Innovative Practices for Learning Human-Computer Interaction by Engineering Learners

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Abstract—**This paper presents an innovative experience with teaching and learning Human-Computer Interaction in the field of Computer Engineering in the Faculty of Physical Sciences and Mathematics at the Universidad de Chile. This is a pioneering course in Latin America, and has been offered every year for the past 20 years without interruption. The content of the course is constantly renewed and updated. As a result, students have been able to learn of a wide range of aspects regarding Human-Computer Interaction that must be taken into consideration when designing any kind of software or device for human use. At the same time, students recognize that the issues and methodologies taught in the course are not only useful for their training as engineers, but are also helpful for everyday decision making.**

Keywords- HCI Learning, HCI in engineering, constructivist learning, usability

I. INTRODUCTION

Throughout the years, learning has been explained as the analysis of several theories proposing various learning models. One of the aspects these models focus on is distinguishing between different degrees of activity/passivity in the role of the student [16].

Traditional or frontal teaching puts the students in front of an instructor who provides them with theories, concepts and a variety of content [8].

In this scenario, the students are mere passive receptors of information that a transmitting instructor presents and explains, be it with the help of old technology (blackboard or whiteboard) or digital technology (projector, computer, etc.) [1]. This way of teaching and learning that responds to a behaviorist-positivist model, has prevailed in education for decades, and is slowly experiencing changes and innovations that point towards a model in which the learner is the main actor and is active in his/her learning, constructing knowledge through change in the meaning of the experience, interaction with others and the organization and reorganization of his/her mental schemes [19].

In this new scenario, the role of the instructor is that of a facilitator of meaningful student experiences and a mediator or coach for the learners' construction of knowledge through practice, discussion, analysis, comprehension and active commitment [2], [16].

It is precisely in this context in which the teaching and learning of Human-Computer Interaction (HCI) in the field of Computer Engineering within the Faculty of Physical Sciences and Mathematics at the Universidad de Chile takes place. This HCI course has been a pioneer in Chile and Latin America. It has been given every year for the past 20 years, being constantly renewed and updated in synch with the newest prevailing technology. As a result, students have been able to learn of a wide range of general situations involved in Human-Computer Interaction that must be considered when designing any kind of software or device for human use. This implies development of a capacity for analyzing problems on a technical, cognitive and functional basis from a design perspective, and critically analyzing interactive Interface design methods and techniques.

The main reason why people do not use fully many specific systems is that their interfaces are not conceived and designed for end-users to interact with them, providing false cues for their use and mechanisms that lead to errors [4], [12]. The objective of HCI is to generate usable, understandable, safe, functional, intelligible and useful products. These are products with interfaces that are easy to interpret and understand, that provide visible cues for their operability, and that consider human error in their design [4], [18].

HCI makes it so that end-users are the center of any development and design [10]. This is to say that the design of the application is born of the needs and interests of the user, occurs with the user's constant participation and culminates in a high degree of usability [21]. For this reason, human-computer interaction favors systems with interfaces that are designed based on the user's needs, coming to know and understand the user, and even making the user part of the design team [7], [13]. In this way it is assured that the application is usable and understandable, and as a consequence, can be used by the end-user [4]. At the same time, these systems must be modeled and implemented by considering all the technical and functional specifications, and by following software engineering methodologies in such a way that a robust, functional and reliable system is obtained [5], [17]. The idea is to generate applications with interfaces that help, improve and widen the sphere of the user's experience, together with providing more reliable solutions, saving costs, improving the efficiency of processes, and most

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importantly improving people's productivity, efficiency and ways of life.

In addition to being associated to software engineering, human-computer interaction is heavily influenced by other disciplines of knowledge, such as the cognitive, biological, psychological, sociological, and anthropological sciences, as well as graphic and industrial design and ergonomics [15]. All these disciplines contribute to and inform the design of human-computer interaction by responding to questions such as: How does the human being behave in social and cultural contexts in time and space? How do his/her social relations and interactions occur? How do users perceive? How do they memorize? How do they process information? How do they know and learn? How do they solve problems? How do the brain and the sensory organs participate in their interaction with the software and with digital devices? How are the concepts, theories, elements and components of graphical and industrial design incorporated into the design of user interfaces?

II. THEORY AND PRACTICE

For Myers [11] it is important that students of computer engineering know and learn of the issues underlying user interfaces. This author points out that interfaces are the added value of computer systems, and generate competitive differences in that the hardware and software become commodities. His reasoning is based on the fact that if students do not know about human-computer interaction, their competences will not be useful with regards to the needs of the industry. Reality coincides with these arguments. The heavy commercial competition of modern technology products is based on the novelty, interactivity, usability and usefulness of interfaces. For example, the current commercial competition in the field of touch-screen interfaces and its various designs points to interface designs that are increasingly natural, usable and understandable for users.

One of the keys of our HCI course has been the learning methodology and its constant renewal, innovation and updating. This learning methodology consists of applying the theories, concepts and models studied in class to practical, applied, real and pertinent case study projects. On the basis of a global issue dealt with during the course, the students resolve and develop a series of HCI application case studies and a final human-computer interaction project that integrates and unifies the results of the previously developed cases, with increasing degrees of requirements, depth and complexity.

Just as today the tendency is for interfaces to revolve around multi-touch devices, technological changes are so fast and diverse that new and varied interfaces are constantly emerging. The field of human-computer interaction is especially sensible to the constant technological changes and innovations in the world of technology. In this way, learning of human-computer interaction implies that, in addition to attending classes, building up knowledge and managing information, students must be constantly reading papers published in the latest HCI journals and conferences in order to know of current HCI tendencies and issues.

The classes for the HCI course are given with a variety of nuances and orientations. Some sessions consist of presenting, analyzing and discussing theories, models and content, while others involve collaborative teamwork, planning, developing and evaluating progress on the design of the application case studies. Periodically the students revise and analyze their progress together with the instructor and teaching assistants, who support, mediate and facilitate the conceptual and functional decisions that students must make.

A. Application case studies

As has already been mentioned, the course presents the students with some application cases studies of a design or the redesign of human-computer interaction that the students must resolve. The students' work evolves from the design of human-machine interfaces to the design of human-computer interfaces. These case studies are organized into a central global issue, such as transportation, education and navigation that are finally linked in order to achieve a more complete HCI design, and produce it for the final project.

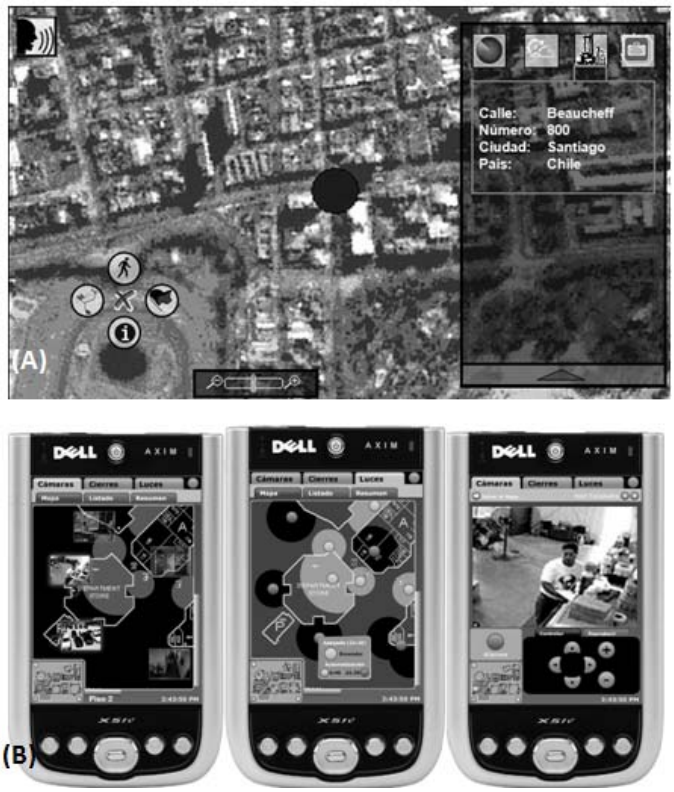

Figure 1. (A) Interface proposal for GPS devices developed by students of the course in 2006 (B) Proposed assisted control system for jails

All of the proposals for the resolution of the application cases from each team of students are presented, analyzed and discussed during the course. This implies that, in addition to learning about concepts and their application, students learn and reinforce their skills for designing and making presentations before an audience. As the course evolves and the application cases become more complex, the demands on the quality of the presentations increase, which obligates students to present, apply and use the course content studied impeccably and in great detail.

Figure 2. (A) Design of a mobile application in support of public transport (B) Proposal of a mobile design for the Transantiago website

The issues involved in the application case studies are varied. Students have designed and redesigned several web sites and portals, audio and information devices for vehicles, remote controls, multifunctional office equipment, remote home control systems, assisted control systems for jails, zoos and shopping malls, GPS navigation devices (see Figure 1), information systems for public transportation and systems related to education, among others. One of the key points of these case studies is that the designs must be user-centered, which implies working with and for end-users. The end-users evaluate the prototype designs providing their particular visions, problems, concerns, interests and needs.

The HCI case studies are not only varied, but are also related to real situations in real contexts. For example, in the year 2001 an analysis was made of the interfaces used in the new automatic charging devices installed in the newly replaced public bus system of Santiago. In 2007 the design of an application that would allow the user to locate the best route to/from work and home, as well as the best means of transportation, was studied.

Figure 3. System interfaces designed by the students for the system-solution of a Transantiago bus stop

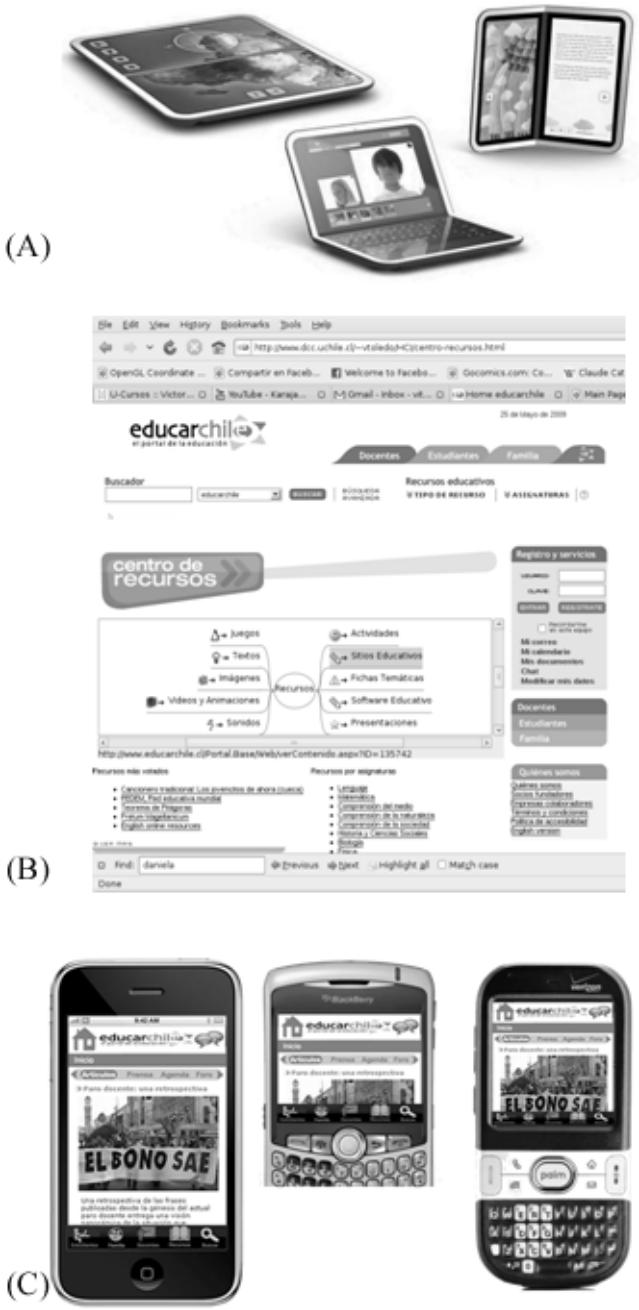

Figure 4. (A) Digital book interfaces designed by a team of students from the course. The students were not only concerned with designing the interface or the hardware device, but considered the context in which the technology designed would be used as well. (B) Redesign of the interface for the EducarChile web site. (C) Proposal of a mobile interface for the EducarChile web site

At the beginning of 2007, a new urban public transport system, called Transantiago, was implemented in Santiago de Chile [20]. This system emerged as a response to the almost unmanageable and chaotic situation with the buses that operated in Santiago up until the end of 2006 [6]. Thus, in 2008 the issue for the course was Transantiago (Figure 2A). Students evaluated and redesigned the Transantiago web site (www.transantiago.cl) (Figure 2B). The final project

systematized, collected and linked all of the previously resolved application case studies during the course, resulting in a higher degree of complexity, as the design of a system-solution for transport focused mainly on providing information in order to help with decision making by taking passenger comfort, context and surroundings into account. To do this, students had to consider that the proposed interface must be implanted at bus stops and subway stations, in addition to other places that students deemed convenient (Figure 3).

Last year, in 2009, the central global issue of the course was education. Under this issue, the students designed an innovative interface for a device that would serve as digital text for high-school students. To do this, students had to find a technological solution that could be used as a book, a workstation, or an information search engine. This had to be done according to the user's needs, in order to be presented as a reusable resource with low maintenance costs, and the contents of which could be updated. To this practical problem, an important technological variable was added; the printed book upon which the device was to be based had still not been replaced by any existing digital technology, for which reason the device had to integrate a correct functionality based on a creative and innovative design. As a result, the students generated interesting and innovative interface proposals, in some cases using existing hardware devices, and in others they generated proposals for the development of new hardware (Figure 4).

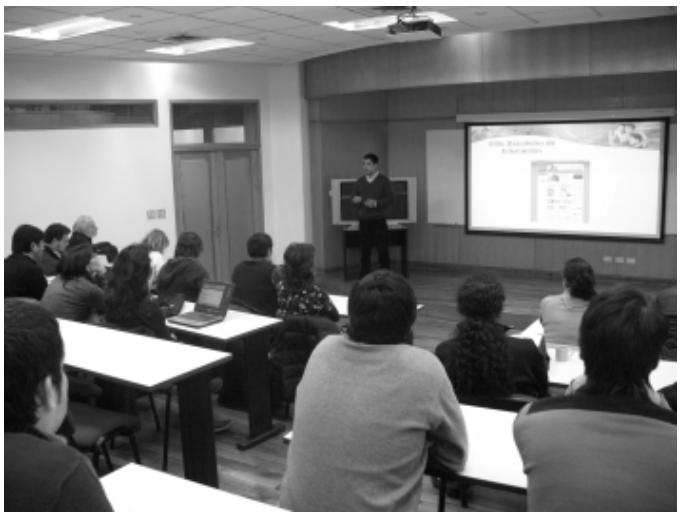

Figure 5. Presentation of the redesign of the EducarChile.cl web site to the manager and professionals of the site from Fundacion Chile and the Enlaces network of the Chilean Ministry of Education

The second application case study this year consisted of students evaluating the interfaces involved in the educational web site of EducarChile (www.educarchile.cl), one of the most visited and used public web sites in the country. After this evaluation, the students redesigned the web site in their final project (keeping the end-users in mind: teachers, students and parents). The final project was presented to a group of professionals responsible for the EducarChile web site from Chile Foundation and the Education and Technology Center, coordinated by the Enlaces Network (www.enlaces.cl) (Figure 5). As a result of this experience, the web page managers redesigned the site to make it more usable, understandable and functional. To do this, the web page professionals created a survey in order to obtain more data and opinions from the end-users (http://www.educarchile.cl/Portal.Base/Web/VerContenido.aspx?GUID=c363e908-c2a3-4b21-bd56-ad0cd6ad6d94&ID=197268).

B. Evaluation

The evaluation of the main concepts studied in the classes is made through the use of the concept mapping technique [14] (Figure 6). In this way, the evaluation is not centered on how much the students remember or memorize, but on how they understand, organize, give hierarchical structure to, associate and relate the main concepts learned in order to construct meaning. Thus it is possible to know the representation of the students' mental conceptual home base for the concepts learned during the course. Each student ended the course with a concept map of the main concepts learned and its associations. This is to say, with a graphic representation of his/her significant learning of HCI concepts.

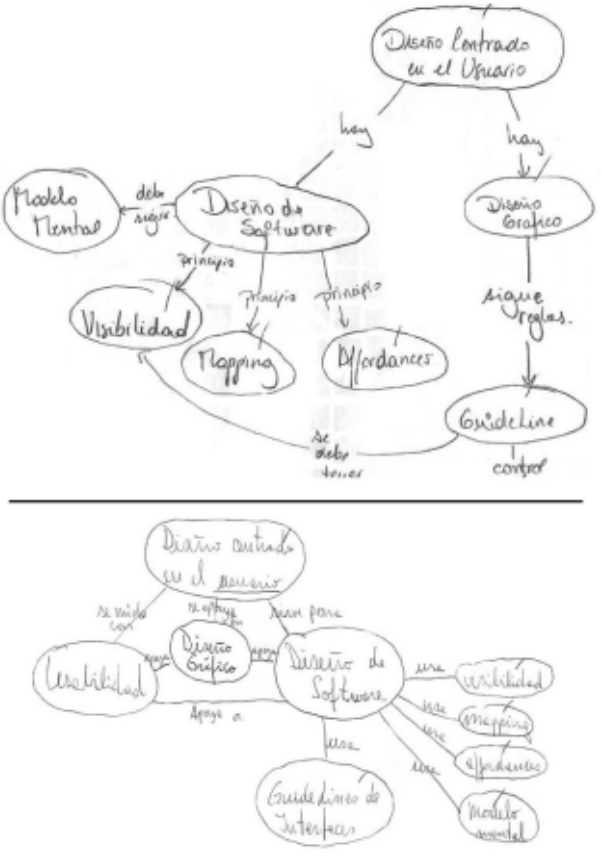

Figure 6. Concept Maps generated by HCI students based on the concepts studied and analyzed in class

Together with the evaluation of the contents seen in classes through the use of concept maps, the students have an intense workload regarding HCI readings. These readings cover the state of the art in the area of HCI and are recent

publications from important conferences in the area, such as ACM CHI [3] and IFIP Interact [9], for example. As such, the students are up to date on the latest progress in the area, the latest technology for HCI that is being developed, and on user experience with different systems and applications.

III. OPINIONS OF EX - STUDENTS

There are several interesting and illustrative opinions offered by some students, several of which have already graduated, who took the human-computer interaction course. Regarding the learning methodology, the students stated that it is a distinct method and that it strongly supports the learning of several of the concepts seen in the course. *"It was a pleasure and a privilege to have been able to learn in that way"* (Victor Toledo, ex-student from 2009); *"The HCI course seemed interesting to me in the way that we studied real cases as a course project. It also allows one as a student to have a free reign on creativity and imagine innovative and interesting solutions"* (Juan Pablo Rodriguez, ex-student from 2008). In addition, the students recognize that the methodology utilized allows them to support the development of other skills that are fundamental for today's professionals: *"The Human-Computer Interfaces course is very interesting, in that it allows you to acquire and develop skills that are not common in other Computer Science courses […] the constant debates that are proposed and the presentations in the course allowed me to strengthen my oral communication skills, which is highly valued in the current labor market."* (Angelo Tadres, ex-student from 2007).

In more global terms, on the applicability of the course, students' opinions coincide in that it is a class that provides useful tools for engineers that have already graduated. Angelo Tadres, ex-student from the 2007 generation, says: *"As future engineers, they constantly teach us to design functional and quality software, but they never ask us to think of the users of these solutions. The HCI course gave me the necessary tools to solve these problems, thus creating much more usable and visually attractive interfaces". "In order to achieve a technical back-up to the intuition that I had before entering the University, the work I did in the Computer Science Department helped me a great deal, especially with the course and posterior workshop in the area of HCI. It was a great experience, putting the notion of what a software application does to leave the user satisfied and able to do his tasks into words and action"* (Ivan Galaz, ex-student from 2004).

Other opinions point out that what was learned in the course is useful for their current professional positions: *"The HCI course given by the Computer Science Department offers its students a vision distinct from software engineering, in which the experience of using the software is as important as the technical quality and its development […] In my case, I am in charge of the development of web applications, the usability of which must be strongly considered, because a poor design of its interfaces and interactions causes a loss of productivity in the systems when they are being used"* (Claudio Oyarzun, ex-student from 2004); *"The interfaces course teaches us to concentrate on what the user will end up using, the software interface, the weak point in many of the software applications that I have had to use"* (Mauricio Zuniga, ex-student from 2004); *"[…] HCI sensibility can always be a favorable tool, a plus among the qualities of a development engineer…and that today is quite scarce, and thus quite valued"* (Miguel Elias, ex-student from 2005); *"Up until I took this course, I was used to making programs oriented towards systems, concentrating only on making the program work. This was the first course within my specialty in which the focus was far from programming, but was rather on the end user's experience of using the program. This is a user who is not necessarily a computer expert. […] In my work I develop a lot of web applications, and this course has helped me tremendously in order to discuss important issues with other programmers, for whom it is hard to put themselves in the place of the end user, and who tend to design programs for themselves"* (Thomas Pieper, ex-student from 2002). *"I currently develop web applications, both for private companies and public organisms, and I am mainly responsible for assuring that the end user has the best information available when performing his/her tasks. For example, I assure that the usability level is included among the decision criteria when designing the flow for each task that the user will perform, that the controls for executing the actions are clearly available and that the actions performed by the user have a clear and precise system response"* (Ivan Galaz, ex-student from 2004).

These opinions reflect how relevant having studied human-computer interaction through a constructivist learning focus with application study cases and software interface design projects performed throughout the course has been for these professionals.

There are even some students who do not only adopt the knowledge and the experience learned in the HCI course into their professional lives, but who also use it on a much more personal basis. This is expressed through a higher level of sensibility to issues related to human-computer interfaces: *"At the end of the course I had already internalized the interface analysis into my daily life, not only regarding the web pages that I visit every day, but also regarding devices like MP3 players and cell phones that I use…something that I have continued to apply both consciously and unconsciously to this day"* (Miguel Elias, ex-student from 2005).

IV. CONCLUSIONS

This article presents an active way of teaching and learning human-computer interaction for computer engineering students. The learning methodology of the HCI course that is given in the Computer Science Department of the University of Chile allows for active, wide-ranging, concrete and up-to-date work that leads students to build up knowledge from practice. The course requires the students to constantly apply the knowledge they study in class. As a result, there is a deeper appropriation of the theory and practice of human-computer interaction.

Our end-users are the students. And their reactions and comments support the fact that the focus of the learning methodology is more centered on the practical work of application than on just the presentation and analysis of the course contents. They also highlight how this helps for the transfer of this knowledge to other areas of their lives.

The relevance of an HCI course in the formation of a computer engineer lies in that it provides another perspective on the systems and solutions that these professionals regularly design and develop. In embedding HCI concepts, ideas, theories and models, there can be more certainty that their developments will be used and understood by the end-users, and thus that their work will be more valuable, solid and sensible to them.

History is plagued with examples of technology applications for which use has been impeded because their interfaces are not usable, accessible, understandable, or because they do not represent the end-users' modes of interaction. An HCI course such as the one described in this paper can make all the difference.

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