International Journal of Engineering Education Vol. 28, No. 4, pp. 767–777, 2012
Printed in Great Britain

0949-149X/91 $3.00+0.00

Human-Centred Design in Engineering Curricula*

PERE PONSA,[1] CRISTINA MANRESA-YEE,[2] DIANA ARELLANO,[2] JOHANNA GÓMEZ[1] and ÀLEX PÉREZ[1]

[1] Automatic Control Department, EPSEVG, BarcelonaTech University, Av. Victor Balaguer s/n 08800 Vilanova i la Geltrú, Barcelona, Spain. E-mail: pedro.ponsa@upc.edu

[2] UGIVIA, Mathematics and Computer Science Department. Universitat Illes Balears, Ed. Anselm Turmeda, Crta. Valldemossa, km. 7.5, Palma, Spain.

This paper describes the inclusion of human-centred design in the curriculum of the Design and Product Development Engineering. The aim is to improve the relationship among experts and to integrate the human factors domain in engineering education. We present case studies of design-centric projects related to home automation systems in the Bachelor and Master of Science programmes. The preliminary results in laboratory conditions with Engineering students and professors show the effectiveness of the integration between engineering and the human factors disciplines. Moreover, it is shown how Engineering students understand the benefits of the Human-centred approach by using holistic models to develop new and innovative products.

Keywords: active methodologies; human-centred design; product design education

1. Introduction

In order to train future engineers as intellectual leaders, skilled and well prepared professionals who are creative, know how to work in teams and how to communicate with other areas, is necessary a framework where design represents its core and it is surrounded by technology, human factors and market opportunities [1–3].

The authors are interested in the connection between design and other disciplines. In the relationship between design and human computer interaction (HCI) is necessary to enhance the integration between usability and product design. For example, Oswald proposes a product design based on user activity [4] and the relevance of this approach for design education is the integration of product, graphic and interactive design in the same discipline.

Integrating usability evaluation in the life cycle of new technological prototypes offers a richer feedback in their development and has an influence on the quality of the product and on the end user's satisfaction [5]. To measure usability there are two approaches: summative and formative evaluation [6–8]. The purpose of formative evaluation is to enhance a system during its development. More specifically it is an iterative design process to improve the product. On the other hand, in summative usability the user's experience with the system helps to set usability goals to be tested (effectiveness, efficiency and satisfaction metrics).

To achieve a usable system, the Human-Centred Design (HCD) approach is concerned with the incorporation of the user's perspective into the software development process [9]. Following this author, the key principles of HCD are:

- Active involvement of users.
- Task requirements analysis.
- Function allocation between the user and the system.
- Iteration of design solutions.
- Multidisciplinary design teams.

In fact, the revisited analysis of the international standard ISO 13407 proposes an extended version of these principles based on relevant aspects of the user's experience when interacting with the product [10, 11]. For example one of the new requirements is: *Users' strengths, limitations, preferences and expectations should be taken into account when specifying which activities are carried out by the users and which functions are carried out by the technology*.

Beyond the HCI approach, the HCD concept can be modelled integrating psychological and social aspects [12]. This integrated model reveals that design evolution, from functionality and usability to desirability, responds to the hierarchy of human needs and can be applied in engineering education.

In the context of engineering education, the Technical School of Vilanova i la Geltrú has previous experience in the application of active methodologies in the engineering curricula (project based learning and role playing approach) [13, 14] and the current challenge is how to develop new engineering curricula in the 21st century.

Next section describes the inclusion of HCD into the engineering design curriculum and the inclusion of design subjects into a HCI curriculum.

* Accepted 4 March 2012.

2. Structure of the Engineering Design Degree curriculum and postgraduate programmes

Since 2010, the Technical school of Vilanova i la Geltrú has been developing a Design and Product development Engineering curriculum [15]. The curriculum is structured in four years, that is, eight semesters (see Fig. 1). One of the advantages of this curriculum in comparison to traditional design engineering is the inclusion of human-centred strategies.

In the first year, students take a generic subject in accessibility and innovation. In this subject, students learn how to consider the final user's capabilities for the development of human technology (requirement analysis, life cycle process, disabilities) and how to incorporate innovation into product design. In the following semesters, students take scientific and design engineering subjects. During the fourth year, students have the opportunity to choose one elective area in HCD. In this area there are three subjects: Inclusive design, Accessibility and Usability Engineering, and Human-System Interaction. And finally, students must develop a final design project in order to achieve the degree.

The aim of the *Inclusive design* subject is to develop assistive technology. In the *Accessibility and usability engineering* the aim is to present the classical methodology of HCI (methods, tools, and user experience). Finally, in the *Human-system interaction* subject the aim is to study the interaction between humans and systems in order to define performance evaluation measures.

The head professor of the *Inclusive design* and *Accessibility and usability engineering* subjects is the academic director of the Accessibility Chair of the Barcelona Tech University. The Accessibility chair promotes, coordinates and manages projects intended to improve the accessibility to physical environments, technology and higher education. For this reason, there is a clear connection between the teaching activity and the development of research works, industrial projects and social activities [16].

In the areas of usability engineering and users' experience one of the professors of the *Accessibility and usability engineering* subject is a member of the Usability Laboratory 4all-L@b [17]. This laboratory develops activities in the area of dependency care and autonomous living [18].

In the *Human-system interaction* subject it is

S1	COMPUTER SCIENCE	MATHEMATICS	CHEMISTRY	PHYSICS I	SOSTENIBILITY
S2	GRAPHICAL EXPRESSION	MATHEMATICS FOR DESIGN	AESTHETICS	PHYSICS II	ACCESSIBILITY AND INNOVATION
S3	MANAGEMENT	STHATISTICAL	DESIGN PRACTICUM I	MECHANICS	ARTISTICAL EXPRESSION
S4	ELECTRIC SYSTEMS	MATERIAL SCIENCE	TECHNICAL DESIGN	DESIGN PRACTICUM II	MATERIAL RESSISTANCE
S5	ELECTRONIC SYSTEMS	,MANUFACTURING SYSTEMS	COMPUTER AIDED DESIGN	SIMPLE DESIGN	GRAPHICAL DESIGN
S6	PROJECT MANAGEMENT	PRODUCT AND DESIGN	DESIGN METHODS	MECHANISM DESIGN	DESIGN PRACTICUM III
S7	INCLUSIVE DESIGN	ACCESSIBILITY AND USABILITY ENG.	HUMAN SYSTEM INTERACTION	OPTIONAL 4	OPTIONAL 5
S8	FINAL PROJECT				OPTIONAL 6

Fig. 1. HCD approach into the Design and Product curriculum.

described the new trends in the development of technological products. Related to this subject, since the year 2008, the IEEE Society has been sponsoring the Human System Interaction International Conference aiming at enhancing the research activities in many areas such as electronics, robotics, computer science, education and human factors [19].

To obtain a set of design skills it is necessary to complement the theory with practicum activities in the laboratory. At the University we count with three related new laboratories (the Mechanical prototyping laboratory, the Interactive Systems Design laboratory and the 4all-L@b Usability laboratory) besides traditional laboratories in Electricity, Electronics and Control.

A laboratory specially focused on evaluating human-automation interaction, ergonomic design, user's experience and usability of industrial and digital home products and services is the Interactive Systems Design (ISD) Laboratory at the Technical School of the Barcelona Tech University [20], see Fig. 2.

The complete equipment inside the laboratory has the following components and services:

- Information, communications and technology (ICT) architecture: Wonderware System Platform with a Data Server, Input/Output Server, driver communication with the controller and software to develop human-machine interface applications (local and teleoperated control).
- Input and output devices: hands-free interface [21, 22], button and visual information devices panel, mouse, joystick with force feedback.
- Scale model of a smart home. Home automation and energy control–domotics: opening/closing doors/windows, switching on/off lights, controlling heating.
- Academic flexible manufacturing system. This system is a set of electropneumatic stations, a robotic station, a quality station and one closed conveyor and produces a set of items.
- Automatic controllers: programmable logic controllers.
- Software for usability testing and user's experience assessment: Morae by TechSmith [23].
- Software for human machine interface design: InTouch by Wonderware.
- Design of supervisory control interfaces with the aid of a display design guideline.
- Study of levels of automation (manual control, shared control) in industrial automation with the aid of the start and stop modes guide.
- Design of haptic interfaces in human robot systems [24].
- Study of the complexity of the human task in control room.
- Development of an online tool for the development of evaluation questionnaires and preparation for remote usability testing [25].
- Collaborative team group (internal web) [26].

In the ISD Laboratory we are developing teaching and research activities. Some engineering students are doing their final year projects in home automation systems, display design, levels of automation and strategy control modes.

Once finished the engineering degree, students can continue with a MSc program. In our university we have the MSc in Automatic Control and Robotics: in the current scenario we are transform-

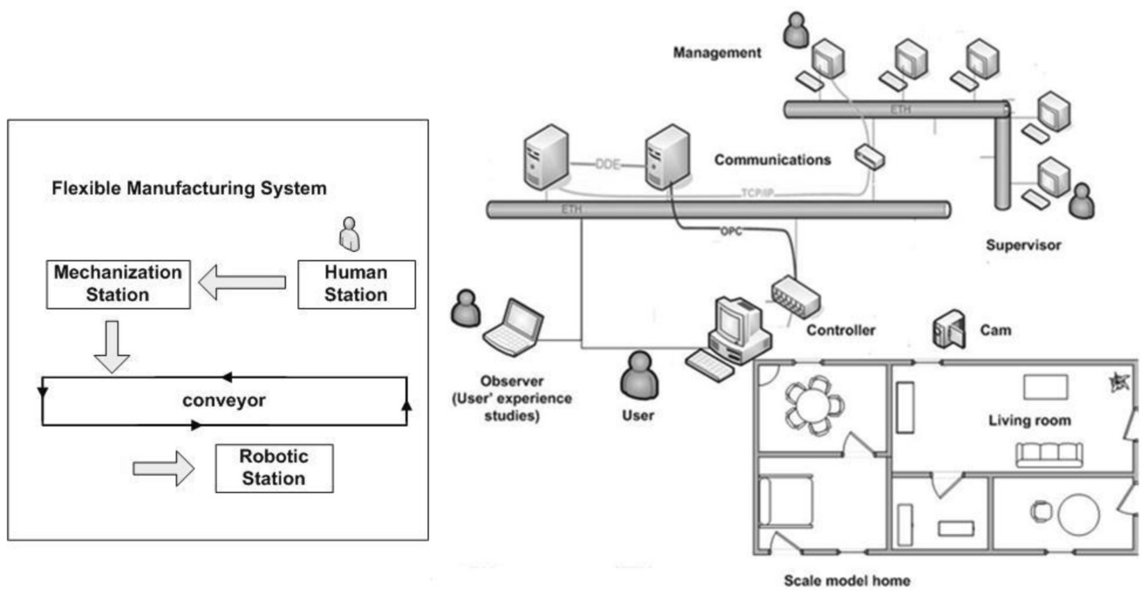

Fig. 2. Activities in the ISD laboratory.

ing this master and we are implementing a new MSc in Automated Systems Engineering and Electronics with an elective area in assistive technologies and ambient intelligence. This MSc will begin in September 2012 and we are preparing projects and methodologies. Another option is the Master's degree in Human-Computer Interaction (HCI) at Universitat of Lleida in Spain [27]. In this master's program (two years, four semesters), students from diverse areas of knowledge (psychology, computer science, industrial engineering) are prepared to work in multidisciplinary teams where the end user is essential (context of use, user centred design, accessibility, etc.). The academic staff of this master's degree develops practical activities in the usability laboratory UsabiliLAB [28].

We highlight the inclusion of human factors subjects into engineering degrees and the inclusion of design subjects in a HCI master aiming to bring up multidisciplinary graduates. As seen in Fig. 3, the grey cells show that design is the core of the Master's degree in HCI. In this MSc one of the problems to solve is the integration of different student profiles. The first semester tries to teach a generic perspective from social aspects to technical aspects.

The first author of this paper teaches the *Industrial design* subject in this MSc and adds design skills into the HCI program. In the *Industrial design* subject the head professor highlights the importance of an ergonomic approach at the first step of the product design. For this reason we are developing teaching material related to product design and HCD. The theoretical chapters of this subject are:

- Introduction: connection between the industrial field (machine, flexible manufacturing system, product design) and human factors and ergonomics.
- Interface design: connection between safety standards, interface design recommendations and control strategies of automation systems in order to design interfaces and facilitate the human intervention (in the control of industrial machines, internal interfaces for elevators, tactile and haptic interfaces).
- Display design: use of the ergonomic display design guideline, GEDIS guideline, to develop displays in the industrial domain and home automation displays for smart environments.
- Control room design: use of the HCD approach in the definition of the industrial human supervisory control task.

One of the aims of the subject is to show that the HCI engineer not only can design web solutions and software solutions in the software engineering domain; but they can design industrial and assistive technologies products.

In the subject, the head professor uses a virtual meeting room when the students discuss about good or bad design, human error and new prototype interfaces (design and use), etc. Students work in pairs and in many occasions one student has a social profile and the other one has a technical profile, therefore, students learn in this master how to develop integrated projects. In this sense we use the project based learning approach trying to develop prototype interfaces, having special care in the specifications of the product design and the analysis requirements of the users' needs.

Next section describes some examples of our applied projects.

S1	PSYCHOLOGY AND HUMAN FACTORS	SOCIOLOGY AND ANTHROPOLOGY	GRAPHIC DESIGN	INDUSTRIAL DESIGN	INFORMATION SYSTEM TECHNOLOGY	INTERACTION TECHNOLOGIES	DIGITAL PUBLISHING	WEB SYSTEMS DESIGN FROM SCRATH
S1	USABILITY ENGINEERING AND USER CENTRED DESIGN	PROTOTYPING TECHNIQUES	INTERACTIVE SYSTEMS DESIGN	MULTI-CULTURALISM	SYSTEM EVALUATION TECHNIQUES		TEST WITH USERS	
S1	INFORMATION ARCHITECTURE I		INFORMATION ARCHITECTURE II		ACCESSIBILITY I		ACCESSIBILITY II	
S2	EMOTIONAL COMPUTING		INTERACTION AND SOSTENIBILITY		COMMUNICATION MANAGEMENT		GRAPHIC DESIGN FOR INTERACTION	
S2	PROFESSIONAL ACTIVITIES				RESEARCH INTRODUCTION			
S2	PRACTICUM				FINAL PROJECT			

Fig. 3. Design approach into the HCI Master curriculum.

3. Cases studies

In this section we describe several projects designed and developed using a human-centred approach.

3.1 Towards an inclusive future: interface design

Design problem: 'To develop a home automation assistive system including a scale model home taking into account inclusive aspects, the physical connection of sensors, actuators and the programmable logic controller, the inclusion of an affective avatar to create an emphatic dialog with the user and the use of a hands-free interface for motion impaired users in computer tasks'.

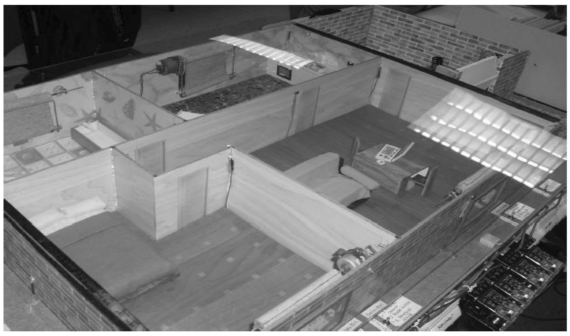

Fig. 4. Scale model prototype. This model is connected with an automatic controller, and this is connected with the graphical interface. The control modes are: automatic, manual.

HCI problem: 'To develop a complete usability test and measure task effectiveness, efficiency and user satisfaction'.

Skills: The student has to apply his engineering knowledge together with skills in design, usability engineering and automation.

Students and Tasks:

- Previous Students (course 2009/2010): two students of Electronic Engineering (development of the scale model home).
- Current Students (course 2010/2011): a student enrolled in the M.Sc. in Automatics and Robotics (integration of the display design of home automation, use of the hands-free interface and inclusion of an affective avatar, simulated scenario, facilitator task role) [29].
- Future Students (course 2011/2012): students of Design and Product Development Engineering (study of levels of automation by programming the automatic controller, usability test over the scale model).

Users and location: Engineering students of the Technical School of Vilanova i la Geltrú, Barcelona Tech University.

Once the home automation interface was built (Fig. 4), we planned an experimental test. This session was carried out in December 2009, where seven users participated in the hands-free settings configuration phase, the use of the display 'dining room' (see Fig. 5), and the use of the help system (3D avatar and voice). Afterwards, they answered a user interface satisfaction questionnaire.

As the hands-free interface includes an event graphical toolbar that appears on the screen's right side, the 'dining room' display's size was adapted (see Fig. 5). Moreover, we analyzed the compatibility between the possible actions to do

Fig. 5. Home automation assistive system prototype: functional integration of the dinning room interface (back), the pop up screen (center) with a message of the empathic avatar Alice and the hands-free interface graphical tool bar (right) to interact.

with the hands-free interface and the events needed to perform an operation on all the devices in the 'dining room'.

Before starting the test task, participants received a brief explanation on the functioning of the hands-free interface. Then the users carried out several head movements to observe how the mouse pointer followed their nose movement. We have to take into account that this was the first time users were having contact with this type of interfaces. The experimental task consisted in presenting the interface 'dining room' to the user and to request him or her to execute diverse actions.

To facilitate the user's task in this experimental study the user had the total control of all the devices. This session had two parts, first the user configured the parameters of the graphical display and then, the second part was to carry out a set of tasks. The tasks were distributed in: control actions (activate/deactivate a device); navigation actions among screens of the application; and operation mode selection actions.

We considered the interaction between the human person and the automated system and the interaction between the human and an avatar, whose task is to assist the user. The chosen avatar was named Alice, a talking head that was modelled using the third-party facial animation tool FaceGen [30] and animated using the MPEG-4 standard. The motivation for using MPEG-4 was the possibility to parameterize the facial expressions. Therefore, a number of different expressions for basic and intermediate expressions were obtained by changing just a number of parameters.

In this application Alice presents facial expressions for basic emotions, because they have been proved to be universally recognized (joy, sadness, disgust, fear, anger and surprise). Nevertheless, previous studies [31–33] showed that intermediate expressions can be perceived, but better results were obtained with expressions similar to the universal ones. The main conclusion from this output was that it is very difficult to classify emotions without a framework, or context, that explains why the avatar is showing certain expression in response to a felt emotion.

For that reason, Alice was adapted to be implemented in the system, choosing the *neutral* expression to be displayed in her face as default state. Then, according to the situation the expression changes to joy or surprise. We also added text-messages for the user to read on screen and audio messages to emphasize the information using Loquendo software libraries.

The options to select were: 'Choose the Help system'; 'Choose a language (Catalan or Spanish)'; 'Choose information over the dining room and the functioning of the devices'; 'Come back to the main screen'.

These components were embedded in the graphical interface of the home automation system and the avatar was programmed to appear by user request.

Two computers were used in the session: the first one had the application to control the house with avatar Alice in help mode and the hands-free interface. The second computer had Morae software installed in order to capture and monitor the user's activity on the first computer.

The facilitator (MSc. student) asked the user to access the help system and to follow the instructions of the avatar. For about three minutes, the user and the avatar interacted in order to help the user to understand better the home automation scenario. Then the facilitator guided the user to the kitchen, asked him or her to switch on the cooking hob and increase the temperature. If the temperature got too high, the avatar popped-up to inform that the temperature was excessive, there was risk of an incident and it was recommended to lower the temperature.

The system's control was done using the hands-free interface. Three 'functional objects' were placed on the screen waiting for an action of the user: the home automation interface, the avatar, and the hands-free graphical event bar on the right side of the screen for the user to select the desired mouse event.

There was no time limitation, but the estimated duration of the task was 240 s.

The outcome of the results is a metric of effectiveness, efficiency and satisfaction. Users showed a high effectiveness in the task, successfully completing most of the tasks. High effectiveness is considered when the user successfully completes 75% of the 24 subtasks. During the execution of the tasks we observed errors following the avatar's instructions for the actions to carry out when the avatar recommended lowering the temperature of the cooking hob: in some cases users did not decrease the temperature or they navigated to other areas of the home without turning off the hob. To avoid ambiguity and confusion we are redesigning the interface and the help information module to make clearer the actions to carry out.

In regard to efficiency, the minimum duration needed to perform the task was 193.72 s, the maximum was 290.5 s and the average time with a standard deviation was 233.89 ± 37.12 s. Two out of the seven users completed the experimental session with a duration above the average. The subtask that required more time for all users was when the user asked for information on the operation of the home automation devices. Regarding this fact, we should analyze the efficiency measure and decide whether to analyze the user's efficiency independently to the avatar's efficiency.

Finally, regarding the satisfaction measurement, we adapted the questionnaire from the System Usability Scale [34]. In this case, this questionnaire presented eight questions in form of a four-point Likert scale and three open questions where the user describes his or her impressions. In particular the last three questions with Likert scale were: assess the quality of the graphical interface, the ease of use of the hands-free interface and the quality of the help system (avatar). The possible answers were: low (1), fair (2), good (3) and very good (4).

In the qualitative assessment about the quality of the home interface one user considered that it was necessary to apply changes to improve the functionality of some devices (increase the object's size, change several graphical icons). Currently, we are modifying graphical objects of the 'Dining room' display in order to improve its use with the hands-free interface. Six out of seven users evaluated the quality home automation interface as good, though several users commented the possible improvement towards more realistic models (see Fig. 6).

In the assessment of the use of the hands-free interface in the eighth question, five users out of seven considered that it was necessary to improve the accuracy. However, in the eighth question (see Fig. 7), in the one that the use of the hands-free is assessed, five out of seven users evaluated the use of this interface as good or very good. Once more, users were novel in the use of the hands-free interface. Despite the difficulties, the overall effectiveness was high. Finally, five out of the seven users considered the help system of the avatar Alice as good and two of them as very good (see Fig. 8), which encourages us to continue analyzing our help system from the point of view of the development of an emphatic avatar and the development of applied research projects in advanced natural interaction in the home automation domain.

In this sense, a study that evaluates the relationship between facial expression of the avatar and user response should be performed to analyze why some users failed to follow Alice instructions. Also, by giving Alice a defined personality, more facial expressions would be elicited in different situations. The reason for this is that personality would act as a modulator of the emotions, enhancing them or decreasing them [33]. Hence perception of the users will be enhanced and the help instructions better understood and fulfilled.

Mood is another psychological aspect that we are studying at the moment, because it can influence the affective response of the avatar, and therefore its facial expressions. Although an assistive avatar should not present very extremes changes of mood, it would be interesting to see how the mood would be useful to decide the performance of other tasks; or to implement avatars with different functionalities.

In future studies we want to develop coordinated tasks between the Universitat of Lleida and the Technical School of Vilanova i la Geltrú. The local area network and the capabilities of the Morae software and the Skype software allow us to define coordinated activities: some students of the Technical School of Vilanova can control the scale model and some students of the Universitat of Lleida can observe the scenario and develop remote usability studies.

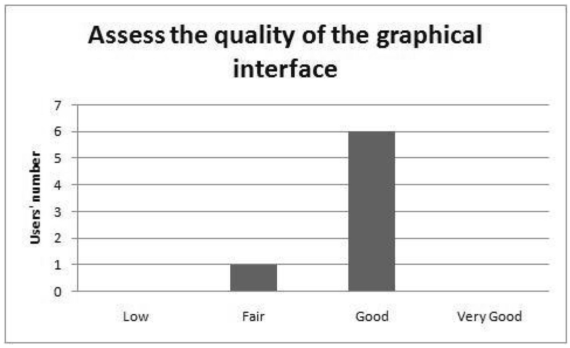

Fig. 6. Seven users have a good assessment of the home interface quality.

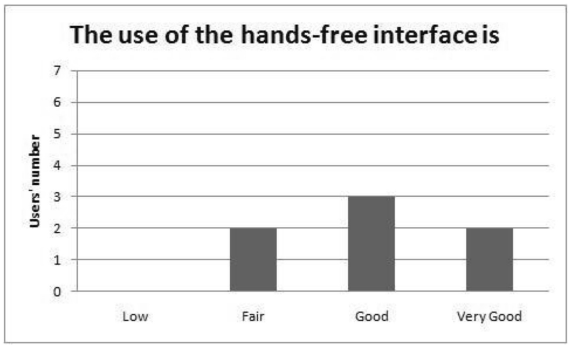

Fig. 7. Six users have a good/very good level of satisfaction.

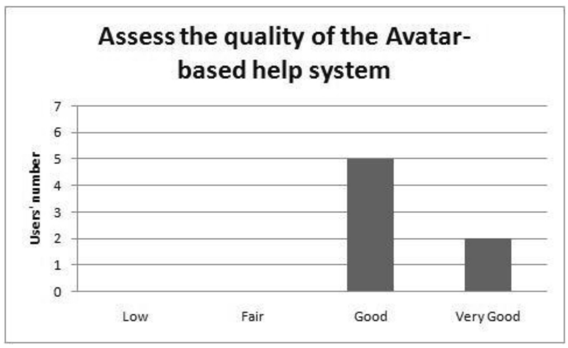

Fig. 8. Assessment of the help system.

3.2 Towards an inclusive future: home automation design

The second example is a project carried out in the Industrial Design subject of the MSc HCI by students with different backgrounds: i.e. a telecommunication student with a computer science student, or a psychologist with a computer science student.

HCI problem: 'To develop a complete model process approach related to home automation systems, defining users profiles, a technology acceptance model, a set of possible scenarios, the human-system interaction and possible usability studies'.

Design problem: 'To detail the home automation assistive technology and design new inclusive interfaces'.

Skills: The student has to apply his or her engineering knowledge together with skills in design, usability engineering and automation.

Students and Tasks:

- Previous Students (course 2009/2010): two students of the Master's degree in HCI (prototype design of a vibrating bracelet help system for deaf people) [35].
- Current Students (course 2010/2011): two students of the Master's degree in HCI (prototype design of an inclusive home) [36].
- Future Students (course 2011/2012): students of the Design and Product Development Engineering degree (design and development of assistive products).

Users and location: HCI students of the Universitat of Lleida.

In the MSc, they have to work together to achieve solutions to a problem applying a human centred product design approach in an effective way.

The Fig. 9 shows an example of an interface for deaf people in home automation systems. The requirements analysis show that there is a lack in the development of assistive technology for deaf people and hearing impaired people. In this case it is necessary the reinforcement of information channels such as the tactile/haptic and the visual channel. A technological relationship with sensors, actuators, microcontrollers and communication technologies allows the development of this type of help systems. The vibrating bracelet has a set of different colour signals. When an event appears, for example, the washing machine has completed the task, a vibrating signal and a coloured light is activated. Each event has its own colour.

These students are experts in computer science and HCI. They commented in class that in the development of a vibrating bracelet physical prototype it would be necessary the collaboration of electronic engineering students to develop the required micro-electronics and the collaboration with graphical designers to develop a friendly product.

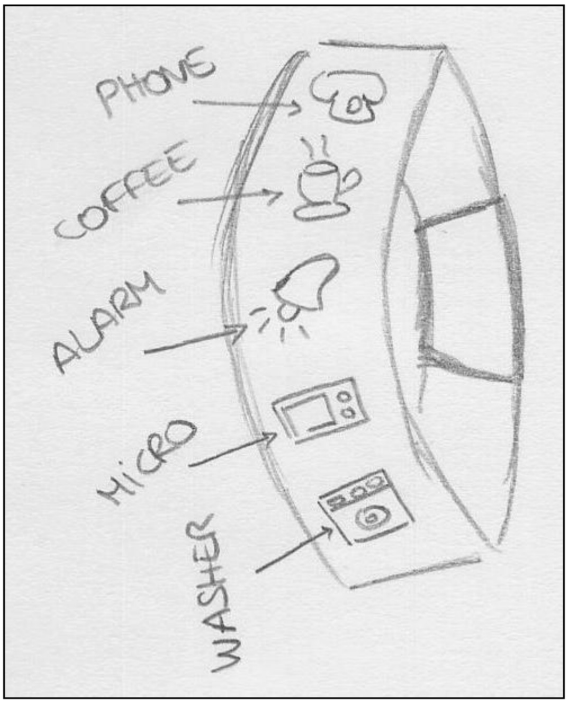

Fig. 9. Vibrating bracelet paper prototype.

The Fig. 10 shows an example of two layout of an inclusive home. In this context the team group needs to develop design skills in order to define a home for disabled people. In the requirements analysis stage, the group can elicit the technological needs (wheelchair, sensors, automation of blinds and lights, etc.). The first layout is an example of how to pre-adapt the physical space to the inclusion of assistive technologies. The second layout is an example of an adapted design of the physical space to a wheelchair user. They are not only theoretical exercises as one student also works in the design department of a Spanish company whose aim is to develop inclusive solutions for people with special needs in our country [37].

4. Conclusions

We are working in degrees and postgraduate engineering programs with human-centred and design approaches, and results suggest that we are training skilled and effective engineering graduates prepared for working in our society offering professional services.

The projects presented in this paper show that is possible an effective an integrated project development taking into account the product design and the

Fig. 10. The top layout is a pre-adapted design. Some walls are mobile; access to each living room is easy. The down layout is an adapted design for a motion impaired user: a gantry system provides the user the mobility from bed to the wheelchair.

human-centred approach. In fact, for the good development of these projects it is necessary:

- a well defined structure where teachers from diverse domain collaborate with each other;
- a good laboratory infrastructure for rapid prototype development;
- a rapid technology transfer to society;
- collaboration between teaching and research activities.

Other projects are being carried out within this two university programs (Technical School of Vilanova i la Geltrú and Universitat of Lleida; Technical School of Vilanova i la Geltrú and the University of the Balearic Islands).

The authors' opinion is that an effective synergy is beneficial in the teaching of the future Engineers.

The Technical School of Vilanova i la Geltrú has previous experience in multidisciplinary team projects. Since the year 2008 in collaboration with the Engineering College of Copenhagen, there is an European Project Semester in our university. Students from different European universities develop an intensive seminar in three weeks and develops a final project [38]. For this reason, our university is preparing a new International Design Project Semester and is planned to start in February 2012 [39]. The aim of this course is to attract towards design engineering European students and develop final projects in human-centred design domain.

Acknowledgments—This research was partially supported by a research program in computer vision FRIVIG. A1/037910/11, granted by MAEC-AECID (a Spain and Latin America interuniversity research and cooperation program). This research was partially supported too by the Human Centred Design of Supervisory Control Systems project, granted by the Barcelona Tech University (year 2010).

References

1. Y. Toft, P. Howard and D. Jorgensen, Human-centred engineers—a model for holistic interdisciplinary communication and professional practice. *International Journal of Industrial Ergonomics*, **31**, 2003, pp. 195–202.
2. D. Schaefer, J. H. Panchal, S-K. Choi and F. Mistree, Strategic design of engineering education for the flat world, *Int. J. Engineering. Education*, **24**(2), 2008, pp. 274–282.
3. M. Press and R. Cooper. The design experience. The role of design and designers in the Twenty-First Century. Ashgate Publishing, 2007.
4. D. Oswald. Towards a redefinition of product design and product design education. International Conference on Engineering and Product Design Education, Norwegina University of Science and Technology, Norway, 2010.
5. S. Rosenbaum, C. E. Wilson, T. Jokela, J. A. Rohn, T. B. Smith and K. Vredenburg. Usability in practice: user experience lifecycle-evolution and revolution. CHI'02 extended abstracts on Human Factors in Computing Systems, 2002, pp. 898–903.
6. G. Gediga, K.-C. Hamborg and I. DüntschTeh, IsoMetrics usability inventory: an operationalization of ISO 9241-10 supporint summative and formative evaluation of software systems, *Behaviour and Information Technology Journal*, **18**(3), 1999, pp. 151–164.
7. M. Maguire, Usability, In *Human factors for engineers*, C. Sandom and R. S. Harvey (eds), IET, 2009, pp. 257–268.
8. B. Shackel, Usability—Context, framework, definition, design and evaluation, *Interacting with Computers*, **21**(5–6), 2009, pp. 339–346.
9. M. Maguire, Methods to support human-centred design, *International Journal of Human Computer Studies*, **55**, 2001, pp. 587–634.
10. ISO. ISO-13407-1999. Human-centred design processes for interactive systems, 1999.
11. ISO. ISO 9241-210. Ergonomics of human-system interaction—Part 210: Human-centred design for interactive systems, 2010.
12. T. Zhang and H. Dong, Human-Centred Design: an emergent conceptual model. Proceedings of Include09. Royal College of Art, London, April. At URL: http://www.hhc.rca.ac.uk/2084/all/1/proceedings.aspx, 2009.
13. P. Ponsa, B. Amante, J. A. Roman, S. Oliver, M. Díaz and J. Vives, Higher education challenges: introduction of active methodologies in engineering curricula, *Int. J. Engineering Education*, **25**(4), 2009, pp. 799–813.
14. P. Ponsa, R. Vilanova, A. Gomà and A. Pérez, The use of role playing in engineering curricula: a case study in human-automation systems, *Int. J. Engineering Education*, **27**(3), 2011, pp. 625–634.
15. Technical School of Vilanova i la Geltrú. Design and Product development Engineering curriculum. At URL: http://www.epsevg.upc.edu/graus-i-enginyeries-a-lepsevg/graus-enginyeria-ambit-industrial/grau-en-enginyeria-de-disseny-industrial-i-desenvolupament-del-producte, Barcelona Tech University, 2010.
16. Accessibility chair. Projects, http://www.catac.upc.edu/?seccio=4, Accessed 15 December 2011.
17. 4all-L@b. Laboratory of usability, http://www.epsevg.upc.edu/cetpd//4all-lab/es/index.htm, Barcelona Tech University, Accessed 15 December 2011.
18. CETpD, Technical Research Center for dependency care and autonomous living, http://www.epsevg.upc.edu/cetpd/. Barcelona Tech University Accessed 15 December 2011.
19. HIS. International Conference on Human System Interaction, http://hsi.wsiz.rzeszow.pl/, Accessed 15 December 2011.
20. ISD. Interactive design systems laboratory, http://www.epsevg.upc.edu/coneix-lepsevg/equipaments-i-serveis/equipaments?&labcod=AL116, Technical school of Vilanova i la Geltrú, Barcelona Tech University, Spain, Accessed 15 december 2011.
21. C. Manresa-Yee. Advanced and natural interaction system for motion-impaired users. Doctoral Thesis from the Balearic Island University. 2009.
22. SINA. Advanced and natural system interaction, URL: http://dmi.uib.es/~ugiv/sina/?m=inicio&=p1. Universitat Illes Balears, Spain, Accessed 15 December 2011.
23. Techsmith. Morae software, http://www.techsmith.com/morae.asp, Accessed 15 December 2011.
24. L. M. Muñoz, P. Ponsa and A. Casals, Design and Development of a Guideline for Ergonomic Haptic Interaction. Human-Computer Systems Interaction: Backgrounds and applications 2, Part 2, Z. S. Hippe, J. L. Kulikowski and T. Mroczek (eds.), *Series Advances in Intelligent and Soft Computing*, **99**, Springer, 2012, pp. 15–29.
25. Evaluation, Evaluation Questionnaire Tool, URL: http://qssi.epsevg.upc.edu/, Technical School of Vilanova i la Geltrú, Barcelona Tech University, Accessed 15 December 2011.
26. Gengrup, Interactive Systems Design. Internal web, https://gengrup.upc.edu/DSI/, Accessed 15 December 2011.
27. Master. Master's degree in Human-Computer Interaction. Universitat de Lleida, http://www.ipo.udl.cat/en/index.html?_locale=en, Accessed 15 December 2011.
28. UsabiliLAB. Usability Laboratory of the HCI research group GRIHO, http://griho.udl.cat/ca/infraestructures/infraestructures.html, Accessed 15 December 2011.P. Ponsa. Design of human automation interactive systems, http://www.epsevg.upc.edu/hcd, Accessed 15 December 2011.
29. J. Gómez. Home automation inferface study of use with the

incorporation of an interactive help system. Thesis Master of the Automatic Control Department of the Barcelona Tech University, 2010.
30. FaceGen, Realistics Faces, http://www.facegen.com/, Accessed 15 December 2011.
31. D. Arellano, J. Varona and F. J. Perales. Generation and visualization of emotional states in virtual characters. In *Computer Animation and Virtual Worlds*, **19**(3–4), 2008, pp. 259–270.
32. D. Arellano, I. Lera, J. Varona and F. J. Perales, Integration of a semantic and affective model for realistic generation of emotional states in virtual characters. International Conference on Affective Computing & Intelligent Interaction (ACII09), Amsterdam, Netherlands, 2009.
33. D. Arellano, N. Bee, K. Janowski, E. André, J. Varona and F. J. Perales. Influence of Head Orientation in Perception of Personality Traits in Virtual Agents. In AAMAS 2011, Taiwan, May, 2011.
34. J. Brooke, 'SUS: a 'quick and dirty' usability scale'. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & A. L. McClelland. *Usability Evaluation in Industry*, London, Taylor and Francis, 1996.
35. A. Amore and Ll. Massip, Ll, Vibrating bracelet protoype: design and discussion, Final project inside the Industrial Design subject, Master's degree in HCI.2010.
36. E. Ballesteros and T. Martínez, Prototype design of an inclusive home. Final project inside the Industrial Design subject. Master's degree in HCI, 2010.
37. BJ Adaptaciones, http://www.bj-adaptaciones.com/en, Accessed 15 December 2011.
38. EPS. European Project Semester. Technical School of Vilanova i la Geltrú, http://www.epsevg.upc.edu/index.php?option=com_content&view=article&id=280&Itemid=374, Accessed 15 December 2011.
39. IDPS International Design Project Semester, P. Ponsa Human Centred Design Course, Technical School of Vilanova i la Geltrú. http://www.epsevg.upc.edu/idps/, Accessed 02 March 2012.

Professor Pere Ponsa works at the Technical Engineering School of Vilanova i la Geltrú (EPSEVG) at the Automatic Control Department (Barcelona Tech University, Spain). Professor Ponsa applies problem/project based learning to Engineering studies. In addition, he develops research in human-centred design and human-automation interaction.

Professor Cristina Manresa-Yee works in the Math and computer Science Department at the Universitat Illes Balears, Spain. She has been working in the development of assistive technology for motor impaired users.

Professor Diana Arellano works in the Math and computer Science Department at the Universitat Illes Balears, Spain. She has been working in the development of an emotional avatar and home automation projects.

Student Johanna Gómez works at the Technical Engineering School of Vilanova i la Geltrú, Spain. She is a current student of the MSc Automatic Control and Robotics.

Student Àlex Pérez works at the Technical Engineering School of Vilanova i la Geltrú. He is a current student of the Master's degree in Human-Computer Interaction (HCI) at Universitat of Lleida, Spain. He is the head manager of senTIC, a new engineering enterprise in information, communication and technology, http://www.sentic.es.