments of the teachers which support the scores.

Lastly, the order of this analysis follows the same as that of the interview, not that of the recommendations (i.e. A, B, etc.). Thanks to this, the reader may better understand how the interviews were conducted. Moreover, some questions related to the evaluation of some elements of the UOC that were asked are not analyzed for this thesis since they are out of the scope this work (however, this information can be useful for future research).

F.2.2.1 Interviewees' profile

As shown in Table F.7, 5 interviewees were men (62.5%) and 3 were women (37.5%). They belonged to two different departments of the UOC: (1) IT, multimedia and telecommunication, and (2) psychology and education sciences.

The informants had wide experience on online teaching, since 6 of them (75%) have been teachers or teaching collaborators at the UOC for 10 or more years (see Figure F.24). Moreover, as shown in Figure F.25, ***they all are usually in charge of at least 4 courses per semester***. Furthermore, two informants, in addition to being teachers, were academic directors at that moment.

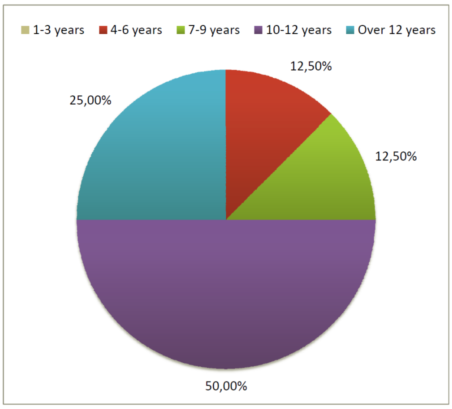
Finally, the three interviewees who belonged to psychology and education sciences had used other VLEs apart from the UOC's one. More specifically, two of them had used Moodle at the UB and the other informant had used WebCT. Likewise, 3 teachers of IT, multimedia and telecommunication had tested Moodle just out of curiosity and another one was currently using the quizzes of this platform in some of his courses.

Department		IT, multimedia and telecommunication	Psychology and education sciences	Total
Number of interviewees	#Male	5	0	5 (62.5%)
	#Female	0	3	3 (37.5%)
	Total	5	3	8 (100%)

Table F.7: Interviews – Breakdown of the interviewees.

v_i	n_i	p_i	P_i
1-3 years	0	0%	0%
4-6 years	1	12.5%	12.5%
7-9 years	1	12.5%	25%
10-12 years	4	50%	75%
Over 12 years	2	25%	100%
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table

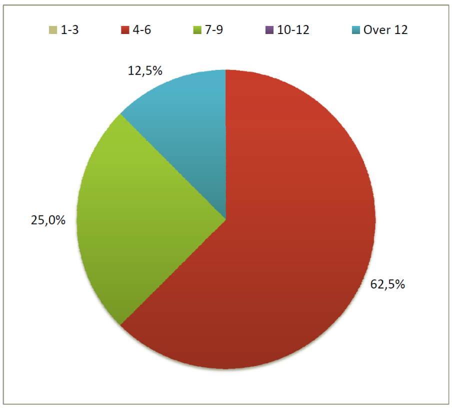


(b) Pie chart

Figure F.24: Interviews – Number of years being teacher/teaching collaborator at the UOC.

v_i	n_i	p_i	P_i
1-3	0	0%	0%
4-6	5	62.5%	62.5%
7-9	2	25%	87.5%
10-12	0	0%	87.5%
Over 12	1	12.5%	100%
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Pie chart

Figure F.25: Interviews – Number of courses per semester.

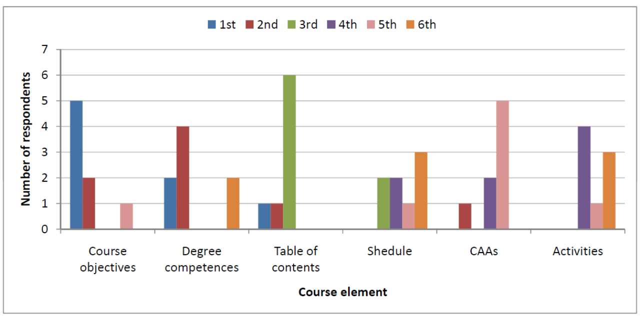
F.2.2.2 Course design (recommendations F and H)

Without knowledge of what AdVisor was, the interviewees were asked to rank different parts of a course from the most important (*1st*) to the least (*6th*) when they design a subject. In other words, the first position had to be for that element from which the instructor began to design a course. As observed in Figure F.26, the first items to be considered when teachers design are the course objectives (median = 1st) and the degree competences (median = 2nd). In fact, several informants expressed that they had wavered between the degree competences and the course objectives as first option, since they both are intertwined. As a result, the decision on which of them was first was almost randomly. This probably affected the result of Kendall's W, which was .475 ($p = .002$), i.e. this value showed a high weak agreement among the interviewees. However, when these two elements were removed from the calculation of Kendall's W, this coefficient reached .625 ($p = .002$), i.e. a high moderate agreement. Actually, there was quite consensus regarding the other items. For example, 6 teachers (75%) indicated that the table of contents was the third element that they used or developed so as to design their courses. In the same way, 5 interviewees (62.5%) agreed that the continuous assessment assignments (CAAs) and practicals were the fifth aspect which they defined during the design. Considering all the responses of the interviews, it was quite clear that ***the three first items which the instructors usually take into account when designing a course are: (1) course objectives, (2) degree competences and (3) table of contents***. Likewise, the activities went to the fifth to the sixth position depending on whether all the activities of the course were part of the assessment or not, respectively. When the subject had both graded and non-graded activities, then the category *CAAs* went prior to the *activities*. Finally, it was concluded that the schedule was the fourth element to be considered when creating a subject.

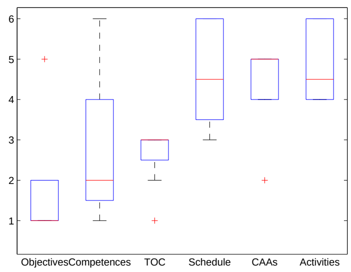
Besides ranking the previous elements, they were asked to indicate the reasons for that ranking, specially, the two first positions. According to two informants, the reason for which the competences and objectives were on the top of the list was because they both *"(...) define the learning*

v_i	Objectives		Competences		Table of contents		Schedule		CAAs and practicals		Activities	
	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i	n_i (p_i)	P_i
1st	5 (62.5%)	62.5%	2 (25%)	25%	1 (12.5%)	12.5%	0	0%	0	0%	0	0%
2nd	2 (25%)	87.5%	4 (50%)	75%	1 (12.5%)	25%	0	0%	1 (12.5%)	12.5%	0	0%
3rd	0	87.5%	0	75%	6 (75%)	100%	2 (25%)	25%	0	12.5%	0	0%
4th	0	87.5%	0	75%	0	100%	2 (25%)	50%	2 (25%)	37.5%	4 (50%)	50%
5th	1 (12.5%)	100%	0	75%	0	100%	1 (12.5%)	62.5%	5 (62.5%)	100%	1 (12.5%)	62.5%
6th	0	100%	2 (25%)	100%	0	100%	3 (37.5%)	100%	0	100%	3 (37.5%)	100%
	$n = 8$		$n = 8$		$n = 8$		$n = 8$		$n = 8$		$n = 8$	

(a) Frequency table



(b) Bar chart

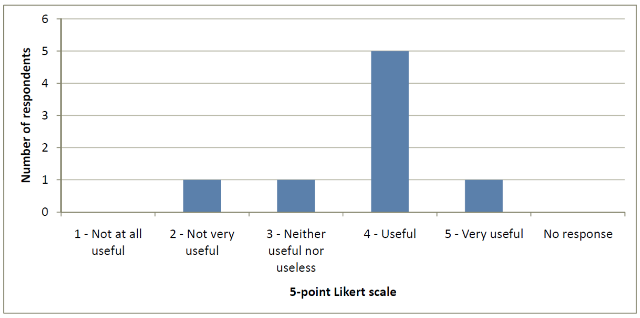


(c) Box plot

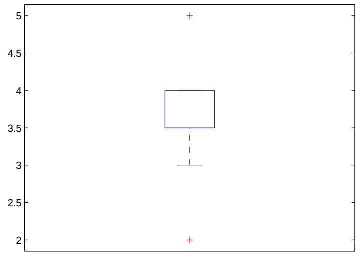
Figure F.26: Interviews – Course design order.

v_i	n_i	p_i	P_i
1 - Not at all useful	0	0%	0%
2 - Not very useful	1	12.5%	12.5%
3 - Neither useful nor useless	1	12.5%	25%
4 - Useful	5	62.5%	87.5%
5 - Very useful	1	12.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.27: Interviews – Usefulness of a smart course editor.

process and the content" and they *"(...) should show teachers the main goal of the course"*.

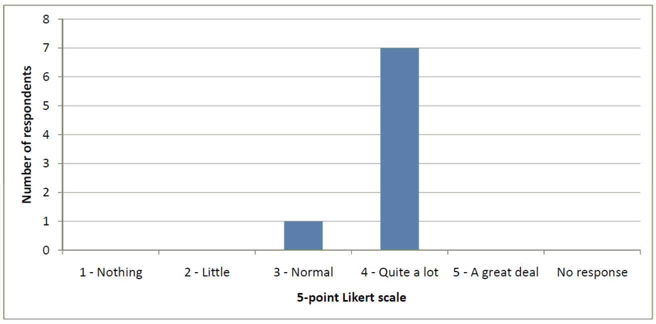
After collecting information related to the habits and procedures of the interviewees when designing their courses, a hypothetical smart course editor was proposed. This tool would aim to help instructors to create effective online subjects by giving them advice and warnings. For example, it could warn of an overload of activities or the fact that some contents, degree competences or course objectives were not addressed by any activity. Considering that imaginary course editor, the interviewees were asked to evaluate how useful this tool could be while designing their subjects on a scale from 1 (*not at all useful*) to 5 (*very useful*). As shown in Figure F.27, ***75% of the informants would find it useful*** (4, 62.5%, mode and median) ***or very useful*** (5, 12.5%). According to their comments, the interviewees indicated that this tool could be especially useful as a checker which helped them to guarantee that their designs were correct. In this regard, some of them would find it interesting that the editor suggested a course schedule based on the list of activities to do. As seen, the presence of a course editor which actively supported the course design task would be welcomed. Therefore, it could be concluded that ***recommendation F***, which encourages VLEs to help teachers to design their courses, ***seemed to make sense***.

At this point of the interview, the most significant features of AdVisor 2.0 were explained to the teachers. Next, it was asked if the fact of having multiple views would change the way in which they design. In general, the response was that ***the design process would not change, except for the workload that the creation of the sessions would entail*** (if the schedule view was used). However, according to some comments, the use of more than one view would help to guarantee that the design of the course is correct, i.e. to ensure that the set of activities encompasses all the degree competences, objectives and sections of the table of contents that are part of the subject.

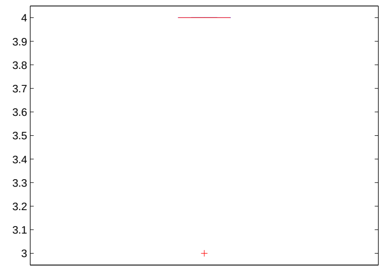
Likewise, the interviewees said that the information structure of AdVisor 2.0 included the most

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	1	12.5%	12.5%
4 - Quite a lot	7	87.5%	100%
5 - A great deal	0	0%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.28: Interviews – To what extent the multiple views would enrich the vision that the students have of the course.

important parts of an online course. They also stressed the flexibility of the schema: *"it allows you to organize your courses from the perspective/s that you want"*. Moreover, when the interviewer explained the structure of AdVisor 2.0 to each teacher, none of them had difficulty understanding the different information spaces. ***This may have meant that the information structure of the platform met recommendation H***, i.e. to provide a flexible schema that is easy to understand.

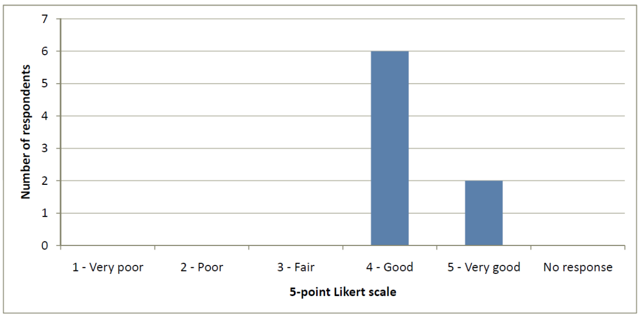
F.2.2.3 Multiple views from students' point of view (recommendations G and A)

As seen in the previous section, the instructors found the information structure of AdVisor 2.0 complete enough to design their online courses. However, it was also needed to know if they thought that the multiples views would enrich the vision of the course that the learners usually have. As shown in Figure F.28, 87.5% thought that the multiple views of the platform would enrich *quite a lot*. Actually, some teachers stated that they have a feeling that many of their students only focus on the CAAs (i.e. those tasks linked to assessment) and ignore the rest of activities and information (i.e. TOC, competences, objectives, etc.). In this regard, ***the informants considered that providing the students with different perspectives of the same course could encourage them to go beyond the CAAs***. Two interviewers also highlighted that the multiple views would enable the platform to better adapt to students' needs and preferences than if this had a single view.

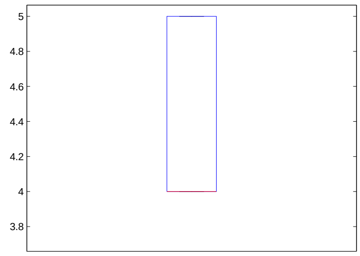
Likewise, the instructors who participated in the interviews assessed the concept of multiple views and the implementation proposed by AdVisor 2.0 as a whole. As shown in Figure F.29, ***all the teachers found it good*** (4, 75%, mode and median) ***or very good*** (5, 25%). However, some interviewees expressed that the interface sometimes showed too much information and, consequently, this could overwhelm the learners. In any case, ***it may be concluded that recommendation G***, i.e.

v_i	n_i	p_i	P_i
1 - Very poor	0	0%	0%
2 - Poor	0	0%	0%
3 - Fair	0	0%	0%
4 - Good	6	75%	75%
5 - Very good	2	25%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.29: Interviews – Overall evaluation of the concept of multiple views and its implementation in Advisor 2.0.

to provide multiple views of the same course, ***was very suitable***.

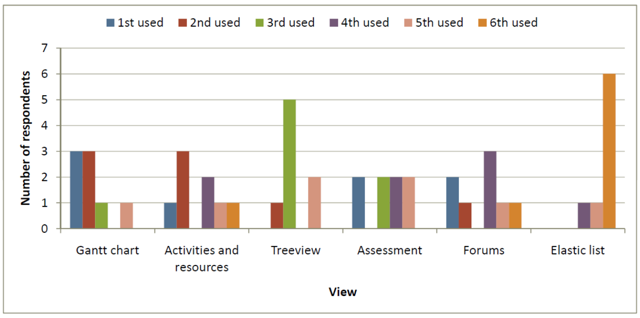
Finally, the interviewees were asked to rank the different views of the platform according to the use which they thought that the students would make of each of them. Although Kendall's W was .375 ($p = .010$), the instructors were sure about the most and least used views (see Figure F.30). In this regard, they considered that ***the Gantt chart***, which was related to the schedule, and ***the elastic list***, which showed the degree competences and course objectives, ***would be the most and the least used views, respectively***.

The interviewees commented that the Gantt chart shows information about the course schedule that is essential for any online learner, i.e. what activities student must do and when. By contrast, ***teachers were convinced that the elastic list would not be useful to most of their learners, since many of them are not interested in the degree competences and course objectives*** which they should attain at the end of the semester. As a teacher said: *"students take it for granted that when they pass a course, they have acquired a set of the competences and attained a set of objectives"*. Paradoxically, as read previously, degree competences and course objectives are essential when teachers design their subjects. This means that ***recommendation A***, i.e. to define competences and objectives clearly, ***is appropriate*** because, on the one hand, its definition and link with the learning activities help teachers to guarantee that the design of the course is correct and, on the other, these two items tell the students what is expected from them.

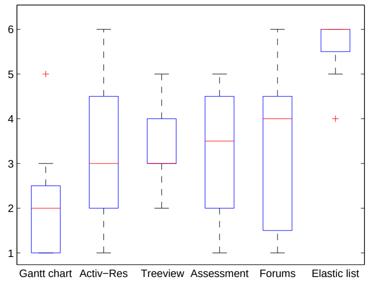
But, given that knowing the competences and objectives that one is developing is not needed daily, some instructors suggested two ways to reduce the cognitive overload of the interface: (1) either to put the elastic list in a secondary place or (2) to remove this view as long as the information on the link between these two elements and the activities continues being in the activity's page.

v_i	Gantt chart		Activities and resources		Treeview		Assessment		Forums		Elastic list	
	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i	$n_i\ (p_i)$	P_i
1st used	3 (37.5%)	37.5%	1 (12.5%)	12.5%	0	0%	2 (25%)	25%	2 (25%)	25%	0	0%
2nd used	3 (37.5%)	75%	3 (37.5%)	50%	1 (12.5%)	12.5%	0	25%	1 (12.5%)	37.5%	0	0%
3rd used	1 (12.5%)	87.5%	0 (0%)	50%	5 (62.5%)	75%	2 (25%)	50%	0	37.5%	0	0%
4th used	0	87.5%	2 (25%)	75%	0	75%	2 (25%)	75%	3 (37.5%)	75%	1 (12.5%)	12.5%
5th used	1 (12.5%)	100%	1 (12.5%)	87.5%	2 (25%)	100%	2 (25%)	100%	1 (12.5%)	87.5%	1 (12.5%)	25%
6th used	0	100%	1 (12.5%)	100%	0	100%	0	100%	1 (12.5%)	100%	6 (75%)	100%
	$n = 8$		$n = 8$		$n = 8$		$n = 8$		$n = 8$		$n = 8$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.30: Interviews – Use of the views of AdVisor 2.0 by the students according to the teachers' opinion.

Last but not least, one of the teachers who were also an academic director went even further and proposed to use the elastic list at degree level. More specifically, she said this view could be used as a degree monitoring tool, e.g. to know which courses provide learners with a particular competence.

F.2.2.4 Self-regulation (recommendations B and C)

Despite the extra work that sessions would involve, the instructors were convinced that it was worth the effort of defining these items in detail, since they thought that ***the session would be a useful*** (4, 37.5%) ***or very useful*** (5, 62.5%, mode and median) ***element for helping their students to plan their learning process*** and to feel guided through the course (see Figure F.31). This reinforces the suitability of ***recommendation B*** (i.e. to guide learners through the course). In addition to displaying the activities defined by the facilitator, one informant suggested enabling the students to add their own tasks/sessions to the Gantt chart.

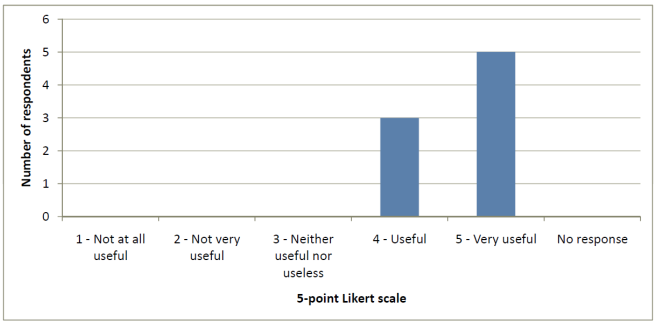
Moreover, as shown in Figure F.32, ***75% of the interviewees found it very useful*** (5, mode and median) ***to allow students to mark an activity/session complete***. However, one teacher warned of the importance of telling the students that the purpose of marking an activity/session as complete is to help them to carry out a personal tracking, not to assess them. Such an instruction may prevent learners from marking activities/sessions finished indiscriminately.

Regarding self-awareness (***recommendation C***), an aspect closely related to self-regulation, AdVisor 2.0 proposed a dashboard (see section 5.4.2.3). Without any explanation of how the dashboard worked, the interviewees were asked to tell what information it showed. The eight teachers had no problem to know what each of the four information areas were about. Therefore, it can be concluded that ***the dashboard were intuitive***.

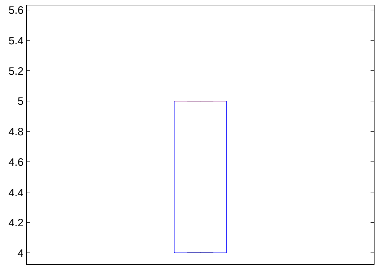
Next, the informants assessed the usefulness of a dashboard like the proposed one to online

v_i	n_i	p_i	P_i
1 - Not at all useful	0	0%	0%
2 - Not very useful	0	0%	0%
3 - Neither useful nor useless	0	0%	0%
4 - Useful	3	37.5%	37.5%
5 - Very useful	5	62.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

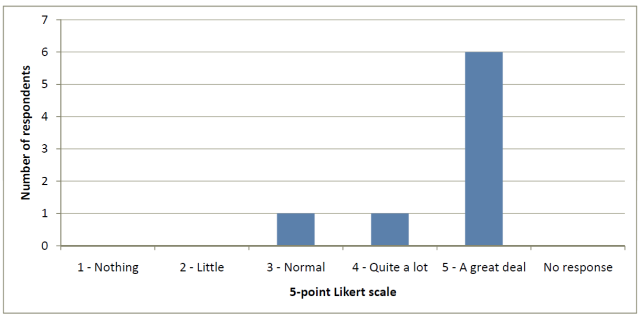


(c) Box plot

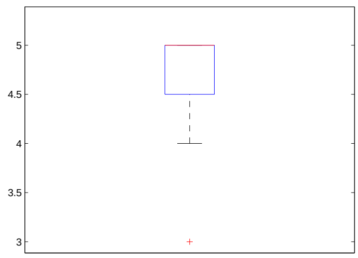
Figure F.31: Interviews – Usefulness of the sessions for planning and guiding.

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	1	12.5%	12.5%
4 - Quite a lot	1	12.5%	25%
5 - A great deal	6	75%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

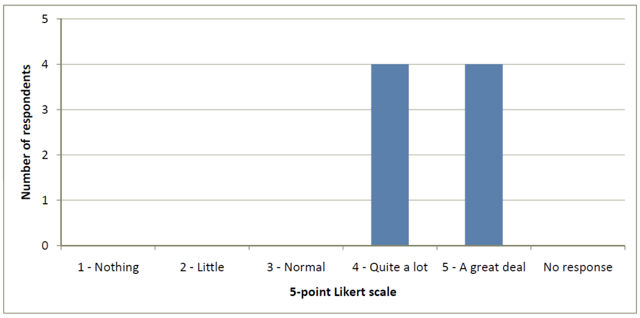


(c) Box plot

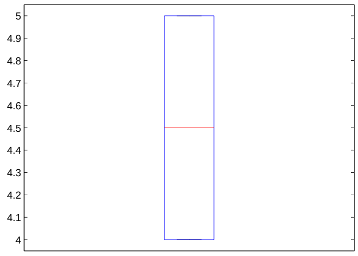
Figure F.32: Interviews – Usefulness of marking an activity/session as complete.

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	0	0%	0%
4 - Quite a lot	4	50%	50%
5 - A great deal	4	50%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.33: Interviews – To what extent the dashboard would be useful to the students according to the interviewees' opinion.

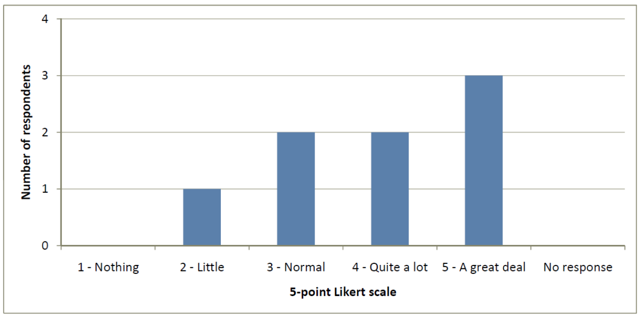
students on a scale from 1 (*not at all useful*) to 5 (*very useful*). As shown in Figure F.33, they thought that ***this type of tool would be useful*** (4, 50%) ***or very useful*** (5, 50%) ***to learners*** because, as an interviewee said, *"[the dashboard] provides a large amount of significant information in a very visual way"*. Moreover, as the dashboard shows the student's global information about all the courses in which she is enrolled, *"this allows the learner to prioritize her resources (e.g. time) based on what she is seeing in the tool. This enables the student to get an idea of where she is [in the totality of the courses in which she is enrolled]"*. More specifically, based on the comments of the teachers, ***it may be concluded that the areas that could be more useful to online students would be the pace and the assessment***. In any case, the evaluation of the dashboard was very positive, which ***reinforces the suitability of recommendation C***, i.e. to provide self-awareness.

Besides scoring the dashboard, several instructors suggested improvements. As for the pace area, four of them indicated that the color of the progress could change depending on the learner's pace. Thereby, the color green would denote a good pace (i.e. on time or ahead of schedule), whereas the color red would mean a bad pace (i.e. behind schedule). Likewise, some interviewees did not like the large amount of data that were shown in the agenda area when a student was behind the schedule. They thought this information overload may discourage this type of learners. As a result, they recommended improving the visual cues and simplify the amount of information that is provided. To this end, one teacher proposed enabling the student to mark those courses of which she has dropped out so that the dashboard does not show their data.

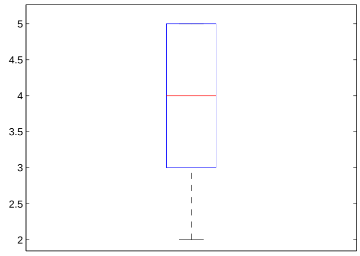
Next, the interviewer explained the differences between the dashboard of the students and that of the teachers. Afterward, the interviewees were asked to evaluate how useful the dashboard could be to their teaching collaborators and them. Unlike the dashboard of the students, ***the instructors'***

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	1	12.5%	12.5%
3 - Normal	2	25%	37.5%
4 - Quite a lot	2	25%	62.5%
5 - A great deal	3	37.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.34: Interviews – To what extent the dashboard would be useful to the teachers.

one was not found such a useful tool (see Figure F.34). The main reason was clearly said by one of the interviewees: *"the needs of a teacher are totally different to those of a teaching collaborator and, at the same time, different to those of a student"*. In this regard, several improvements were proposed. One of the suggestions for helping teaching collaborators was to show, in the pace area, either the median of the class's studying pace (instead of the mean) or the percentage of students who are behind the schedule. Another possible improvement was to allow to see the studying pace of each learner as well as checking the level of completeness of each session on the part of the whole class. Likewise, in the assessment area, instead of displaying the average grade of each CAA, showing the distribution of grades (e.g. a bar chart).

Moreover, to make the course management easier, one interviewee proposed including information that enabled teachers to track the performance of their teaching collaborators, e.g. an alert message which warns of the absenteeism of the collaborators in the classroom for 48 hours or more, a warning that indicates that the statement of a CAA has not been published yet, etc.

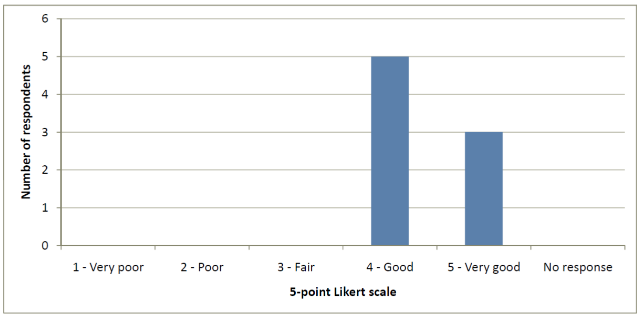
Despite the drawbacks detected by the informants, ***62.5% rated AdVisor 2.0's dashboard for instructors useful*** (4, 25%, median) ***or very useful*** (5, 37.5%, mode).

Finally, the teachers who participated in the interviews were asked to evaluate the concept of the dashboard as a whole without considering the specific proposal of AdVisor 2.0. As shown in Figure F.35, ***they all found the idea of the dashboard good*** (4, 62.5%, mode and median) ***or very good*** (5, 37.5%). They highlighted that this type of tool was very visual and, hence, it showed significant information at a glance.

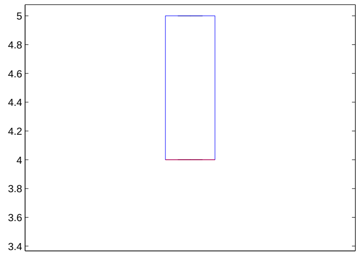
Given that the items related to self-regulation (i.e. sessions, the functionality of marking an activity/session as complete and the dashboard) were evaluated positively, it can be concluded that ***recommendations B and C were strongly supported by the teachers who were interviewed***.

v_i	n_i	p_i	P_i
1 - Very poor	0	0%	0%
2 - Poor	0	0%	0%
3 - Fair	0	0%	0%
4 - Good	5	62.5%	62.5%
5 - Very good	3	37.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.35: Interviews – Overall evaluation of the concept of dashboard.

F.2.2.5 To promote social interaction (recommendation D)

At the UOC, all the classrooms have discussion forums. For this reason, the first question related to social interaction was: *"In general, how important are discussion forums in your courses?"* (see Figure F.36). ***75% of the instructors said a great deal*** (5, mode and median).

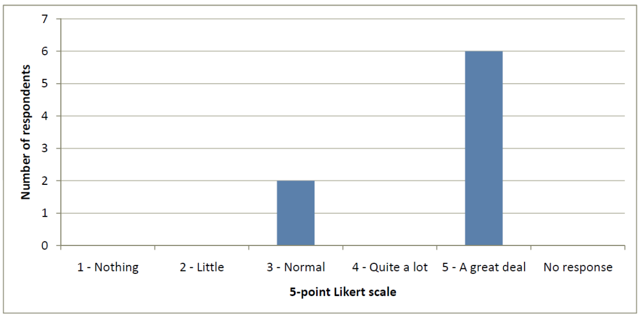
Despite the previous result, it is worth stressing a feeling who some interviewees have with regard to the forums. One of the informants who marked the option *great a deal* said that she was convinced that the forums are very useful to a small number of students. According to her, a course usually has few active learners who really take advantage of this tool. This matches the opinion of the two interviewees who considered the importance of the forums in their courses as *normal* (3, 25%). These two teachers are of the opinion that, in general, less and less students use the UOC forums in order to ask their questions. Instead, according to these instructors, learners use other resources that they find on the Internet (e.g. other forums, Wikipedia, etc.). Such is the lack of use that one of them said she believes that her courses could even work without forums.

Next, the interviewer explained the features of AdVisor 2.0's forums to the instructors. Afterward, a set of questions were asked. First of all, the teachers were asked to evaluate how suitable they found the organization based on one forum per activity. As shown in Figure F.37, ***75% thought this way to organize the messages was good*** (4, 37.5%, median) ***or very good*** (5, 37.5%). Currently, most of the interviewees create an organization based on folders that corresponds to one folder per CAA, at least. Some of them, moreover, create a folder for each learning unit. And, what is more, two instructors followed the same criterion that the one proposed by AdVisor 2.0, i.e. one folder per activity (including graded and non-graded).

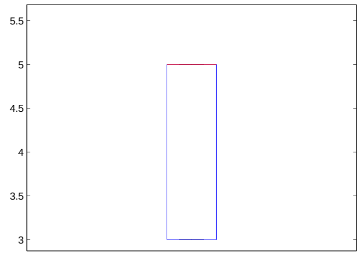
Secondly, three features of the forums were evaluated (see Figure F.38): (1) the like-it button,

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	2	25%	25%
4 - Quite a lot	0	0%	25%
5 - A great deal	6	75%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

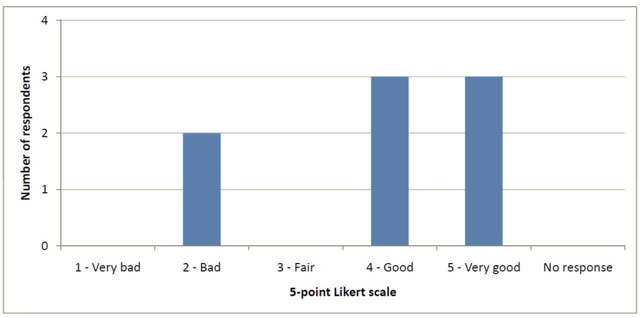


(c) Box plot

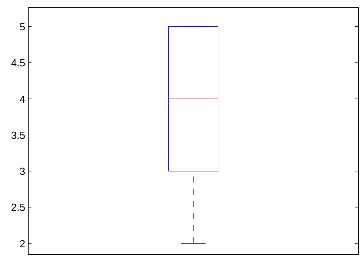
Figure F.36: Interviews – Importance of the forums in the interviewees' courses.

v_i	n_i	p_i	P_i
1 - Very bad	0	0%	0%
2 - Bad	2	25%	25%
3 - Fair	0	0%	25%
4 - Good	3	37.5%	62.5%
5 - Very good	3	37.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

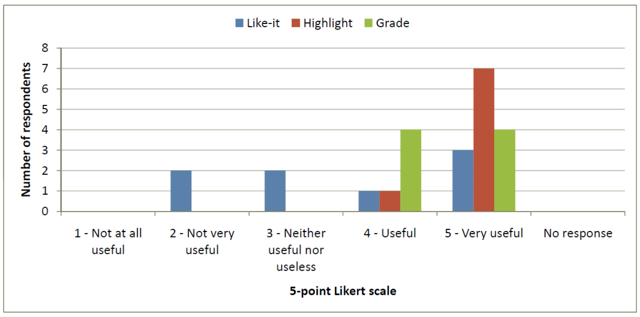


(c) Box plot

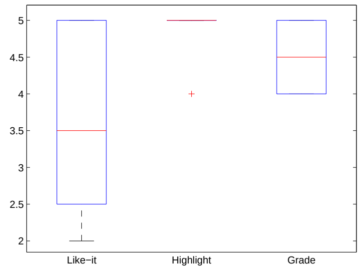
Figure F.37: Interviews – Suitability of one forum per activity.

v_i	Like-it			Highlight			Grade		
	n_i	p_i	P_i	n_i	p_i	P_i	n_i	p_i	P_i
1 - Not at all useful	0	0%	0%	0	0	0%	0	0%	0%
2 - Not very useful	2	25%	25%	0	0%	0%	0	0%	0%
3 - Neither useful nor useless	2	25%	50%	0	0%	0%	0	0%	0%
4 - Useful	1	12.5%	62.5%	1	12.5	12.5%	4	50%	50%
5 - Very useful	3	37.5%	100%	7	87.5	100%	4	50%	100%
No response	0	0%	0%	0%	0	0%	0	0%	0%
	$n = 8$	$\sum p_i = 100\%$		$n = 8$	$\sum p_i = 100\%$	$n = 8$	$\sum p_i = 100\%$		

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.38: Interviews – Usefulness of the functionalities like-it, highlight and grade messages.

(2) to allow instructors to highlight a message, and (3) to enable teachers to grade a message.

Regarding the like-it button, the opinions were very divided. One of the conclusions that could be drawn from the interviews was that this functionality would not be used too much due to the lack of participation of the students in the forums. Likewise, one instructor said that it would be important to encourage all the learners of the classroom to use this option of the forum correctly. Otherwise, only the opinion of a small proportion of the class (i.e. those that participate actively) would be known and, therefore, the information provided by the like-it button would not be useful.

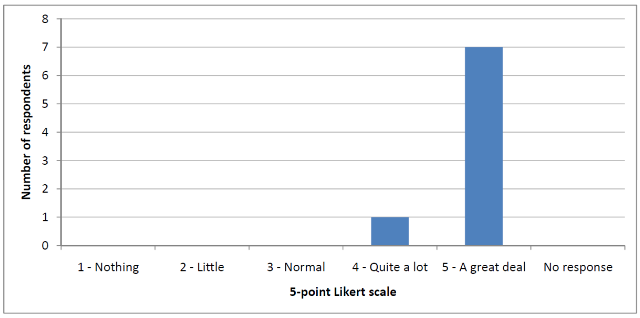
As for the functionality that allowed teachers to highlight messages, the responses were practically unanimous: ***this would be very useful*** (5, 87.5%). In fact, UOC's forums have a similar functionality which the interviewees stated that they used. Lastly, one interviewee said a private mark, which could only be seen by teachers and teaching collaborators, would be very useful too.

With regard to the last feature, i.e. ***to grade messages, was found useful*** (4, 50%, mode and median) ***or very useful*** (50%, mode). According to one interviewee, *"[this feature] is very important, because there is currently no way to convert the contributions in the forums, whether meaningful or not, into something that is tangible (e.g. a grade)"*. Moreover, the doubt that most of the interviewees had was if the grades would have to be public or private.

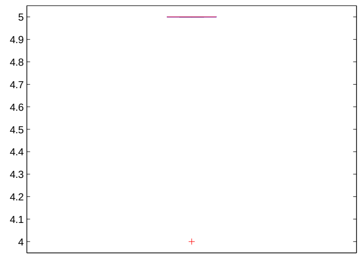
In conclusion, the forums and other types of communication/social tools are important in online education. However, according to the teachers who were interviewed, there is evidence that the participation in the forums is decreasing. Despite this, instructors know that the forums are very useful to those students who really use them correctly. Therefore, although it seems that the number of beneficiaries is small, ***recommendation D*** (i.e. to promote social interaction) ***made sense and was supported by the interviewees***. Furthermore, those tools which improved the interaction and the teaching-learning process within the forums were, in general, well-received.

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	0	0%	0%
4 - Quite a lot	1	12.5%	12.5%
5 - A great deal	7	87.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.39: Interviews – Importance of the continuous assessment.

F.2.2.6 To provide teachers with a student monitoring tool (recommendation E)

This recommendation is the only one that have not been evaluated up to now. To assess it, different questions were asked. These can be categorized into:

- Student monitoring process that is performed by the interviewees
- Evaluation of FACRO

As seen, the first set of question attempted to elicit information about how the teachers (and their teaching collaborators) who were interviewed usually monitor their students. The second set of questions asked interviewees to evaluate FACRO (FAceted Class ROster), the educational monitoring tool that is proposed in this research work. Next, each of the two categories is analyzed.

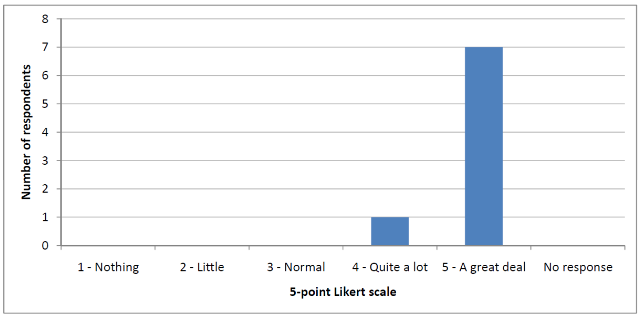
Student monitoring process that is performed by the interviewees

The first question asked instructors how important continuous assessment is in their courses. ***7 of the 8 interviewees were convinced that continuous assessment is very important*** (5, 87.5%, mode and median) during the teaching-learning process of their subjects (see Figure F.39). The words of a teacher clearly said why the continuous assessment is so important: *"[continuous assessment] forces students to do a set of exercises before the exam, they would otherwise not do so. (...) [This] helps students to learn the new concepts and allows to consolidate the acquired knowledge. (...) [Continuous assessment] allows teachers to monitor their students' progress"*.

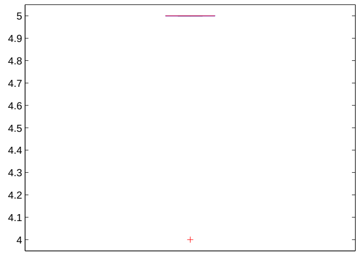
Furthermore, as shown in Figure F.40, the same number of informants said that ***monitoring online students throughout the semester is also very important*** (5, 87.5%, mode and median).

v_i	n_i	p_i	P_i
1 - Nothing	0	0%	0%
2 - Little	0	0%	0%
3 - Normal	0	0%	0%
4 - Quite a lot	1	12.5%	12.5%
5 - A great deal	7	87.5%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.40: Interviews – Importance of monitoring students throughout the course.

Next, the instructors who participated in the interviews were asked: *"do you monitor/track your students beyond the CAAs?"*. Once again, 7 of the 8 answered *yes*. In order to monitor their students and the whole class, besides the grades of the CAAs, the interviewees mainly use the following information: (1) the participation in the forums as well as the content and the quality of the messages, (2) e-mails to the teaching collaborators, and (3) the last log-in date of the students. Likewise, the interviewees said that these monitoring data are scattered across the UOC campus. To reduce the search of this information, some of the instructors expressed that they or their teaching collaborators store all or part of these data in a spreadsheet. In this regard, ***the interviewees responded that it is necessary*** (4, 25%) ***or very necessary*** (5, 75%, mode and median) ***that the UOC campus provides teachers with a tool which helps them to monitor their students*** (see Figure F.41). This monitoring tool should be a hub that collected all the information of the students.

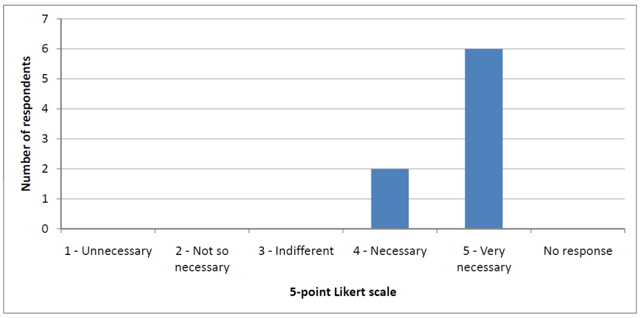
Finally, the teachers gave some of the reasons why they use monitoring data: (1) to reduce dropouts, (2) to decide the final grade of a student when this is a borderline pass/fail, (3) to give individual feedback to each student, (4) to identify misunderstandings and give more examples, information etc., (5) to check the difficulty of the CAAs, etc.

Evaluation of FACRO

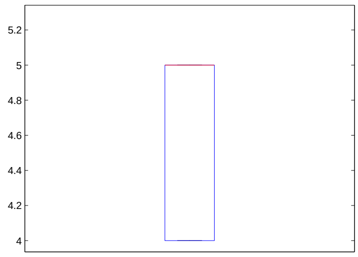
At this stage of the interview, the interviewer introduced FACRO to the interviewees. Broadly speaking, the first impression of this tool was good (see Figure F.42). More specifically, ***87.5% thought FACRO would be useful*** (4, 25%) ***or very useful*** (5, 62.5%, mode and median). However, due to the information which FACRO provided, some informants thought this tool would be much more useful to teaching collaborators than teachers.

v_i	n_i	p_i	P_i
1 - Unnecessary	0	0%	0%
2 - Not so necessary	0	0%	0%
3 - Indifferent	0	0%	0%
4 - Necessary	2	25%	25%
5 - Very necessary	6	75%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart

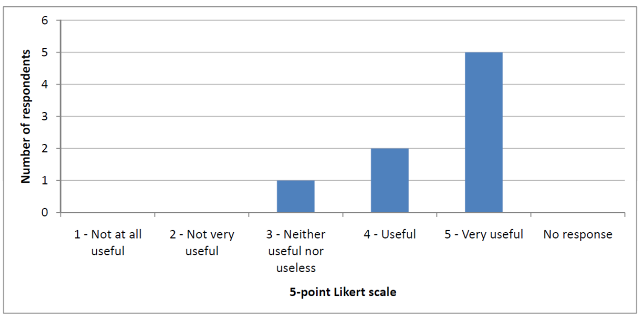


(c) Box plot

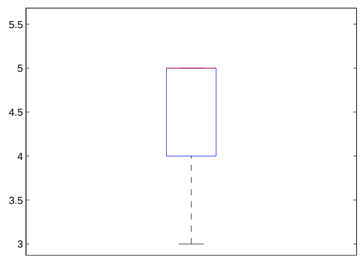
Figure F.41: Interviews – To what extent the UOC campus should provide a tool which helps teachers to monitor their students.

v_i	n_i	p_i	P_i
1 - Not at all useful	0	0%	0%
2 - Not very useful	0	0%	0%
3 - Neither useful nor useless	1	12.5%	12.5%
4 - Useful	2	25%	37.5%
5 - Very useful	5	62.5%	100%
No response	0	0%	0%
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.42: Interviews – Potential usefulness of FACRO in the courses of the interviewees.

Likewise, ***all the teachers who participated in the interviews expressed that they would use FACRO in their courses if this were available***.

Finally, the teachers were asked about what thing/s they found more positive and negative (or missed). Regarding the positive ones, some of them were: *"the slidebars are easy to use"*, *"it integrates information that is faceted"*, *"the information is found quickly"*, *"it allows to detect problems in time"*, *"it allows teachers to gain control over how their students are carrying out their learning process"*, etc. As for possible improvements, it is worth stressing: to enable to create presets with the most frequent searches, to allow to send messages to the result set, to show aggregate data with graphics (e.g. bar charts), the system should inform teachers/teaching collaborators of those learners who are about to drop out, to display the performance of the course in previous semesters, etc.

Conclusions

As seen, most of the interviewees stated that monitoring students is very important. In this regard, they considered continuous assessment to be a good way to monitor their learners in terms of understanding of the contents of the course. Apart from continuous assessment, they also use other type of information so as to gain an insight into teachers' learning process. However, they commented that all those data are scattered across the UOC campus and, hence, they need a tool that gathers all the available information of the students together. FACRO seemed to be a good first step toward this goal.

In conclusion, the previous results have shown that ***teachers require tools which help them to monitor their students (i.e. recommendation E)***.

F.2.2.7 Overall evaluation

From the pictures and the real demo that were shown, the interviewees were asked to rate AdVisor 2.0 on a scale from 1 (*very bad*) to 5 (*very good*). As shown in Figure F.43, ***50% considered the tool good and the other 50% very good***. Obviously, it was needed to be cautious with this evaluation, since the interviewees could not use AdVisor 2.0. Instead, they assessed the tool from what they had seen during the interview. Nevertheless, the result was a good indicator.

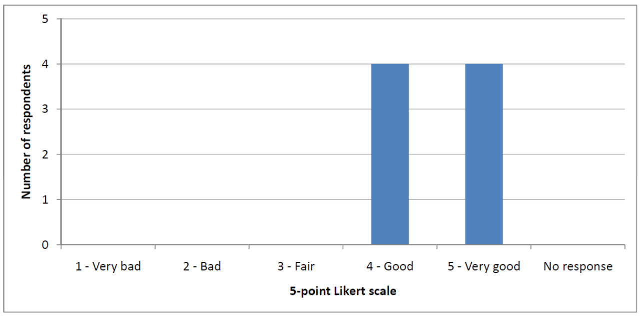
Likewise, all the informants expressed that they would use an online classroom like AdVisor 2.0 if this were available in the UOC campus. Some of the reasons for this were: *"better information architecture"*, *"it includes degree competences and course objectives"*, *"to provide multiples perspectives beyond the CAAs"*, *"it is a major evolution compared to the current UOC classroom, (...) it focuses on the organization, scheduling, tracking of one's progress"*, *"more visual than the UOC classroom"*, *"integration with a monitoring tool"*, etc.

By contrast, the instructors also indicated some negative aspects which should be improved in future: *"the interface is overloaded"*, *"the platform would have to allow more customization"*, *"the style is different to that of UOC which they are used to using"*, etc.

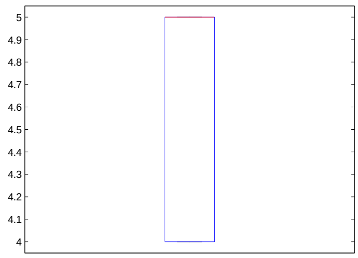
Broadly speaking, ***both AdVisor 2.0 and FACRO were well received by the teachers who participated in the interviews***.

v_i	n_i	p_i	P_i
1 - Very bad	0	0%	0%
2 - Bad	0	0%	0%
3 - Fair	0	0%	0%
4 - Good	4	50%	50%
5 - Very good	4	50%	100%
No response	0	0%	
	$n = 8$	$\sum p_i = 100\%$	

(a) Frequency table



(b) Bar chart



(c) Box plot

Figure F.43: Interviews – Overall evaluation of AdVisor 2.0.

G Educational monitoring tools

This appendix presents an overview of educational monitoring tools. After a brief introduction (see section G.1), these systems are classified from two perspectives (see section G.2):

- The data processing techniques that they use (see section G.2.1)
- The element which they monitor (see section G.2.2)

G.1 Introduction

Instructors need appropriate means to set up a monitoring process that allows them to be aware of the students' learning process and provide learners with just-in-time assistance. Furthermore, monitoring allows teachers to forecast potential problems (e.g. dropouts) and avoid them in time.

To monitor their students, online teachers often use tracking information (e.g. logs) and monitoring tools which are available in virtual learning environments (VLEs). However, a comparative study of tracking functionalities of various VLEs (Hijón and Velázquez-Iturbide, 2006) shows that none of them offer much tracking ability. One of the reasons is that these platforms often provide tracking data in a tabular format which is commonly poorly structured, incomprehensible and difficult to understand (Mazza and Dimitrova, 2004). To tackle such problems, different tools have been proposed in the literature.

Next, a brief state of the art on educational monitoring tools is presented.

G.2 Classification of educational monitoring tools

Educational monitoring tools may be classified from two perspectives:

- The data processing techniques that they use
- The element which they monitor

These two points of view are described below.

G.2.1 Data processing techniques

The main goal of any monitoring tool, whether this has an educational purpose or not, is to give users some insight into the data at which they are looking. To this end, two different data processing techniques are mainly used:

- Information visualization (InfoVis) techniques
- Data mining (DM) algorithms

Next, they both are briefly explained together with some educational examples.

G.2.1.1 Information visualization (InfoVis)

One of the most well-known definitions of information visualization (InfoVis) is:

Information visualization (InfoVis)

> The use of computer-supported, interactive, visual representations of abstract data to amplify cognition.
>
> (Card et al., 1999)

In other words: ***InfoVis encompasses a set of techniques that transform data into effective graphical representations by taking advantage of the properties of human visual perception***. Thus, these visual representations reveal facts and trends which allow users to infer some unknown information by combining the visual inputs with their knowledge of the data. At this point, it is important to stress that the data processing which is performed in InfoVis is mainly based on simple mathematical and statistical functions, e.g. sum, percentages, mean, median, mode, etc.

In the educational context, some proposals based on InfoVis techniques have been suggested. Two of the most relevant tools are CourseVis (Mazza and Dimitrova, 2004) and, its successor, GISMO (Mazza and Milani, 2004). The former is a stand-alone visualization tool that obtains tracking data from WebCT, transforms them into a form convenient for processing and generates graphical representations that can be explored and manipulated by instructors. Thereby, teachers can examine social (it uses a 3D visualization of discussion boards), cognitive (it uses a matrix in which each cell is the grade attained by a specific student in a particular quiz), and behavioral (it shows information about access and participation in a timeline) aspects of their students. CourseVis mainly uses 2D visualization techniques, but it also uses color and shape as a third dimension.

As far as GISMO is concerned, this also uses VLEs' tracking data, but in this case from Moodle, to display graphical representations (e.g. bar charts, matrices, etc.) about overall classroom accesses and detailed information of a specific student. This was developed as a Moodle block, but its interface is detached from Moodle's one.

Similarly, Zhang et al. (2007) designed Moodog, a visual student tracking data plug-in for Moodle which also sends automatic reminder e-mails to students. This displays information about the course, students, resources and access time. Unlike GISMO, the information provided by Moodog is integrated into Moodle's interface, keeping the original Moodle's layout as much as possible.

There are many other works that have also proposed different representations based on InfoVis techniques. For instance, Hardy et al. (2008) constructed, as a graph, the route taken by one student through the course material during a single work session; Hijón-Neira and Velázquez-Iturbide (2008) suggested an interactive graph (for students' grades) and a data mountain (for access) by using Prefuse API; Juan et al. (2008), likewise, proposed scatter plots and quadrants as well as an evolution graph so as to represent students' performance; and Bakharia and Dawson (2011) created SNAPP, a social network analysis tool that displays, as a graph, the evolution of the participants' relationships within the discussion forums of a VLE.

G.2.1.2 Data mining (DM)

Next, it is presented one possible definition of what data mining (DM) techniques are:

Data mining (DM)

Data mining (DM) techniques are able to infer underlying patterns from a large database, generating some new type of valuable information such as student models or predictions. These new data can be delivered in writing or visually.

According to Romero and Ventura (2007), data mining (DM) techniques can be classified into four categories: (1) clustering, classification and outlier detection; (2) association rule mining and sequential pattern mining; (3) text mining; and (4) statistics and visualization. However, the latter is not universally seen as a category of DM (Baker and Yacef, 2009), since the data processing that is carried out is minimum compared to the one of the rest of categories, which are based on ***artificial intelligence algorithms***. In fact, this fourth category accords with the definition of InfoVis presented in the previous section. Hence, regarding this thesis, only the first three categories defined by Romero and Ventura (2007) are considered as belonging to data mining.

Recently, more and more educational monitoring tools based on DM have been proposed. For example, Kosba et al. (2005) developed TADV, a system that builds student, group and class models by using fuzzy logic. From these models, TADV gives instructors advice, e.g. to advise a learner to review a concept. Thanks to TADV, teachers have extra data to make decisions during the course.

Hung and Zhang (2008) used statistical models and machine learning algorithms to analyze patterns of online learning behaviors and make predictions on learning outcomes.

Likewise, Zorrilla et al. (2010) proposed a decision support system that utilizes several techniques. Firstly, two clustering algorithms, Expectation-Maximization (EM) and K-Means, are used to characterize, on the one hand, students and, on the other, sessions. The output of EM, a probability distribution, allows to determine the number of clusters with which K-Means is executed. Depending on the input data, the clusters obtained from K-Means describe either student behavior models or session patterns. In addition to the information provided by the clusters, the proposal of Zorrilla et al. also indicates the resources that has usually been used together. To obtain these data, Apriori, an algorithm for finding association rules, is employed.

More proposals of educational monitoring tools based on DM techniques can be found in (Baker and Yacef, 2009; Romero and Ventura, 2007).

G.2.1.3 Information visualization vs. data mining

One of the main differences between information visualization (InfoVis) and data mining (DM) is how new information is inferred. Due to the complexity of ***the algorithms used in DM, these are able to suggest latent information*** with an explanation based on text, rules, clusters, etc. For example, a tool based on DM techniques could give the following output: *"student S is about to* *drop out because she has not acceded to the classroom for two weeks"*. By contrast, in the case of ***the tools based on InfoVis techniques, new information is not inferred by an algorithm, but by users*** who combine the visual inputs of the graphics with their knowledge of the domain.

As a result of the manner of inferring new information, two issues arise: (1) reliability, and (2) computational cost. Regarding reliability, the users of tools based on DM must rely on the accuracy of the information suggested by the algorithm, whereas the users of tools based on InfoVis infer reliable information based on their own expertise. As far as computational cost is concerned, InfoVis techniques calculate statistical data that require minimum processing, while ***tools based on DM execute complex artificial intelligence algorithms which are usually time-consuming***.

Another important aspect is user-friendliness. In this regard, Merceron and Yacef (2008) argue that it is essential to use techniques and measurements which are fairly intuitive and easy to interpret. This may be one of the weak points of the applications based on DM techniques, because the explanation provided by this kind of tool often requires users to master the algorithm so as to understand it. Unfortunately, a lot of users neither have this knowledge nor can make time for acquiring it. On the contrary, tools based on InfoVis seem to best meet these requirements, since they use simple statistical data and focus on displaying information in a visual and effective way.

Despite the differences between information visualization and data mining, they can work together in an application. For instance, a system could first infer some latent information from a large database by using a DM algorithm and then display it by using a visual representation based on InfoVis techniques. Thereby, users can benefit from the advantages of each technique: on the one hand, the possibility of inferring new data automatically and, on the other, the capability of visual representations to convey information effectively. This combination of DM algorithms with InfoVis techniques is called *visual data mining* (Keim et al., 2002). Nowadays, there is every indication that this new discipline will become a promising research area.

G.2.2 Monitored element

Although the most popular term is *student monitoring tools*, it would be more correct to call them *educational monitoring tools*, since they can monitor other items in addition to learners. In this regard, this section describes the elements that are usually monitored in an educational context.

- Class
- Student group
- Individual student
- Resources

At this point, it is important to stress that both InfoVis and DM techniques can be used to track any of these items.

G.2.2.1 Class

The most common item is the whole class, i.e. all the students are considered a unique entity. This entity is characterized by the overall information that comes from combining all students' tracking data, e.g. class's average grade in each assignment. Thanks to this, instructors get an overview of their learners' performance. As a result, teachers can make decisions that affect the whole class. Most educational monitoring tools show data of the class.

G.2.2.2 Student group

A particular case of the previous monitoring is the one which focuses on groups that consist of students from the same class. This kind of monitoring is really useful when group activities are proposed, e.g. tasks that belong to a project-based learning. In this regard, the supervision of the groups enables to obtain information about how the students interact each other, who are the most and least participative members of a group, which group has the best and the worst performance, etc. In this regard, (Bakharia and Dawson, 2011; Juan et al., 2008; Pirrone et al., 2009) are examples of group monitoring tools.

G.2.2.3 Individual student

Teachers often need to take a closer look at a particular learner or make comparisons between students. For this reason, they need tools that provide detailed information about an individual learner, e.g. how many times a student has accessed to the VLE. These data may help instructors to gain an understanding of the reasons why a specific learner has a particular behavior. Thanks to this understanding, teachers can offer each student a better support and a tailored learning experience. Regarding this, CourseVis (Mazza and Dimitrova, 2004) and Moodog (Zhang et al., 2007) are two tools that display information of a particular student.

G.2.2.4 Resources

The term *resource* encompasses a wide spectrum of elements, from learning materials (e.g. documents, videos, quizzes, etc.) to educational tools (e.g. forum, chat, VLE's pages, etc.). In this regard, there are multiple types of data related to resources that can be tracked, e.g. how many times a document has been read, how many messages a forum has, the path that a learner followed while she was navigating through a VLE, etc. Hence, monitoring resources may provide teachers with valuable information on the instructional design (e.g. to detect a bad design of content pages) and students' performance (e.g. to detect whether learners are engaging in the course thanks to forums participation). An example of this kind of monitoring is (Zorrilla et al., 2010).

At this point, it is worth stressing that a graphic can simultaneously provide information about various items depending on how this is read. For instance, Mazza and Dimitrova (2004) use a matrix to show students' performance on quizzes. When teachers pay attention to a specific column, they observe the performance of a particular student in all course quizzes. By contrast, when a row is observed, then teachers analyze the performance of the whole class in a specific quiz.

H List of publications

The work described in this thesis resulted in the following scientific publications:

[1] García-Solórzano, D., Cobo, G., Santamaría, E., Morán, J. A., and Adelantado, F. (2009). Herramientas para la Gestión del Proceso de Aprendizaje en un Entorno Virtual. In *Proceedings of the Conferencia conjunta Iberoamericana sobre Tecnologías para el Aprendizaje (CcITA 2009), Recursos Digitales para el Aprendizaje en Iberoamérica*, pages 514–519, ISBN: 978-607-7573-17-3

[2] García-Solórzano, D., Cobo, G., Santamaría, E., Morán, J. A., and Melenchón, J. (2011). Representation of a course structure focused on activities using information visualization techniques. In *Proceedings of the 11th IEEE International Conference on Advanced Learning Technologies (ICALT'11)*, pages 443–445, ISBN: 978-1-61284-209-7, DOI: 10.1109/ICALT.2011.138

[3] García-Solórzano, D., Cobo, G., Santamaría, E., Morán, J. A., Melenchón, J., and Monzo, C. (2012). Evaluation of a learning management system focused on activities. In *Proceedings of the IEEE Global Engineering Education Conference (EDUCON'12)*, pages 1–6, ISSN: 2165-9559, DOI: 10.1109/EDUCON.2012.6201107

[4] García-Solórzano, D., Cobo, G., Santamaría, E., Morán, J. A., Monzo, C., and Melenchón, J. (2012). Educational monitoring tool based on faceted browsing and data portraits. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (LAK'12)*, pages 170–178, New York, NY, USA. ACM, ISBN: 978-1-4503-1111-3, DOI: 10.1145/2330601.2330645

Some parts of the work presented in this thesis have been published in the aforesaid articles:

- **Paper [1]**: this article explains the features of AdVisor 0.0. In this thesis, this information can be found in section 5.2.2.

- **Paper [2]**: it introduces AdVisor 1.0 by emphasizing, on the one hand, the information structure and, on the other, the visual elements and the views of the interface. The content of this article was used to write section 5.3.2 of this dissertation.

- **Paper [3]**: this describes AdVisor 1.0 by introducing, moreover, the new dashboard based on four information areas (see section 5.3.2). This description is based on the three cornerstones of a VLE that were defined by Mastoras et al. (2005), i.e. pedagogy, information structure and usability (see section 3.3). Moreover, a summary of the discussion on if current VLEs are effective tools for fully online education was published in this article (see section 3.5). Finally, this paper shows the most significant results drawn from the questionnaire of this prototype (see section 5.3.5 and Appendix E).

- **Paper [4]**: this article introduces FACRO (see section 5.4.2.4) together with the literature review of educational monitoring tools presented in Appendix G.

During the research period, I have also collaborated with other researchers on topics related to online education:

[5] Farrús, M., Costa-Jussa, M. R., Cobo, G., García-Solórzano, D., Villarejo, L., and Banchs, R. E. (2010). Automatic evaluation of continuous assessment tests. In *Proceedings of the 6th International Conference of the Society of ICT in Analysis, Teaching and Learning of Language (ICTATLL 2010)*, pages 173–180, ISBN: 978-0-947649-76-0

[6] Costa-Jussa M. R., Cobo, G., Duran J., García-Solórzano, D., and Cortés, F. (2011). Plataforma web de evaluación automática de pruebas de respuesta abierta (Automatic test assessment web platform). In *Promotion and Innovation with New Technologies in Engineering Education (FINTDI'11)*, pages 1–4, DOI: 10.1109/FINTDI.2011.5948888

[7] Cobo, G., García-Solórzano, D., Santamaría, E., Morán, J. A., Melenchón, J., and Monzo, C. (2011). Modeling students' activity in online discussion forums: a strategy based on time series and agglomerative hierarchical clustering. In *Proceedings of 4th International Conference on Educational Data Mining (EDM'11)*, pages 253–258, ISBN: 978-90-386-2537-9

[8] Cobo, G., García-Solórzano, D., Morán, J. A., Santamaría, E., Monzo, C., and Melenchón, J. (2012). Using agglomerative hierarchical clustering to model learner participation profiles in online discussion forums. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (LAK'12)*, pages 248–251, New York, NY, USA. ACM. ISBN: 978-1-4503-1111-3, DOI: 10.1145/2330601.2330660

References

Aidi, X. (2009). Cognitive overload and its countermeasures from the angle of information processing. In *Proceedings of the 2009 Third International Symposium on Intelligent Information Technology Application - Volume 01*, IITA '09, pages 391–394, Washington, DC, USA. IEEE Computer Society. 27

Allen, E., Seaman, J., and Garrett, R. (2007). Blending in: The extent and promise of blended education in the united states. Web. Retrieved on October 3, 2011 from `http://sloanconsortium.org/sites/default/files/Blending_In.pdf`. 15

Allen, I. E. and Seaman, J. (2011). Going the distance: Online education in the United States, 2011. Technical report, Babson Survey Research Group and Quahog Research Group, LLC. 2, 20

Ally, M. (2004). *Foundations of educational theory for Online Learning*, chapter 1. AU Press, Athabasca University, first edition. 31

Althaus, S. L. (1997). Computer-mediated communication in the university classroom: An experiment with on-line discussions. *Communication Education*, 46(3):158–174. 17

Anderson, J. (2000). *Learning and memory: an integrated approach*. Wiley. 29

Anderson, T. and Dron, J. (2011). Three generations of distance education pedagogy. *International Review of Research in Open and Distance Learning*, 12(3):80–97. 31

Anderson, T., Elloumi, F., and et al. (2004). *Theory and Practice of Online Learning*. Athabasca University. 28, 29

Anderson, T. D. and Garrison, D. R. (1998). Learning in a networked world: new roles and responsibilities. In Gibson, C., editor, *Distance Learners in Higher Education: Institutional Responses for Quality Outcomes*, Diversity Series. Atwood Pub. 21

Ardito, C., Costabile, M. F., De Marsico, M., Lanzilotti, R., Levialdi, S., Plantamura, P., Roselli, T., Rossano, V., and Tersigni, M. (2004a). Towards guidelines for usability of e-learning applications. In Stary, C. and Stephanidis, C., editors, *User-Centered Interaction Paradigms for Universal Access in the Information Society*, volume 3196 of *Lecture Notes in Computer Science*, pages 185–202. Springer Berlin Heidelberg. 165

Ardito, C., De Marsico, M., Lanzilotti, R., Levialdi, S., Roselli, T., Rossano, V., and Tersigni, M. (2004b). Usability of e-learning tools. In *Proceedings of the working conference on Advanced visual interfaces*, AVI '04, pages 80–84, New York, NY, USA. ACM. xxi, xxii, 45, 68, 81, 170, 174, 175, 176

Attwell, G. (2007). Personal Learning Environments - the future of elearning? *eLearning Papers*, 2(1). 37

Baath, J. A. (1985). A note on the origin of distance education. In *ICDE - Bulletin*, 1, pages 61–62. 13

Baker, R. S. and Yacef, K. (2009). The State of Educational Data Mining in 2009: A Review and Future Visions. *JEDM - Journal of Educational Data Mining (ISSN 2157-2100)*, 1(1):3–17. 306

Bakharia, A. and Dawson, S. (2011). SNAPP: a bird's-eye view of temporal participant interaction. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*, LAK '11, pages 168–173, New York, NY, USA. ACM. 305, 308

Bargh, J. A. and Ferguson, M. J. (2000). Beyond behaviorism: on the automaticity of higher mental processes. *Psychological bulletin*, 126(6):925–945. 29

Barker, I. (2005). What is information architecture? Retrieved on October 15, 2011 from `http://www.steptwo.com.au/papers/kmc_whatisinfoarch/index.html`. 44

Barnard-Brak, L., Lan, W. Y., and Paton, V. O. (2010). Profiles in self-regulated learning in the online learning environment. *International Review of Research in Open and Distance Learning*, 11(1):61–80. 25

Beaudoin, M. (1990). The instructor's changing role in distance education. *The American Journal of Distance Education*, 4(2):21–29. 34

Beishuizen, J. and Steffens, K. (2011). A conceptual framework for research on self-regulated learning. In Carneiro, R., Lefrere, P., Steffens, K., and Underwood, J., editors, *Self-Regulated Learning in Technology Enhanced Learning Environments*, volume 5 of *Technology Enhanced Learning*, pages 3–19. SensePublishers. 72

Berge, Z. L. (1995). Facilitating computer conferencing: Recommendations from the field. *Educational Technology*, 35(1):22–30. 33, 34

Bertram, D. (2007). Likert scales... are the meaning of life. Retrieved on October 3, 2011 from `http://poincare.matf.bg.ac.rs/~kristina/topic-dane-likert.pdf`. 186

Besser, H. and Bonn, M. (1997). Interactive distance-independent education: challenges to traditional academic roles. *Journal of Education for Library and Information Science*, 38(1):35–42. 35

Bigony, L. (2010). Can you go the distance? Attending the virtual classroom. *Orthopaedic Nursing*, 29(6):390–392. 16, 18

Bippus, A. M., Kearney, P., Plax, T. G., and Brooks, C. F. (2003). Teacher access and mentoring abilities: Predicting the outcome value of extra class communication. *Journal of Applied Communication Research*, 31(3):260–275. 18

Booth, C. (2011). *Reflective Teaching, Effective Learning: Instructional Literacy for Library Educators*. American Library Association. 32

Bri, D., Coll, H., García, M., and Lloret, J. (2008). Analysis and comparative of virtual learning environments. In *Proceedings of the 5th WSEAS/IASME International Conference on Engineering Education*, EE'08, pages 312–317, Stevens Point, Wisconsin, USA. World Scientific and Engineering Academy and Society (WSEAS). 150

Bri, D., García, M., Coll, H., and Lloret, J. (2009). A study of virtual learning environments. *WSEAS Transactions on Advances in Engineering Education*. 150

Card, S., Mackinlay, J., and Shneiderman, B. (1999). *Readings in information visualization: using vision to think*. The Morgan Kaufmann series in interactive technologies. Morgan Kaufmann Publishers. 305

Cheong, C. S. (2001). E-learning – a provider's prospective. *The Internet and Higher Education*, 4(3-4):337 – 352. 16, 18

Coffield, F., Moseley, D., Hall, E., and Ecclestone, K. (2004). Learning styles and pedagogy in post-16 learning: a systematic and critical review. Technical report, Learning and Skills Research Centre/University of Newcastle upon Tyne. 17

Cook, C., Heath, F., and Thomphson, R. (2000). A meta-analysis of response rates in web- or internet-based surveys. *Educational and Psychological Measurement*, 60(6):821–836. 227

Cooper, A., Reimann, R., and Cronin, D. (2007). *About Face 3: The Essentials of Interaction Design*. Safari Books Online. Wiley Publishing. 78

Coopman, S. (2009). A critical examination of Blackboard's e-learning environment. *First Monday*, 14(6). 48

Couper, M. (2000). Web surveys: a review of issues and approaches. *Public Opinion Quarterly*, 64(4):464–494. 227

Cronk, B. C. (2004). *How to Use SPSS: A Step-by-Step Guide to Analysis and Interpretation*. Pyrczak Pub. 200

Da, S. (2010). Research on the design of online intelligent tutoring agents. In *Proceedings of the 2010 International Conference on Electrical and Control Engineering*, ICECE '10, pages 4755–4758, Washington, DC, USA. IEEE Computer Society. 27

Dabbagh, N. (2007). The online learner: Characteristics and pedagogical implications. *Contemporary Issues in Technology and Teacher Education*, 7(3):217–226. 22, 24

Dabbagh, N. and Kitsantas, A. (2004). Supporting self-regulation in student-centered web-based learning environments. *International Journal on E-Learning*, 3(1):40–47. 25, 72

Davies, J. and Graff, M. (2005). Performance in e-learning: online participation and student grades. *British Journal of Educational Technology*, 36(4):657–663. 26

Deubel, P. (2003). Learning from Reflections - Issues in Building Quality Online Courses. *Online Journal of Distance Learning Administration*, 6(3). Retrieved on October 16, 2012, from `http://www.westga.edu/~distance/ojdla/fall63/deubel63.html`. 35

Diaz, D. (2000). *Comparison of Student Characteristics, and Evaluation of Student Success, in an Online Health Education Course*. PhD thesis, Nova Southeastern University. 19

Dillman, D. A., Phelps, G., Tortora, R., Swift, K., Kohrell, J., Berck, J., and Messer, B. L. (2009). Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet. *Social Science Research*, 38(1):1–18. 227

Dirckinck-Holmfeld, L., Jones, C., and Lindström, B. (2009). *Analysing networked learning practices in higher education and continuing professional development*. Technology-enhanced learning. Sense. 16, 17

Dolan, K. (2008). Comparing modes of instruction: The relative efficacy of on-line and in-person teaching for student learning. In *PS: Political Science & Politics*, volume 41, pages 387–391. 19, 20

Donath, J., Dragulescu, A., Zinman, A., Viégas, F., and Xiong, R. (2010). Data portraits. In *SIGGRAPH '10: ACM SIGGRAPH 2010 Art Gallery*, pages 375–383, New York, NY, USA. ACM. 122

Dougiamas, M. (2000). Improving the effectiveness of tools for Internet based education. In Hermann, A. and Kulski, M., editors, *Flexible Futures in Tertiary Teaching. Proceedings of the 9th Annual Teaching Learning Forum*. 55

Dragulescu, A. C. (2009). *Data Portraits: Aesthetics and Algorithms*. PhD thesis, Massachusetts Institute of Technology. 124

Dringus, L. and Cohen, M. (2005). An adaptable usability heuristic checklist for online courses. In *Frontiers in Education, 2005. FIE '05. Proceedings 35th Annual Conference*, pages T2H–6–T2H–11. xxii, 81, 170, 178, 179

Dutton, J., Dutton, M., and Perry, J. (2001). Do online students perform as well as lecture students? *Journal of Engineering Education*, 90(1):131–136. 19

Dutton, J., Dutton, M., and Perry, J. (2002). How do online students differ from lecture students? *Journal of Asynchronous Learning Networks (JALN*, 6(1). 22, 24

Duval, E. (2011). Attention Please!: Learning Analytics for Visualization and Recommendation. In *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*, LAK '11, pages 9–17, New York, NY, USA. ACM. 102, 149

Ertmer, P. A. and Newby, T. J. (1993). Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective. *Performance Improvement Quarterly*, 6(4):50–72. 28, 29, 31

Fertalj, K., Jerković, H., and Hlupić, N. (2006). Comparison of e-Learning Management Systems. In *Proceedings of the 5th WSEAS International Conference on E-ACTIVITIES*, pages 189–194. 150

Firdiyiyek, Y. (1999). Web-based courseware tools: where is the pedagogy? *Educational Technology*, 39(1):20–34. 61

Friday, E., Friday-stroud, S. S., A, F., Green, A. L., and Hill, A. Y. (2006). A multi-semester comparison of student performance between multiple traditional and online sections of two management courses. *Behavioral and Applied Management*, 8(1):66–81. 19

Friesen, N. (2003). Three objections to learning objects and e-learning standards. In *Online Education Using Learning Objects*. Taylor & Francis Books Ltd, London. 44, 71

Fuentes, J. M., Álvaro Ramírez, García, A. I., and Ayuga, F. (2011). Use of Virtual Learning Environments (VLE) in Spanish Universities: Current State and Comparison of E-learning Tools. In *The 9th International Conference on Education and Information Systems, Technologies and Applications (EISTA'11)*. 150

Gabriel, M. A. (2004). Learning together: Exploring group interactions online. *Journal of Distance Education*, 19(1):54–72. 26

Gallin, J. and Ognibene, F. (2012). *Principles and Practice of Clinical Research*. Academic Press. Elsevier Science & Technology, third edition. 197

Galusha, J. (1997). Barriers to learning in distance education. *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century*, 5(3–4):6–14. Retrieved on March 26, 2012, from `http://www.infrastruction.com/barriers.htm`. 27, 35

Garrison, D. and Anderson, T. (2003). *E-learning in the 21st century: a framework for research and practice*. RoutledgeFalmer. 13

Garrison, D. R. (1985). Three generations of technological innovation in distance education. *Distance Education*, 6(2):235–241. 13

Ghauth, K. I. B. and Abdullah, N. A. (2011). The effect of incorporating good learners' ratings in e-learning content-based recommender system. *Educational Technology & Society*, 14(2):248–257. 76

Gilbert, S. (2000). *How to be a successful online student*. McGraw-Hill. 22, 94, 209, 210

Glasersfeld, E. (1996). *Radical constructivism: a way of knowing and learning*. Studies in mathematics education series. Routledge Falmer. 30

Govaerts, S., Verbert, K., Klerkx, J., and Duval, E. (2010). Visualizing activities for self-reflection and awareness. In Luo, X., Spaniol, M., Wang, L., Li, Q., Nejdl, W., and Zhang, W., editors, *Advances in Web-Based Learning - ICWL 2010*, volume 6483 of *Lecture Notes in Computer Science*, pages 91–100. Springer Berlin / Heidelberg. 75, 102, 149

Govindasamy, T. (2002). Successful implementation of e-learning pedagogical considerations. *Internet and Higher Education*, 4(3):287–299. 3, 60, 61

Gros, B., Lara, P., García, I., Mas, X., López, J., Maniega, D., and Martínez, T. (2009). The UOC's educational model: evolution and future perspectives. Technical report, Universitat Oberta de Catalunya (UOC), ISBN: 978-84-692-6036-4. 158

Grosse, C. U. (2004). How distance learning changes faculty. *International Journal of Instructional Technology and Distance Learning*, 1(6):25–34. 35

Guralnick, D. (2007). Designing effective e-learning user interfaces. In Isaías, P., Nunes, M. B., and Barroso, J., editors, *Proceedings of IADIS International conference on the WWW and the Internet*, pages 3–10. 45

Hara, N. and Kling, R. (2000). Students' distress with a web-based distance education course. *Information, Communication and Society*, 3(4):557–579. 27

Harasim, L. (1989). *On-line education: a new domain*, pages 50–62. Oxford, Pergamon Press. 14

Hardy, J., Bates, S., Hill, J., and Antonioletti, M. (2008). *Tracking and Visualisation of Student Use of Online Learning Materials in a Large Undergraduate Course*, volume 4823 of *Lecture Notes in Computer Science*, pages 464–474. Springer Berlin / Heidelberg. 305

Hayenga, A. O. and Corpus, J. H. (2010). Profiles of intrinsic and extrinsic motivations: A person-centered approach to motivation and achievement in middle school. *Motivation and Emotion*, 34:371–383. 25

Healey, J. (2011). *Statistics: A Tool for Social Research*. Wadsworth Cengage Learning, 9 edition. 190

Herrington, J., Reeves, T. C., and Oliver, R. (2005). Online learning as information delivery: Digital myopia. *Journal of Interactive Learning Research*, 16(4):353–367. 61

Heuer, B. P. and King, K. P. (2004). Leading the band: The role of the instructor in online learning for educators. *The Journal of Interactive Online Learning*, 3(1). 34, 35

Hijón, R. and Velázquez-Iturbide, J. A. (2006). E-learning Platforms Analysis and Development of Students Tracking Functionality. In Pearson, E. and Bohman, P., editors, *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006*, pages 2823–2828, Chesapeake, VA. AACE. 61, 304

Hijón-Neira, R. and Velázquez-Iturbide, J. A. (2008). How to Improve Assessment of Learning and Performance through Interactive Visualization. In *ICALT '08: Proceedings of the 2008 Eighth IEEE International Conference on Advanced Learning Technologies*, pages 472–476, Washington, DC, USA. IEEE Computer Society. 305

Hill, C. and Corbett, C. (2010). *Why so few? Women in Science, Technology, Engineering and Mathematics*. AAUW. 209, 227

Hillman, D. C., Willis, D. J., and Gunawardena, C. N. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *The American Journal of Distance Education*, 8(2):30–42. 21

Hoic-Bozic, N., Mornar, V., and Boticki, I. (2009). A Blended Learning Approach to Course Design and Implementation. *IEEE Transactions on Education*, 52(1):19 –30. 31

Horgen, S. A., Larsen, J., and Hjertø, G. (2005). Improving the Quality of Online Tests and Assessments. In *11th International Conference on Technology Supported Learning & Training*, pages 338–340. 17

Hung, J. L. and Zhang, K. (2008). Revealing Online Learning Behaviors and Activity Patterns and Making Predictions with Data Mining Techniques in Online Teaching. *Journal of Online Learning and Teaching*, 4(4):428–437. 306

Icke, I. and Sklar, E. (2008). A visualization tool for student assessments data. In *From Theory to Practice: Design, Vision and Visualization Workshop. IEEE VisWeek (2008)*. 122

ISO-9241 (1998). ISO-9241: Software ergonomics requirements for office work with visual display terminal (VDT). 174

Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education*, 38(12):1217–1218. 187

Jeffries, R., Miller, J. R., Wharton, C., and Uyeda, K. (1991). User interface evaluation in the real world: a comparison of four techniques. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Reaching through technology*, CHI '91, pages 119–124, New York, NY, USA. ACM. 164, 165

Johnson, S. D. and Aragon, S. R. (2003). An instructional strategy framework for online learning environments. *New Directions for Adult and Continuing Education*, 2003(100):31–43. 31

Jonassen, D. (1991). Objectivism versus Constructivism: Do We Need a New Philosophical Paradigm? *Educational Technology Research and Development*, 39:5–14. 10.1007/BF02296434. 30

Jonassen, D. (1992). Evaluating Constructivist Learning. In Duffy, T. and Jonassen, D., editors, *Constructivism and the Technology of Instruction*, pages 137–148. Lawrence Erlbaum Associates, Hillsdale, NJ. 30

Juan, A. A., Daradoumis, T., Faulin, J., and Xhafa, F. (2008). Developing an Information System for Monitoring Student's Activity in Online Collaborative Learning. In *CISIS '08: Proceedings of the 2008 International Conference on Complex, Intelligent and Software Intensive Systems*, pages 270–275, Washington, DC, USA. IEEE Computer Society. 305, 308

Kalat, J. W. (2001). *Introduction to psychology*. Psychology Series. Wadsworth-Thomson Learning. 29

Kanuka, H. and Anderson, T. (1999). Using Constructivism in Technology-Mediated Learning: Constructing Order out of the Chaos in the Literature. *International Journal of Radical Pedagogy*, 1(2):21–35. 30

Kearsley, G. (2002). Is online learning for everybody? *Educational Technology*, 42(1):41–44. 25, 26

Keegan, D. (1990). *Foundations of distance education.* Routledge, London ; New York, 2nd edition. 12, 15, 21

Keim, D. A., Müller, W., and Schumann, H. (2002). Visual data mining. In Fellner, D. and Scopigno, R., editors, *STAR Proceedings of Eurographics 2002*, pages 49–68. Eurographics Association. 307

Kennedy, D., Hyland, A., and Ryan, N. (2006). Writing and using learning outcomes: a practical guide (C 3.4-1). In Froment, E., Kohler, J., Purser, L., Wilson, L., Davies, H., and Schurings, G., editors, *EUA Bologna Handbook: Making Bologna Work*, EUA Bologna Handbook: Making Bologna Work. Raabe Academic Publishers. 74

Kerr, B. (2007). A Challenge to Connectivism. Conference speech. Transcript of Keynote Speech, Online Connectivism Conference. University of Manitboa. `http://ltc.umanitoba.ca/wiki/index.php?title=Kerr_Presentation`. 33

Khan, J. (2008). *Research Methodology.* APH Publishing Corporation. 190

Kolas, L. and Staupe, A. (2007). *A personalized E-learning Interface*, pages 2670–2675. IEEE Press. 62

Koren, J., Zhang, Y., and Liu, X. (2008). Personalized interactive faceted search. In *Proceeding of the 17th international conference on World Wide Web*, WWW '08, pages 477–486, New York, NY, USA. ACM. 119

Kosba, E., Dimitrova, V., and Boyle, R. D. (2005). Using Student and Group Models to Support Teachers in Web-Based Distance Education. In Ardissono, L., Brna, P., and Mitrovic, A., editors, *UM2005 User Modeling: Proceedings of the 10th International Conference*, pages 124–133, Edinburgh, Scotland. Springer Verlag. 306

Laanpere, M., Pata, K., Normak, P., and Põldoja, H. (2012). Pedagogy-Driven Design of Digital Learning Ecosystems: The Case Study of Dippler. In Popescu, E., Li, Q., Klamma, R., Leung, H., and Specht, M., editors, *Advances in Web-Based Learning - ICWL 2012*, volume 7558 of *Lecture Notes in Computer Science*, pages 307–317. Springer Berlin Heidelberg. 3, 44, 60

Laanpere, M., Poldoja, H., and Kikkas, K. (2004). The Second Thoughts about Pedagogical Neutrality of LMS. *Advanced Learning Technologies, IEEE International Conference on*, 0:807–809. 3, 44, 60, 63, 78

Lane, L. (2007). Course Management Systems and Pedagogy. Web. Retrieved on October, 31, 2011, from `http://lisahistory.net/pages/CMSandPedagogy.htm`. 48

Lane, L. M. (2008). Toolbox or Trap? Course Management Systems and Pedagogy. *EDUCAUSE Quarterly*, 31(2):4–6. 49, 63

Lao, T. and Gonzales, C. (2005). Understanding Online Learning Through a Qualitative Description of Profesors and Students' Experiences. *Journal of Technology and Teacher Education*, 13(3):459–474. 35

Larson, D. K. and Sung, C.-H. (2009). Comparing Student Performance: Online Versus Blended Versus Face-to-Face. *Journal of Asynchronous Learning Networks*, 13(1). 19

Lebrun, M. (2007). *Théories et méthodes pédagogiques pour enseigner et apprendre: Quelle place pour les TIC dans l'éducation?* Perspectives en éducation et formation. De Boeck Université, 2nd edition. 49, 50

Lehman, D. (1998). Barriers to distance education. Web. Retrieved on October 18, 2011, from `http://udel.edu/~dlehman/educ/barrier.html`. 35

Leroy, G. (2011). *Designing User Studies in Informatics*. Health Informatics. Springer. 196, 197

Lewis, B., MacEntee, V. M., DeLaCruz, S., Englander, C., Jeffrey, T., Takach, E., Wilson, S., and Woodall, J. (2005). Learning Management Systems Comparison. In *Proceedings of the 2005 Informing Science and IT Education Joint Conference*, pages 17–29. 150

Li, L., Finley, J., Pitts, J., and Guo, R. (2011). Which is a better choice for student-faculty interaction: synchronous or asynchronous communication? *Journal of Technology Research*, 2. 18

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 22(140):1–55. 186

Liu, H.-J. (2010). The Relation of Academic Self-Concept to Motivation among University EFL Students. *Journal of Humanities and Social Sciences*, 1(20):207–225. 26

Lladós, J. (2009). Quality assurance of e-learning. In *ENQA Workshop on quality assurance of e-Learning*. `http://www.enqa.eu/files/Sigtuna_JosepLlados_short.pdf`. 23, 157

Luchini, K., Bobrowsky, W., Curtis, M., Quintana, C., and Soloway, E. (2002a). Supporting learning in context: extending learner-centered design to the development of handheld educational software. In *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education*, pages 107 – 111. 68

Luchini, K., Quintana, C., and Soloway, E. (2002b). ArtemisExpress: A Case Study in Designing Handheld Interfaces for an Online Digital Library. In Paterno, F., editor, *Human Computer Interaction with Mobile Devices*, volume 2411 of *Lecture Notes in Computer Science*, pages 51–51. Springer Berlin / Heidelberg. 70

Maeroff, G. I. (2003). *A classroom of one: how online learning is changing our schools and college*. Palgrave Macmillan, New York, 1st edition. 16

Malikowski, S. (2005). Recommendations for Addressing Drop-Out in Online, Teacher Education Courses. In Crawford, C., Carlsen, R., Gibson, I., McFerrin, K., Price, J., Weber, R., and Willis, D. A., editors, *Proceedings of Society for Information Technology & Teacher Education International Conference 2005*, pages 501–505, Phoenix, AZ, USA. AACE. 19

Maor, D. (2003). The teacher's role in developing interaction and reflection in an online learning community. *Educational Media International*, 40(1/2):127–138. 33

Martens, R., Bastiaens, T., and Kirschner, P. A. (2007). New Learning Design in Distance Education: The impact on student perception and motivation. *Distance Education*, 28(1):81–93. 25

Mastoras, T., Fotaris, P., Politis, A., and Manitsaris, A. (2005). Establishing effective learning management systems through simplicity. In *Proceedings of the 5th WSEAS International Conference on Distance Learning and Web Engineering*, pages 111–115, Stevens Point, Wisconsin, USA. World Scientific and Engineering Academy and Society (WSEAS). xxi, 43, 45, 60, 150, 310

Matera, M., Costabile, M., Garzotto, F., and Paolini, P. (2002). SUE Inspection: An Effective Method for Systematic Usability Evaluation of Hypermedia. *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on*, 32(1):93–103. 164, 174

Mazza, R. and Dimitrova, V. (2003). Informing the design of a course data visualisator: an empirical study. In *5th International Conference on New Educational Environments (ICNEE 2003)*. 121

Mazza, R. and Dimitrova, V. (2004). Visualising Student Tracking Data to Support Instructors in Web-Based Distance Education. In *Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters*, WWW Alt. '04, pages 154–161, New York, NY, USA. ACM. 18, 35, 149, 304, 305, 308

Mazza, R. and Milani, C. (2004). GISMO: a Graphical Interactive Student Monitoring Tool for Course Management Systems. In *T.E.L.'04 Technology Enhanced Learning '04 International Conference. Milan*, pages 18–19. 305

McConachie, J., Danaher, P., Luck, J., and Jones, D. (2005). Central Queensland University's Course Management Systems: Accelerator or brake in engaging change? *International Review of Research in Open and Distance Learning*, 6(1):1–15. 37, 42

McInnis, C., James, R., and McNaught, C. (1995). First year on campus. A commissioned project of the Committee for the Advancement of University Teaching. Technical report, Canberra: Australian Government Publishing Service. 27

McPherson, M. and Nunes, M. B. (2004). The Role of Tutors as an Integral Part of Online Learning Support. In *Proceedings of the Third European Distance Education and E-Learning Network (EDEN) Research Workshop*. 34

Mehlenbacher, B. (2002). Assessing the Usability of Online Instructional Materials. In Anderson, R. S., Bauer, J. F., and Speck, B. W., editors, *Assessment strategies for the on-line class: From theory to practice*, number 91 in New Directions for Teaching and Learning Series, San Francisco, CA. Jossey-Bass. 177

Mehlenbacher, B., Bennett, L., Bird, T., Ivey, M., Lucas, J., Morton, J., and Whitman, L. (2005). Usable e-Learning: A Conceptual Model for Evaluation and Design. In *Proceedings of HCI International 2005: 11th International Conference on Human-Computer Interaction - Theories, Models, and Processes in HCI*, pages 1–10. xxii, 81, 170, 177

Merceron, A. and Yacef, K. (2008). Interestingness Measures for Associations Rules in Educational Data. In *Proceedings of Educational Data Mining (EDM'08)*, pages 57–66. 307

Moore, M. G. (1989). Three types of interaction. *American Journal of Distance Education*, 3(2):1–6. 21

Morphew, V. N. (2000). *Web-based learning and instruction: A constructivist approach*, pages 1–15. IGI Global. 31

Morville, P. and Rosenfeld, L. (2006). *Information architecture for the World Wide Web*. O'Reilly Web Studio Series. O'Reilly, 3rd edition. 44

Muijs, R. D. (1997). Predictors of academic achievement and academic self-concept: a longitudinal perspective. *British Journal of Educational Psychology*, 67(3):263–277. 26

Murray, B. (2001). What makes students stay?: concern over quitters has online programs stepping up retention strategies. *eLearn*, 2001. 19

Negash, S. and Vanderieft, J. (2008). Student Satisfaction: Face-to-Face with Online. In *Proceedings of the Southern Association for Information Systems (SAIS) Conference*. 20

Nicol, D. J. and Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2):199–218. 75

Nielsen, J. (1994a). Heuristic evaluation. In Nielsen, J. and Mack, R., editors, *Usability Inspection Methods*. John Wiley & Sons. xxi, 78, 79, 80, 81, 150, 165, 166, 169, 170, 172, 173, 178, 180

Nielsen, J. (1994b). *Usability Engineering*. Morgan Kaufmann Series in Interactive Technologies. Morgan Kaufmann Publishers Inc. 166

Nielsen, J. and Molich, R. (1990). Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people*, CHI '90, pages 249–256, New York, NY, USA. ACM. 166, 173

Nipper, S. (1989). Third generation distance learning and computer conferencing. In Mason, R. and Kaye, A. A., editors, *Mindweave: Communication, computers and distance education*, pages 63–73. Oxford: Pergamon. 13

Norman, D. (1988). *The design of everyday things (republished in 2002)*. Basic Books. xxi, 165, 166, 168, 170

Norman, D. A. and Draper, S. W. (1986). Cognitive engineering. In Norman, D. A. and Draper, S. W., editors, *User Centered System Design; New Perspectives on Human-Computer Interaction*, pages 31–62. L. Erlbaum Associates Inc., Hillsdale, NJ, USA. 68

Nulty, D. D. (2008). The adequacy of response rates to online and paper surveys: what can be done? *Assessment & Evaluation in Higher Education*, 33(3):301–314. 107, 227

Nunnally, J. (1978). *Psychometric theory*. McGraw-Hill Series in Psychology. McGraw-Hill. 187

Oates, B. J. (2006). *Researching Information Systems and Computing*. Sage Publications Ltd. 7, 184

Oblinger, D., Barone, C., and Hawkins, B. (2001). *Distributed Education and Its Challenges: An Overview*. Distributed education: challenges, choices, and a new environment. American Council on Education. 35

Ochoa, X. (2005). Learning Object Repositories are useful, but are they usable? In *Proceedings of IADIS International Conference Applied Computing*, pages 138–144. 18

OECD (2004). Learning for Tomorrow's World | First Results from PISA 2003. Technical report, Organisation for Economic Co-operation and Development (OECD). 27

Oppenheim, A. V., Willsky, A. S., and Nawab, S. H. (1996). *Signals & systems*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA, 2nd edition. 85

O'Quinn, L. and Corry, M. (2002). Factors that Deter Faculty from Participating in Distance Education. *Online Journal of Distance Learning Administration*, 5(4). 35

OU (2011). The OU's annual report 2010-2011. Technical report, The Open University. Retrieved on November 14, 2012, from `http://www.open.ac.uk/about/documents/about-annual-report-2011.pdf`. 3, 23

Palloff, R. and Pratt, K. (2000). Making the Transition: Helping Teachers to Teach Online. In *EDUCAUSE 2000: Thinking IT through. Proceedings and post-conference materials*. 36

Paulsen, M. F. (2003). *Online Education and Learning Management Systems: Global E-learning in a Scandinavian Perspective*. NKI Forlaget, NKI Forlaget. 15

Paulsen, M. F. (2007). *Megaproviders of e-learning in Europe*. NKI Publishing House. 3, 21, 156

Piaget, J. (1971). *Genetic epistemology*. Norton Library. W. W. Norton & Co. 30

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In Boekaerts, M., Pintrich, P. R., and Zeidner, M., editors, *Handbook of self-regulation*, pages 451–502. Academic Press, San Diego, CA. 25

Pirrone, R., Cannella, V., and Russo, G. (2009). A map-based visualization tool to support tutors in e-learning 2.0. In *HSI'09: Proceedings of the 2nd conference on Human System Interactions*, pages 482–487, Piscataway, NJ, USA. IEEE Press. 308

Powell, R., Symbaluk, D., and Honey, P. (2008). *Introduction to Learning and Behavior*. Wadsworth Cengage Learning. 195

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5). October 2001. 24

Puzziferro, M. (2008). Online Technologies Self-Efficacy and Self-Regulated Learning as Predictors of Final Grade and Satisfaction in College-Level Online Courses. *American Journal of Distance Education*, 22(2):72–89. 25

Quinn, C. N. (1996). Pragmatic Evaluation: Lessons from Usability. In Christie, A., James, P., and Vaughan, B., editors, *Proceedings of 13th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education*, pages 437–446. Australasian Society for Computers in Learning in Tertiary Education. xxi, 68, 81, 170, 171

Quintana, C., Krajcik, J., and Soloway, E. (2000). Exploring a Structured Definition for Learner-Centered Design. In Fishman, B. and O'Connor-Divelbiss, S., editors, *Fourth International Conference of the Learning Sciences*, pages 256–263, Mahwah, NJ, Erlbaum. 68, 69

Quintana, C., Krajcik, J., Soloway, E., and Norris, C. (2003). A framework for understanding the development of educational software. In Jacko, J. A. and Sears, A., editors, *The human-computer interaction handbook*, pages 823–834. L. Erlbaum Associates Inc., Hillsdale, NJ, USA. 70

Quintana, C., Soloway, E., and Norris, C. (2001). Learner-Centered Design: Developing Software That Scaffolds Learning. *IEEE International Conference on Advanced Learning Technologies*, pages 499–500. 68, 69

Reeves, T. C., Benson, L., Elliott, D., Grant, M., Holschuh, D., Kim, B., Kim, H., Lauber, E., and Loh, S. (2002). Usability and Instructional Design Heuristics for E-Learning Evaluation. In Barker, P. and Rebelsky, S., editors, *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2002*, pages 1615–1621, Denver, Colorado, USA. AACE. xxi, 68, 78, 81, 170, 173, 178

Rice, W. (2006). *Moodle E-Learning Course Development: A complete guide to successful learning using Moodle*. Packt Publishing. 44

Roach, V. and Lemasters, L. (2006). Satisfaction with Online Learning: A Comparative Descriptive Study. *Journal of Interactive Online Learning*, 5(3). 20

Robertson, J. (2012). Likert-type Scales, Statistical Methods, and Effect Sizes. *Commununications of the ACM*, 55(5):6–7. 187

Romero, C. and Ventura, S. (2007). Educational data mining: A survey from 1995 to 2005. *Expert Systems with Applications*, 33(1):135–146. 306

Ryan, R. M. and Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1):68–78. 25

Salomon, P. C. (1992). The changing role of the teacher: From information transmitter to orchestrator of learning. In Oser, F. K., Dick, A., and Petry, J., editors, *Effective and responsible teaching: The new synthesis*, pages 35–49. Jossey-Bass, San Francisco, CA. 34

Schlechty, P. (1991). *Schools for the 21st Century: Leadership Imperatives for Educational Reform*. Jossey-Bass education series. Jossey-Bass Publishers. 61

Schmidt, R. C. (1997). Managing Delphi Surveys Using Nonparametric Statistical Techniques. *Decision Sciences*, 28(3):763–774. 198

Schunk, D. H. (2011). *Learning Theories: An Educational Perspective*. Addison Wesley, 6th edition. 28, 30

Scott, B. and Neil, T. (2009). *Designing Web Interfaces*. O'Reilly Media. 78, 79

Sellani, R. J. and Harrington, W. (2002). Addressing administrator/faculty conflict in an academic online environment. *The Internet and Higher Education*, 5(2):131 – 145. 35

Seufert, S., Lechner, U., and Stanoevska, K. (2002). A Reference Model for Online Learning Communities. *International Journal on E-Learning*, 1(1):43–54. 2

Sheely, S. (2006). Persistent technologies: Why can't we stop lecturing online? In *Proceedings of the 23rd annual ascilite conference: Who's learning? Whose technology?*, pages 769–774. 3

Shneiderman, B. (1987). *Designing the user interface: strategies for effective human-computer interaction*. Addison-Wesley. xxi, 165, 166, 167, 170

Siemens, G. (2005). Connectivism: A learning theory for the digital age. In *International Journal of Instructional Technology and Distance Learning*. 33

Skinner, B. (1938). *The Behavior of Organisms: An Experimental Analysis*. The Century Psychology Series. Appleton-Century-Crofts. 28

Smith-Gratto, K. (1999). Best practices and problems North Carolina A & T State University. *Distance Education Evaluation Task Force Distance Education*. Retrieved on December 3, 2011 from `http://qed.ncat.edu/ir&p/report.htm`. 19

Snyder, L. (2010). *Fluency With Information Technology: Skills, Concepts, & Capabilities*. Pearson Education Canada, 4th edition. 44

Soloway, E., Guzdial, M., and Hay, K. E. (1994). Learner-Centered Design: The Challenge for HCI in the 21st Century. *interactions*, 1(2):36–48. 69

Soloway, E., Jackson, S. L., Klein, J., Quintana, C., Reed, J., Spitulnik, J., Stratford, S. J., Studer, S., Eng, J., and Scala, N. (1996). Learning Theory in Practice: Case Studies of Learner-Centered Design. In *Proceedings of the SIGCHI conference on Human factors in computing systems: common ground*, CHI '96, pages 189–196, New York, NY, USA. ACM. 68

Soonthornphisaj, N., Rojsattarat, E., and Yim-ngam, S. (2006). Smart E-Learning Using Recommender System. In Huang, D.-S., Li, K., and Irwin, G., editors, *Computational Intelligence*, volume 4114 of *Lecture Notes in Computer Science*, pages 518–523. Springer Berlin / Heidelberg. 76

Spector, M. J. (2005). Time Demands in Online Instruction. *Distance Education*, 26(1):5 – 27. 35

Squires, D. and Preece, J. (1999). Predicting quality in educational software: Evaluating for learning, usability and the synergy between them. *Interacting with Computers*, 11(5):467–483. xxi, 68, 77, 78, 81, 170, 172

Srivastava, S. C., Chandra, S., and Lam, H. M. (2009). Usability Evaluation of E-Learning Systems. In *Encyclopedia of Information Science and Technology, Second Edition*. IGI Global. 69

Ssemugabi, S. and de Villiers, R. (2007). A Comparative Study of Two Usability Evaluation Methods Using a Web-Based E-Learning Application. In *Proceedings of the 2007 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries*, SAICSIT '07, pages 132–142, New York, NY, USA. ACM. xxii, 78, 81, 166, 170, 180, 181

Stefaner, M. and Muller, B. (2007). Elastic lists for facet browsers. In *18th International Workshop on Database and Expert Systems Applications, 2007. DEXA '07*, pages 217–221. 103

Steffens, K. (2006). Self-Regulated Learning in Technology-Enhanced Learning Environments: lessons of a European peer review. *European Journal of Education*, 41(3–4):353–379. 25

Stevens, S. (1946). On the Theory of Scales of Measurement. *Science, New Series*, 103(2684):677–680. `http://www.mpopa.ro/statistica_licenta/Stevens_Measurement.pdf`. 184

Swan, K. (2002). Building learning communities in online courses: The importance of interaction. *Education, Communication & Leadership*, 2(1):23–49. 26

Taylor, J. C. (2001). Fifth generation distance education. *e-Journal of Instructional Science and Technology (e-JIST)*, 4(1):1–14. 14

Taylor, J. C. (2002). Teaching and Learning Online: The Workers, The Lurkers and The Shirkers. In *Keynote address presented at the 2nd Conference on Research in Distance & Adult Learning in Asia: CRIDALA 2002*. 26, 125

Thompson, M. M. (1998). Distance learners in higher education. In Gibson, C., editor, *Distance learners in higher education: Institutional Responses for Quality Outcomes*, pages 9–24. Madison, WI: Atwood. 24

Thorndike, E. L. (1898). Animal Intelligence: An Experimental Study of the Associate Processes in Animals. *Psychological Review, Monograph Supplement*, 2(4):1–8. 28

Triacca, L., Bolchini, D., Botturi, L., and Inversini, A. (2004). MiLE: Systematic Usability Evaluation for E-learning Web Applications. In Cantoni, L. and McLoughlin, C., editors, *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004*, pages 4398–4405, Lugano, Switzerland. AACE. 164

Tselios, N., Avouris, N., Dimitracopoulou, A., and Daskalaki, S. (2001). Evaluation of Distance-learning Environments: Impact of Usability on Student Performance. *Journal of Educational Telecommunications*, 7(4):355–378. 45

Tu, C.-H. (2000). Critical examination of factors affecting interaction on CMC. *Journal of Network and Computer Applications*, 23:39–58. 18, 75

UAb (2011). UAb in figures. Technical report, Universidade Aberta. Retrieved on November 14, 2012, from `http://www.uab.pt/web/guest/uab/uab-em-numeros`. 3

UAb (2012). Factos & Números 2011-2012. Technical report, Universidade Aberta. Retrieved on November 16, 2012, from `http://www.uab.pt/web/guest/uab/uab-em-numeros/dados-estatisticos-2011-2012`. 23

Ullrich, C., Shen, R., and Gillet, D. (2010). Not Yet Ready for Everyone: An Experience Report about a Personal Learning Environment for Language Learning. In *Advances in Web-Based Learning ICWL 2010*, volume 6483, pages 269–278. Springer Berlin / Heidelberg. 37

Underhill, A. F. (2006). Theories of Learning and Their Implications for On-Line Assessment. *Online Submission*, 7(1):10–174+. 31

UNED (2011). UNED's annual reports. Technical report, Universidad Nacional de Educación a Distancia. Retrieved on November 14, 2012, from `http://portal.uned.es/portal/page?_pageid=93,25170900,93_25170901&_dad=portal&_schema=PORTAL`. 3

UOC (2011). Summary of the UOC's annual report, academic year 2010-2011. Technical report, Universitat Oberta de Catalunya. Retrieved on May 13, 2012, from `http://www.uoc.edu/portal/_resources/EN/documents/memories/1011/uoc-sintesi-curs10-11-en.pdf`. 3, 6, 23, 156, 157

Ury, G., McDonald, M., McDonald, G., and Dorn, B. (2006). Student Performance Online vs Onground: A Statistical Analysis of IS Courses. *Information Systems Education Journal*, 4(98). 19

Utts, J. and Heckard, R. (2011). *Mind on Statistics*. Available Titles Aplia Series. Cengage Learning, 4th edition. 196, 197

UWG (2010). LMS Usability Evaluation Report. Technical report, Tufts University. LMS Usability Working Group. 62, 63, 165

van Biljon, J. and Renaud, K. (2009). Distance Education as enabler in crossing the digital divide: will the Phoenix fly? In *The Proceedings of IDIA2009 Development Informatics Conference*. 37, 42

Viégas, F. B. (2004). Newsgroup crowds and authorlines: Visualizing the activity of individuals in conversational cyberspaces. In *Proceedings of the 37th Hawaii International Conference on System Sciences, IEEE*. 122

Vivoda, M. (2005). Distance learning. *RDH*, 25(8):71–73. 16

Vovides, Y., Sanchez-Alonso, S., Mitropoulou, V., and Nickmans, G. (2007). The use of e-learning Course Management Systems to support learning strategies and to improve self-regulated learning. *Educational Research Review*, 2:64–74. 35, 63

Vrasidas, C. (2004). Issues of Pedagogy and Design in e-learning Systems. In *Proceedings of the 2004 ACM symposium on Applied computing*, SAC '04, pages 911–915, New York, NY, USA. ACM. 31, 35, 63

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press. 30, 75

Wallace, R. M. (1999). Learners as Users, Users as Learners: What's the Difference? In *Annual meeting of the Human Computer Interaction Consortium (HCIC 99)*. 69

Wang, S.-C. (2009). University Instructor Perceptions of the Benefits of Technology Use in E-learning. In *Proceedings of the 2009 Second International Conference on Computer and Electrical Engineering - Volume 01*, ICCEE '09, pages 580–585, Washington, DC, USA. IEEE Computer Society. 18

Warschauer, M. (1997). Computer-Mediated Collaborative Learning: Theory and Practice. *The Modern Language Journal*, 81(4):470–481. 17

Watson, W. R. and Watson, S. L. (2007). An Argument for Clarity: What are Learning Management Systems, What are They Not, and What Should They Become? *TechTrends*, 51(2):28–34. 25, 61

West, R., Waddoups, G., and Graham, C. (2007). Understanding the experiences of instructors as they adopt a course management system. *Educational Technology Research and Development*, 55(1):1–26. 10.1007/s11423-006-9018-1. 35, 48, 63

Wigfield, A. and Karpathian, M. (1991). Who Am I and What Can I Do? Children's Self-Concepts and Motivation in Achievement Situations. *Educational Psychologist*, 26(3-4):233–261. 26

Xiong, R. and Donath, J. (1999). PeopleGarden: Creating Data Portraits for Users. In *UIST '99: Proceedings of the 12th annual ACM symposium on User interface software and technology*, pages 37–44, New York, NY, USA. ACM. 122

Yee, K.-P., Swearingen, K., Li, K., and Hearst, M. (2003). Faceted Metadata for Image Search and Browsing. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, CHI '03, pages 401–408, New York, NY, USA. ACM. 119

Yukselturk, E. (2010). An Investigation of Factors Affecting Student Participation Level in an Online Discussion Forum. *The Turkish Online Journal of Educational Technology (TOJET)*, 9(2):24–32. 17, 75

Yukselturk, E. and Bulut, S. (2007). Predictors for Student Success in an Online Course. *Educational Technology & Society*, 10(2):71–83. 75

Zardas, G. (2008). The Importance of Integrating Learning Theories and Pedagogical Principles in AHES (Adaptive Hypermedia Educational Systems). In *Proceedings of the 2008 Eighth IEEE International Conference on Advanced Learning Technologies*, pages 884–885, Washington, DC, USA. IEEE Computer Society. 44

Zhang, H., Almeroth, K., Knight, A., Bulger, M., and Mayer, R. (2007). Moodog: Tracking Students' Online Learning Activities. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007*, pages 4415–4422. 305, 308

Zhao, W., Chellappa, R., Phillips, P. J., and Rosenfeld, A. (2003). Face Recognition: A Literature Survey. *ACM Comput. Surv.*, 35:399–458. 121

Zimmerman, B. J. (1986). Development of self-regulated learning: Which are the key subprocesses? *Contemporary Educational Psychology*, 16:307–313. 72

Zimmerman, B. J. (1990). Self-Regulated Learning and Academic Achievement: An Overview. *Educational Psychologist*, 25(1):3–17. 72

Zimmerman, B. J. (2002). Becoming a Self-Regulated Learner: An Overview. *Theory into practice*. 72, 73

Zorrilla, M., García, D., and Álvarez, E. (2010). A Decision Support System to improve e-Learning Environments. In *Proceedings of the 2010 EDBT/ICDT Workshops*, EDBT '10, pages 11:1–11:8, New York, NY, USA. ACM. 306, 308