

# **An Introductory Course on Human-Computer Interaction: Program, Bibliography, Practical Classes and Assignments**

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**Abstract** – As Computer curricula have developed, Human-Computer Interaction has gradually become part of many of those curricula and the recent ACM/IEEE report on the core of Computing Science and Engineering, includes Human-Computer Interaction as one of the fundamental sub-areas that should be addressed by any such curricula. However, both technology and Human-Computer Interaction are evolving rapidly, thus a continuous effort is needed to maintain a program, bibliography and a set of practical assignments up to date and adapted to the current technology. This paper briefly presents an introductory course on Human-Computer Interaction offered to Electrical and Computer Engineering students at the University of Aveiro.

## **1. Introduction**

The industry of computer systems is reaching maturity. Currently, average users are not technologically savvy; therefore those systems have to be designed taking into consideration the needs, capacities and limitations of their target users; i.e. in this phase of the industry a human centred development cycle is required [Norman99] and the problem of the user interface has become increasingly important.

On the other hand, a lesson learned repeatedly by engineering disciplines is that design problems have a context and, that the overly narrow optimisation of one part of a design can be rendered invalid by the broader context of the problem. Thus, even from a direct computer science perspective, it is advantageous to frame the problem of human-computer interaction broadly enough so as to help students (and practitioners) avoid the classic pitfall of design divorced from the context of the problem [ACM/SIGCHI96]. Moreover, the design of many modern computer applications inescapably requires the design of some component of the system that interacts with a user [Sommerville01]. This component typically represents more than half a system's lines of code. It is intrinsically necessary to understand how to decide on the functionality a system will have, how to bring this out to the user, how to build the system and how to test the design.

The above mentioned reasons were recently acknowledge by several authors [Hu03] [Evans03] [McGettrick03]; moreover, the reports concerning Computer Science and Engineering Curricula [ACM/IEEE01] [ACM/IEEE03] recognize that these curricula should reflect the ever growing importance of the human-computer interface. Taking into consideration all this, an introductory course on Human-Computer Interaction is offered at the University of Aveiro. This course was created in 1993/94 and has been offered to students of two different degrees, one in the area of Electrical Engineering and another in the area of Computer Engineering. In the former this course is offered as an elective in the 5<sup>th</sup> year and in the latter it is mandatory in the 3<sup>rd</sup> year [Sousa Santos03]. For some years it was also offered to MSc students as an elective course.

The course is introductory and does not intended to train the students as human-computer interaction engineers, but to expose them to the basic concepts of the field. The main specific objectives are:

- 1- to emphasize the importance of good user interface design;

- 2- to introduce the literature of Human-Computer Interaction;
- 3- to introduce tools, techniques and ideas for user interface design, implementation and evaluation;
- 4- to facilitate communication between human-computer interaction experts and the soon-to-be engineers.

In addition to these specific objectives, this course also intends to foster important general capacities such as critical thinking, team work and communication skills.

Several books are used as main bibliography [Dix98][Meyhew92,99]. For each topic one book is used as main reference according to its approach; however, other references (books, papers, web sites) are also used.

This paper briefly describes the course contents and presents a commented bibliography as well as the practical classes and practical assignments.

## 2. Course contents

Human-Computer Interaction is a rapidly evolving discipline, which implies that courses in this area must be carefully put together so that its concepts are not quickly out of date. This is particularly important since, although the content of a course can be revised, people cannot generally be recalled for retraining; they must build their own future understanding upon the foundations provided by the courses taken when they were students.

According to the ACM/SIGCHI report- *Curricula for Human-Computer Interaction* [ACM/SIGCHI96]: “Human-Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and the study of major problems surrounding them”. It thus has science, engineering, and design aspects. These topics can be classified in two main areas:

- Foundations of Human-Computer interaction;
- Design, implementation and evaluation of user interfaces.

Below all the topics are presented according to this classification. The sequence in which they are introduced has slightly changed along the years due to several reasons (e.g. adjustment to practical classes).

- Foundations of Human-Computer Interaction:
  - Introduction to the problem: introduction to Human-Computer Interaction, definition of user interface, general usability principles and paradigms;
  - User profile: Human Information Processing System, other relevant characteristics;
  - Conceptual models: conceptual and mental models;
  - Input/output devices: existing devices and usability issues.
- Design, implementation and evaluation of user interfaces:
  - Dialog styles: a classification, some experimental results, characteristics and applicability of each dialog style, principles and guidelines to its use;
  - Screen layout and colour: principles and guidelines; main colour models;
  - Evaluation methods: analytic methods and methods that involve users, their characteristics and how to choose them;

- Response time: general observations and guidelines;
- Help and documentation: ideal characteristics and guidelines to their preparation.
- User centred design of user interfaces: overview of a methodology; phases of the lifecycle of interactive software and Usability Engineering.

These topics have been addressed along approximately 26 hours in 2h lectures; next the specific topics dealt with in each lecture, in the sequence used in the academic year of 2004/2005, are presented. Evaluation and design methodology are for the most part tackled in practical classes; however an overview is given in a lecture.

1<sup>st</sup> lecture: - Objectives, syllabus, advised reading and evaluation method for the course (0.5h).

- Introduction to the problem of user interfaces in interactive systems (1.5h):
  - Historical perspective;
  - Ergonomics and Human Factors;
  - Importance and scope of Human-Computer Interaction;
  - Usability and Usability Engineering;
  - Two complementary approaches to user interface design: principles and paradigms.

2<sup>nd</sup> lecture: - Usability principles and paradigms (2h):

- Principles: compatibility, consistency, feedback, familiarity, simplicity, flexibility, robustness, protection, etc.
- Main usability objectives: ease of learning, ease of use and satisfaction.
- Paradigms: timesharing, personal computing, WIMP (Windows, Icons, Menus and Pointing devices), metaphors, direct manipulation, hypertext, multimodality, CSCW (Computer-Supported Cooperative Work), WWW (World Wide Web), and ubiquitous computing.

3<sup>rd</sup> and 4<sup>th</sup> lectures: - The user (4h):

- Importance of knowing the user profile;
- Characteristics determining user performance (internal and external);
- Introduction to the Human Information Processing System (HIPS): main characteristics and implications in user interface design of each sub-system:
  - perceptual (sensory buffer and pattern recognition);
  - cognitive (memories and processes);
  - motor (Fitts law);
- Other characteristics: (psychological and physical, task, knowledge and experience), and their implication in users interface design;
- Mental and conceptual models:
  - what are mental models, some characteristics and why people use them;
  - what are conceptual models; guidelines to their design.

5<sup>th</sup> and 6<sup>th</sup> lectures: - Input/Output devices (4h):

- Keyboards: existing types, main characteristics and usability issues;
- Pointing devices: existing types (mouse, track-ball, joy-stick, touch- screen, etc.), introduction to technology and usability issues;

- Other input devices (eye-trackers, data-gloves, other 3D devices);
- Display devices: existing types (CRT based, LCD, plasma and others), introduction to their technology;
- Voice interaction: main usability issues and applicability; guidelines for the use of voice recognition and synthesis.

7<sup>th</sup> and 8<sup>th</sup> lectures: - Dialog styles (4h):

- A classification;
- Menus: characteristics and existing types; applicability; some studies; main guidelines;
- Direct manipulation, fill-in-forms, question-and-answer, function-keys, command languages and natural language: characteristics, applicability and main guidelines.

9<sup>th</sup> lecture: - Screen layout (0,5h) and colour (1,5h).

- Screen layout:
  - main characteristics that influence user performance;
  - main guidelines and some examples;
- Colour:
  - importance and pitfalls of colour in user interfaces;
  - main guidelines and some examples;
  - importance of colour quantification and introduction to colour models (RGB, CMY, HSV, HLS).

10<sup>th</sup> and 11<sup>th</sup> lectures: - Models to be used in user interface design process (4h):

- User models:
  - importance, main types of user models and their applicability;
  - cognitive models (GOMS- *Goals, Objectives, Selections and Methods*);
  - Physical models (KLM- *Keystroke Level Model*);
- Task analysis:
  - importance and main types of techniques;
  - HTA- *Hierarchical Task Analysis*;
  - main information sources;
  - using task analysis in user interface design;
- Dialog notation:
  - importance and main types;
  - diagrammatic and textual notations: advantages and disadvantages;
  - main graphical notations (*State Transition Networks, Petri Nets, State Charts*), some simple examples.

12<sup>th</sup> lecture: Evaluation of user interfaces (2h):

- Importance of evaluation and when to use it;
- Evaluation styles;
- Evaluation methods:
  - analytic methods (Cognitive Walkthrough, Heuristic Evaluation, review based methods and model based methods);

- methods involving users (controlled experiments, observation methods, query methods): characteristics, advantages and disadvantages;
- how to select evaluation methods.

13<sup>th</sup> lecture: Response Time (0.5h), help and documentation (0.5h), user centred design (1h):

- Response time:
  - general observations;
  - main guidelines and examples;
- Help and documentation:
  - importance and existing types;
  - ideal characteristics;
  - examples;
- User centred design:
  - overview of a methodology;
  - phases of interactive software lifecycle.

### 3. Bibliography

A good bibliography is fundamental to support students in their individual learning effort, thus a reading list is provided for every topic in the program. This reading list contains book chapters that every student should read (shown in Table 1), as well as some advanced reading, book chapters, papers or web sites, provided for more interested students.

Table 1. Advised readings per lecture and topic

Lectures	Topics	Basic readings	Complementary readings
1	Introduction to the problem	Dix98-cap1 Mayhew92-cap1	Blinn05; Preece94 Schneiderman98
2	Usability principles and paradigms	Dix98-cap4	Cerf97
3,4	The user: Human Information Processing System; Mental models	Mayhew92-cap2,3	Newman95
5,6	Input/output devices	Hearn04-cap2 Mayhew92-cap12	Schneiderman98 Neumann04
7,8	Dialog styles	Mayhew92-cap4-10	Schneiderman98
9	Screen layout and colour usage; Colour models	Mayhew92-cap14 Hearn04-cap12	Schneiderman98 Tufte90
10,11	Models in user interface design process	Dix98-cap6-8	Harrocks99
12	Evaluation of user interfaces	Dix98-cap11	Nielsen93; Preece94
13	Response time; Help and documentation; User centred design	Mayhew92-cap15 Dix,98-cap12 Mayhew99-cap1	Schneiderman98

The book by Alan Dix et al. [Dix98] has been used as a text book; it is, according to its authors, meant to students in the areas of computer science and engineering. In spite of the fact that the author of this paper considers this book has a general approach adequate to her students, she feels the need to use other books. This

is due to two reasons: on one hand, [Dix98] tackles some issues at such a high abstraction level that some more specific examples are needed; on the other hand, some topics important to the general understanding of the problems addressed in the course are not addressed in enough detail. Therefore, students are advised to read about the Human Information Processing System and mental models on [Mayhew92], since it addresses these subjects using a more detailed and explicit approach. The same book is also used for the study of response time, which is not addressed as an independent subject in [Dix98]. The author also has used the book by Mayhew as a guide to address dialog styles, and screen design since it presents a lot more examples and guidelines than [Dix98]. On the subject of guidelines, a word of caution is due; notwithstanding guidelines help understand the principles and concepts and thus they should be used, unlike general principles, they become obsolete as technology evolves; thus, their use needs a frequent update. Another book by Mayhew [Mayhew99] is used because it presents in a structured and easy to understand manner a methodology to implement the usability software lifecycle, which is a good example of how the concepts introduced along the course can be used in a user-centred design of an interactive product. The book [Hearn04], which is an up dated Computer Graphics text book, is used to support the study of input and output devices.

The new (3<sup>rd</sup>) edition of the book by Alan Dix et al. [Dix04] includes additional examples, supplementary material on subjects that were already addressed in the 2<sup>nd</sup> edition and tackles new issues; thus it may be used to support some more topics addressed throughout the course.

Besides the above mentioned bibliographic references that have been used along the years, some other books, papers and Web sites are used (changing often) in order to present a few novel developments, discuss currently important issues or illustrate concepts in a different or more up to dated way. In 2004/2005 the following papers were given to the students as optional reading supporting subjects that were introduced in the lectures:

- a chapter from a book (published by ACM in its 50th anniversary) about ubiquitous computing, which includes a scenario of its possible use in everyday life [Cerf97];
- a paper by Jim Blinn, from *IEEE-Computer Graphics and Applications*, criticising and joking about poor user interfaces at gymnasium facilities [Blinn05].
- a paper from *IEEE-Spectrum* presenting two three-dimensional displays [Sullivan04];
- a set of papers from *ACM-Communications* concerning the problems of electronic voting [Neumann,04], an important contemporary problem where user interfaces are critical;

Bellow, the commented bibliography including all the books that have been used in this course is presented divided into three different categories: basic, complementary and opinion bibliography. The first three books in the first category can be considered textbooks in Human-Computer Interaction, albeit they have different approaches and target audiences. The following three books address mainly user interface design, and the last five books have been used to support a few specific issues. All the chapters recommended as mandatory reading belong to books in this category. The complementary bibliography includes six books (having a narrower scope) that tackle some issues in detail and which can be useful to extract examples for the lectures and practical classes or to support assignments of more advanced students. Moreover, this category comprises three other books: a Handbook indispensable to the researcher, a classic reference in Visualization and a book that presents various approaches to Human-Computer Interaction based on several different scientific areas (as cognitive psychology and sociology), which helps to understand the truly interdisciplinary nature of this

scientific area. The last category includes books by well know authors that convey personal and critical views about technology and interactive products that it has been producing, speculate on future developments and point out new ways to adapt technology and its products to the users' needs and capabilities. Reading at least some of these books is essential to anyone lecturing in this area.

### 3.1. Basic bibliography

- Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, *Human-Computer Interaction*, 1st, 2nd, 3rd edition, Prentice Hall, 1993, 1998, 2004

The first edition of this book was one of the first text books in the area; it was used to support courses that had been appearing at Universities, and simultaneously it helped to “crystallize” the content of the field that was still spread throughout the literature. Human-Computer Interaction is approached from a Computer Science perspective. This book addresses the main subjects in the area; however the emphasis is on design methods of interactive systems.

The following editions have been extensively revised and rewritten. The 3<sup>rd</sup> edition includes much new material and is organised in parts covering basic material suitable for introductory courses, including a new chapter on interaction design, and more advanced material focused on different HCI models and theories, suited for more advanced courses, as well as researchers new to the field. Detailed coverage of the particular domains such as web applications, ubiquitous computing and Computer Supported Collaborative Work (CSCW) is also given.

- Jenny Preece, Yvonne Rogers, Helen Sharp, D. Benyon, S. Holland, T. Carey, *Human-Computer Interaction*, Addison Wesley, 1994

This book covers the major subjects in Human-Computer Interaction, using concepts from Computer Science, Psychology, Sociology and industrial design. It introduces the main issues in user interface design and development and addresses applications as CSCW, hyper- and multimedia. According to its authors, this book is meant to students in the areas of Computer Science, Psychology and Sociology.

- Ben Shneiderman, *Designing the User Interface- Strategies for Effective Human-Computer Interaction*, 3rd ed., Addison Wesley, 1998

This book gives an overview of the issues central to designing, implementing, managing, maintaining and refining the user interface of interactive systems. It is meant primarily, to designers and managers but also to researchers, mainly in the study of user performance, having different backgrounds. Moreover, it is useful to the educator. According the author, the quality of user interfaces has improved greatly in the last years, and this book is meant to help researchers as well as designers keep up the momentum and encourage further progress.

- Deborah Mayhew, *Principles and Guidelines in Software User Interface Design*, Prentice Hall, 1992

This book presents principles and guidelines for all aspects of user interface design, including conceptual models, dialog styles, screen layout, user documentation and response time. It also presents a literature review concerning each subject. According to its author, it is aimed at practitioners as well as Computer Science students; nevertheless it is still useful, it should be used with caution since in various subjects it is already dated.

- William M. Newman, Michael G. Lamming, *Interactive System Design*, Addison Wesley, 1995

This book presents a set of methods fundamental to the design of interactive systems. Its authors intend to provide a framework that allows integrating methods specific to interactive systems with more general methods. The addressed issues are: methods to study the user, systems analysis, requirement specification, prototyping, as well as methods for the design and evaluation of user interfaces. Moreover, this book comprises a set of case studies very useful to the educator. Its authors consider this book adequate to students as well as practitioners.

- Jenny Preece, Yvonne Rogers, Helen Sharp, *Interaction Design- Beyond Human-Computer Interaction*, John Wiley, 2002

Interaction design is approached in a more comprehensive way than what has been usual in Human-Computer Interaction. According to its authors, interaction design currently transcends the design of interaction systems meant to be used by a user set in front of a computer; thus, subjects as ubiquitous computing using wireless and cooperative technologies are addressed. Moreover, the book presents a lot of examples and is meant to be used by practitioners and students as well.

- David Redmond-Pyle, Alan Moore, *Graphical User Interface Design and Evaluation - a Practical Process*, Prentice Hall, 1995

This book introduces a set of techniques, described as a flexible, practical process for user interface design. It was written by developers for developers (software designers, analysts, programmers and managers); however it is simple and allows non-experts to develop usable software products and it can also be useful to educators since it presents the resolution of an example throughout the complete process.

- Jakob Nielsen, *Usability Engineering*, Morgan Kaufmann, 1993

This is an essential reference in the area of Usability Engineering. It introduces, in a simple way adequate to non-experts, methods to improve usability as well as evaluation methods, which can be used even with very low budgets. This book is indispensable to the educator and its reading is strongly advised to practitioners.

- Deborah Mayhew, *The Usability Engineering Lifecycle - a Practitioner's Handbook for User Interface Design*, Morgan Kaufmann, 1999

This book presents a structured approach to the User Interface design as an interactive software lifecycle. The proposed lifecycle encompasses a set of Usability Engineering tasks used in a pre-determined order during the development of a product. This approach may be used in the development of any interactive product, not only in the project of user interfaces for mainstream software. This is a pragmatic book meant for practitioners, according to its author; however it can be useful to the educator as a source of examples or as an illustration of a specific interactive software development methodology.

- James Foley, Adries van Dam, S. Feiner, John Hughes, Richard Phillips, *Introduction to Computer Graphics*, Addison Wesley, 1993

This is an adaptation of a larger text that has been considered as a reference in Computer Graphics. This smaller version is meant to be used in introductory courses; however it is useful for practitioners who need to learn basic principles. It includes chapters on input/output devices and basic graphical interaction techniques.

- David Hearn, M. Pauline Baker, *Computer Graphics using Open GL*, 3rd ed., Prentice Hall, 2004

This book presents the principles of design, use and understanding of Computer Graphics systems and applications, along with OpenGL programming examples. Both software and hardware components are discussed using an integrated approach of two dimensional and three dimensional topics, and no background in Computer Graphics is assumed. It has chapters on input and output devices and interaction techniques.

### 3.2. Complementary bibliography

- Ian Harrocks, *Constructing the User Interface with Statecharts*, Addison Wesley, 1999

This book introduces an interactive software design technique to be used before coding. According to its author, it aims at filling a gap in the literature, which tackles mostly issues related to interaction design

(addressing only the external behaviour of the software), software design (often not addressing the user interface design) and programming languages (explaining the syntax, generally disregarding the overall structure of the software). It seems interesting for practitioners; however it may be useful to educators willing to prepare practical examples.

- Scott Weiss, *Handheld Usability*, John Wiley & Sons, 2002

This book is a practical guide to the user interface design for handheld devices (PDA- Personal Digital Assistants, mobile phones, pagers). It introduces the characteristics of these devices and their differences, the main phases as well as a set of guidelines for the user interface design. Additionally, it addresses issues related to prototyping and usability evaluation, which makes it useful for practitioners and for educators who wish to prepare practical classes on this subject.

- Carolyn Snyder, *Paper Prototyping - The Fast and Easy Way to Design and Refine User Interfaces*, Morgan Kaufmann, 2003

This book describes paper prototypes and explains how they can be used to develop user interfaces and conduct usability tests. It explains in what conditions they should and shouldn't be used, showing their advantages and disadvantages as well as other aspects that have to be considered when evaluating the possibility of using them as a tool. It has a pragmatic approach and can be useful to practitioners and educators.

- Dan Diaper, Neville Stanton (eds.), *The Handbook of Task Analysis for the Human-Computer Interaction*, Laurence Erlbaum Associates Publishers, 2004

This book is a collection of papers addressing the fundamentals of Task Analysis as well as different perspectives from the information technology industry, the user and the computer. It also includes a summary of main issues in this field of Human-Computer Interaction and points out promising ways. This book is meant to researchers and can be useful to support assignments of more advanced students.

- Jan Borchers, *A Pattern Approach to Interaction Design*, John Wiley, 1996

This book proposes a pattern based framework to the design of interactive systems. It also shows how this framework improves the communication among project team members and how it can help to convey accumulated experience to new members, future projects or in education.

- Alan Cooper, Robert Reimann, *About Face 2.0 - The Essentials of Interaction Design*, John Wiley, 2003

This book is a new up to date version of *About Face*, by Alan Cooper. It is intended to foster a better understanding of how users interact with interactive products (not only in desktop platforms), and introduces and explains the concept of Goal-Directed Design. This method advocates significant changes to conventional methods of software development (including defining archetypal users- personas- use them in scenarios, and follow principles of design for behaviour). The target audience includes programmers, designers, usability experts among other types of practitioners, but it is also interesting for academics.

- Eduard Tufte, *Envisioning Information*, Graphics Press, 1990

This is a classic reference in the area of Information Visualization; it addresses mainly how to escape from the limitations of two-dimensional representations revealing design strategies for enhancing the dimensionality and density of portrayals of information.

This book includes a chapter on colour and information presenting examples of bad and good colour usage in user interfaces.

- John Carroll (ed.), *HCI Models, Theories and Frameworks, Toward a Multidisciplinary Science*, Morgan Kaufmann, 2003

This book presents several diverse approaches to Human-Computer Interaction. Each chapter identifies the scientific field or tradition the approach rests upon, showing how particular principles of a discipline beyond HCI were specialized and developed, providing a foundation for describing in more operational detail how the approach is employed in HCI work. Moreover, each chapter comments on the state of the art suggesting issues that may be relevant during the next decade. Due to these characteristics, it is fundamental to the understanding of the multidisciplinary nature of Human-Computer Interaction.

- Julie Jacko, Andrew Sears (eds.), *The Human Computer Interaction Handbook*, Lawrence Erlbaum Associates, 2002

This is a collection of papers encompassing diverse aspects in Human-Computer Interaction, addressing not only the fundamental principles, but also new developments in design and evaluation of interactive systems. It tackles issues related to different platforms (virtual, mobile, networked) and users (adults, the elderly, children, etc.), in the scope of specific applications (e-commerce, telecommunications, education, health, government, games, etc.). Due to its broad-spectrum nature this book is important to researchers, educators and practitioners.

### 3.3. Opinion bibliography

- Donald Norman, *The Design of Everyday Things*, The MIT Press, 1998

Donald Norman examines several examples of bad design in everyday objects, which causes usage difficulties due to ignoring the user needs and cognitive psychology principles. It also shows examples of good design and provides a list of simple rules to improve the usability of objects as diverse as automobiles, computers, doors or phones. This book has become one of the main references in the area of Human-Computer Interaction; it is indispensable to educators and advisable to interested students and practitioners.

- Donald Norman, *The Invisible Computer - Why Good Products Can Fail, the Personal Computer Is So Complex and Information Appliances Are the Solution*, The MIT Press, 1998

This book shows why computers are difficult to use and why this complexity is intrinsic to their nature. According to Donald Norman, the only solution is to develop information appliances that adjust to people's needs. In order to attain this goal, industry must change its way of developing products. Reading this book is advisable to educators as well as interested students and practitioners.

- Jeff Raskin, *The Humane Interface - New Direction for Designing Interactive Systems*, Addison Wesley, 2000

It begins by the following phrase: "*We are oppressed by our electronic servants. This book is dedicated to our liberation*", which demonstrates the nature of this book. It analyses the cognitive basis of interaction between a user and a computer in order to ascertain why user interfaces succeed or fail. It describes some of the flaws of existing user interfaces and presents solutions to overcome them. Jeff Raskin demonstrates that many of the current paradigms are "dead ends" and asserts that new approaches are needed to make computers significantly more usable. Moreover, it provides many ideas to the design and development of user interfaces; thus, this book is useful for educators and interested practitioners.

- Ben Shneiderman, *Leonardo's Laptop - Human Needs and the New Computing Technology*, The MIT Press, 2002

According Ben Sheiderman, there have been significant changes in the way people look at computer technology; which resulted in a greater emphasis on the issues related to users; nowadays the goal is not so much automating as it is helping people to pursue their activities. In this book Ben Shneiderman wonders how

an approach typical of Leonardo da Vinci, which integrates science, technology and art, would take us to new technologies, applications and designs in the areas of e-learning, e-business, e-healthcare, e-government.

#### **4. Practical assignments**

Practical assignments are very important to help students understand and consolidate the concepts addressed in lectures; they have evolved along the years as a consequence of a change on the number of hours of the course, number and background of the students, progression of the area and changes in technology.

For pedagogical and motivation reasons, it is advantageous that some of the assignments in courses offered to graduated and post-graduated students respond to real needs, be those in research or industry. Thus, whenever possible, the author tries to include one assignment that corresponds to proposing a user interface prototype of an application or the participation in usability tests or controlled experiments as subjects or evaluators for a real “client” external to the course. These clients have been post-graduated students, and some of the work developed in the scope of this course has been included mainly in national publications but also in international publications; an example of a user interface developed during one edition of the course can be found in [Ferreira96].

In the first years, the course had no practical classes, it was offered simultaneously to graduate and post-graduated students, and was attended by a small number of students (between twelve and sixteen). During this phase, team assignments involving six to eight graduation students, coordinated by an MSc student, were developed. The MSc student acted as a project leader and had the responsibility to integrate the contributions of the other students. Meetings involving all the students and often an application domain expert were conducted by the teacher along the semester. The author considers that the experience was generally positive and that this approach is particularly interesting because the need of a good team work strategy becomes more evident as the teams get larger and the students usually work in teams of only two elements. However, it demands a tight control of the work each member is doing; otherwise the risk of getting a collection of modules that cannot be integrated is too high. Also, during this first phase of the course, some MSc students performed individual practical assignments on subjects proposed by them, albeit subjected to the teacher’s validation. All those assignments involved designing a user interface, implementing a prototype and evaluating it in some extent. These user interfaces were frequently intended to integrate an interactive system under development. Results obtained by some of those assignments were presented in internal publications or national conferences. Later, the course was no longer offered to MSc students and started to have practical classes (2h/week during a term of approximately 13 weeks). The number of students increased to an average of twenty students per class and the practical assignments became more guided. This was a direct consequence, not only of the increasing number of students, but also of a policy to oppose the generalised practice of giving mini-project type practical assignments in most courses, which was having negative impact on the students performance in the graduation project. In fact, at the time, students were devoting less attention to their graduation project, which should be their main concern throughout their graduation year.

In this second phase of the course, the suggestion of [Strong94] concerning the organization of practical assignments has been followed; the first assignments are devoted to user interface evaluation and the final assignment is devoted to design. In addition to the practical assignments concerning evaluation and design, currently, some time is also devoted to an introduction to two interesting tools for user interface prototyping: Visual Basic and HTML. After this introduction, which consists in a general description of the main features of the language, the students are advised to work on some examples. The author believes that, albeit very brief, this introduction is important to motivate the students to learn more by themselves.

Table 2 shows the topics that have been addressed at the practical assignments in the last years, as well as the number of hours devoted to each subject during practical classes. All the assignments are performed by groups of two students. In the following sub-sections some more detail will be given.

Table 2. Practical assignments and number of hours devoted to them in class

<b>Type</b>	<b>Practical assignments</b>	<b>Hours in class</b>
Evaluation	Observation techniques	2
Evaluation	Controlled experiments	2
Evaluation	Heuristic evaluation	4
Evaluation	Mobile phone evaluation	2
S/W	Introduction to Visual Basic	2
S/W	Introduction to HTML	2
Design	Design of a user interface	12

#### *4.1. Assignments on user interface evaluation*

Beginning by studying user interface evaluation methods has the advantage of allowing the students to feel the difficulties users have when using user interfaces and motivates them to study the other topics addressed throughout the course. In fact, according to J. Nielsen [Nielsen93], most professional programmers and students acquire a different attitude after witnessing tests where users “struggle” to use supposedly easy to use software. According to the same author, this effect is even greater if they have developed the tested software. Thus, in order to foster this change of attitude, the first practical classes are devoted to applying some evaluation methods such as observer techniques, controlled experiments and heuristic evaluation where students act not only as experimenters but also as users. In these classes S/W applications, web sites and mobile phones are evaluated; however, other interactive systems as photocopiers or digital cameras have also been the subject of evaluation. Also the final assignment includes some evaluation.

In the first practical assignment, about observation techniques, some simple tasks in the context of e-shopping are defined. Each student has to perform these tasks in a given e-shopping web site, acting as user, while his/her colleague observes and registers some usability measures as well as the answers to a few questions to assess user satisfaction. At the end they change roles and the new user has to perform the same tasks but at a different web site.

This has been performed using sites of two on-line shops (either two different ones, or the same but in different countries) and allows the students to observe that different designs (sometimes only with slight differences)

offering the same functionality and information can support user tasks in a very different way. It also introduces the students to the most commonly used user performance measures [Nielsen93]. Given that this is the first practical assignment, a detailed guide describing the tasks to be performed, the measures to be used and the questions to be answered by the user, as well as how the observer has to behave and what he/she has to register is given to the students.

In the second practical assignment, about controlled experiments, students are asked to participate as users in a controlled experiment. Usually it corresponds to a real experiment ran in the scope of the research work of the author or of a post-graduated student who had asked for collaboration. The students are not forced to participate as subjects, they may stay in the lab just watching; though, in general they participate and enjoy doing it. The procedure adopted is the same as in any other session of the experiment, with any other subjects; however, after the session is over, the author or the designer of the experiment explains its main aspects, including the motivation to perform the experiment, the hypothesis formulated, the independent and dependent variables and the experimental design. If some results of the statistical analysis are obtained before the end of the semester, some time is allocated to present them in another practical class.

The third practical assignment is devoted to perform a heuristic evaluation of an application or web site; the students are allowed to propose the subject of evaluation. Each student conducts a general appreciation of the application or site in order to understand its functionality and overall organization and then analyses it in more detail using the 10 usability heuristics of J. Nielsen [Nielsen93] and classifying the severity of each usability problem according the severity rate proposed in [Nielsen04]. In the end, both students confront their findings and prepare a report. On the next week, each group makes an oral presentation to the class describing their main findings. No guide is provided for this assignment; in order to prepare it, students are advised to read [Nielsen04].

The fourth practical assignment consists in designing a simple mobile phone usability test. Students are advised to read about usability tests and a document concerning the Common Industry Format Usability Test Reporting (that became an ANSI-354 standard in 2001) [ANSI01] is provided. Each group proposes the type of users, the tasks and the measures to be used; a general discussion is conducted and a joint proposal is written on the blackboard. Finally, each group uses a mobile phone model unknown to one of the students, who performs part of the tasks, while the other observes and registers some usability measures. In the end, each group reports informally to the class the main findings.

#### *4.2. Final assignment (on user interface design)*

The final assignment involves the requirement analysis, proposal of a conceptual model, implementation of part of a prototype and some evaluation of a user interface. All this should be performed following a user centred design methodology.

Students are allowed to present their own proposals or they may choose one of two different given problems. If they want to propose their own subject they have to submit one page stating the objectives and the reason why they are interested in working on that subject. In general, most students end up choosing one of the given

problems; however some submit proposals concerning a user interface they need to develop in the scope of their graduation projects.

In 2004/05, the final assignment consisted in proposing the user interface for either a web application that would allow to buy and/or reserve meals at any of the University restaurants and canteens or another that would allow the students to register in exams. Only a general description of the intended functionality is given so that students can propose the specific functionality based on their work on the requirements.

At the first practical class devoted to this assignment, the teacher briefly describes a usability engineering lifecycle as proposed in [Mayhew99] with all its phases and advises student to follow it. The following classes are devoted to work on the problem and to discuss possible solutions with the teacher and the class. Finally, in the last class, each group must make a demonstration of their work. Students may implement the prototype using whichever tool or language they prefer, as long as it can be demonstrated in the lab.

#### *4.3. Other activities*

In the scope of this course, students have also been collaborating with other people in their research or development work. Besides participating as users in controlled experiments as mentioned above, they performed heuristic evaluations of websites and applications and participated as observers in usability tests. Examples of such collaboration are the usability test and the controlled experiment described in [Sousa Santos04] and [Silva05]. The author considers that this collaboration has been very constructive given that it allows the students, on the one hand to be exposed to the use of the evaluation methods in real circumstances and, on the other hand, better understand the importance of correctly dealing with people that collaborate as users in usability tests and controlled experiments.

#### *4.4. Writing reports*

Writing a report is for most students a difficult task; therefore, an explanation of how to do it is given in class before the first report is due. In order to support this explanation, a simple document is given; this document contains a straightforward description of the various parts a report should have, and some guidelines on style, format and using references. The students are also advised to browse a book published by IEEE that addresses the subject of writing and speaking in the technology professions [Beer92]. Students are required to read each others reports before they hand them to the teacher, which corrects them and shows her corrections and comments to each group. All the groups are given the opportunity to improve and re-submit the report concerning the heuristic evaluation (the first they have to produce during the semester). This procedure has been followed in the last years and the author has noticed a significant increase in the average quality of the reports.

## 5. Discussion and Conclusions

In this paper an introductory Human-Computer Interaction course offered since 1993 at the University of Aveiro, to Electrical and Computer Engineering students, is presented. Since technology and Human-Computer Interaction are evolving rapidly, a continuous effort is needed to maintain up dated program and bibliography as well as practical assignments that help students to consolidate the concepts acquired along the course, and are adapted to the current technology.

In fact, maintaining an introductory on Human-Computer Interaction up to dated is a hard task. Actually, if on one hand a lot of the theory seems already reasonably stable, as for instance usability principles that depend more on human nature than on technology, on the other hand, in order to foster the understanding of that theory, it is necessary to present instances of good practice, which of course depend heavily on current technology; however, technology evolves very rapidly and students are familiar with it. Therefore, to stay current and maintain an up to dated “look” of the course, an educator in this area must, not only be aware of the new developments in the field but also often change or adapt the examples. The same concern is valid for practical assignments.

Recently, in the course described in this paper, students have been performing, in groups of two elements, two types of practical assignments: first evaluation and latter design of user interfaces. While evaluation assignments have been addressing desktop applications, websites, handheld devices or consumer electronics products, the design assignment has been involving only the design of a user interface and implementation of a prototype for desktop or web applications. However, the author is considering the possibility of including handheld devices, namely PDAs, in the design assignment, given that these platforms are becoming increasingly important.

The author has lectured Computer Graphics, Visualization, Image Processing and Human-Computer Interaction as separate courses; yet she is convinced that, as these subjects are becoming ever more intertwined in their practice as well as in research, it probably makes sense to lecture them together, bringing in topics traditionally addressed in different courses. Thus, in recent years the introductory course offered to the students of Computer Engineering at the University of Aveiro, follows this model, introducing not only the basic concepts of Human-Computer Interaction, but also topics of Computer Graphics. This is in agreement with the proposal recently presented in [Paquette05], based on an analysis of more than 70 curricula, considering many aspects: existing Computer Graphics, Image Processing, and Human-Computer Interaction courses; curricula such as Computer Engineering, Computer Science, Information Technology and Software Engineering; the difference between introductory and advanced courses, etc.. This analysis suggests that, given the different types of universities and curricula, there should be more alternative courses tailored to the needs of particular curricula involving Computer Graphics, Human-Computer Interaction and Image Processing.

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