Professional Skills in International Multidisciplinary Teams

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Abstract: The international engineering education programs must guarantee that a graduate possesses the attributes to work effectively within a global environment. It is therefore necessary to establish the competencies required for this effective working within an international context. The International Design Project Semester (IDPS) program integrates technical knowledge and professional engineering skills from a point of view of multidisciplinary and international teams. The preliminary results shows that it is possible to integrate international students in the classroom using the model role playing (each team has his own role and it is necessary share and collaborate with other teams) and next, observe the acquisition of skills of the engineering students (creative thinking, interact with others, dealing with conflicts, positive attitude).

Key words: Multidisciplinary teams; professional skills; human centred design.

1 Introduction

The current high education involves a shift from teaching to learning, requiring students to take on an active role, developing autonomy and a capacity for life-long learning [1]. In this context, courses must be designed by specifying the learning outcomes that students are expected to attain, expressed in terms of different types of competences that are developed throughout the learning process.

The Delft University in engineering design courses show a set of competences related to design methods, tips and deliberations inside a design guide [2]. These competences are:

- Planning & Design
- Communication & Design
- Reflection & Design
- Traps, Tricks and Strategies & Concept Development
- Teamwork & Design
- Finding Information & Design

Following the competences of Teamwork and Design, current products become increasingly complex and therefore cannot be designed by one person alone. They require diverse expertise in different fields of engineering, social sciences, interaction design, human factors, manufacturing, logistics, marketing, etc. The normal way of developing products is in teams where different people contribute part of the knowledge and effort [3].

The Tuckman's team development model shows how improve the relationship between behaviors and tasks using a fourth steps model process: forming, storming, norming and performing [4]. There are a set of basic action in order to move from one step to the next: set a mission, set goals, establish roles, listen to each other, everybody works actively, share responsibility; understand the skills of the other members of the group, etc. In this context, the teaching role is monitoring the scenario, users, tasks and give feedback when the system is functioning in an abnormal mode. A model that only takes into account the engineers competences and the teaching competences is not enough. The development of competencies for engineers within a global context is necessary. To study the professional engineering competencies there are two main international systems: the Engineers Mobility forum and the European Federation of National Engineering Associations, In this last system, the graduate attributes are specified by the EUR-ACE (EURopean Accredited Engineer): knowledge and understanding, engineering analysis, engineering design, investigations, engineering practice and transferable skills [5].

Other important fact is the effective management of a team. The Belbin team role theory shows the effective management of teams: how a team can succeed or fail: from tackling language barriers in international firms, to addressing change strategy, to personal development of young people [6].

From theory to practice, there is a technique called role playing that is very useful in engineering design. The Role-playing technique can be useful creating products ideas and concepts. Following again the

recommendations of Delft University, this technique can help us in developing and determining the interaction between user and product. In a role-playing technique, designers perform the tasks of the interaction by means of re-enactment.
With the aim to study professional skills in international multidisciplinary teams [7], this paper show in the second section a brief summary related to the engineering degree of industrial design and product development and the connection between this Spanish engineering curricula with the International Design Project Semester, IDPS, an European mobility program that allow us define the context of international design teams [8]. As a part of the IDPS program, The Human Centred Design HCD subject is presented in the third section of this paper [9]. The fourth section explains a study case in the use of the role playing technique detailing the interaction quality between three team designers working in collaborative tasks [10]. The fifth section explains the set of final projects inside the IDPS program and the relationship between the contents of these projects with human-computer interaction domain (HCI) [11]. The sixth section shows details of a final degree project related to the design of small graphical interfaces. In this sense, an informal evaluation study of three tablets PC is presented with the help of three designers in the role of facilitators and nine industrial designers in the role of end-users. Finally, conclusions and future lines are shown.

2 Engineering degree in industrial design and product development and the International Design Project Semester

Inside the engineering degree in industrial design and product development in the technical school of Vilanova i la Geltrú, we have been working the last four years in the inclusion of human centred design methodologies inside the curriculum [12]. In the first academic year, we have the “Accessibility and Innovation” subject where the students follows a model process engineering approach taking into account the design of interactive systems and design for all approaches [11]. This subject consists of two parts. On the accessibility part, the universal design is considered. In the innovation part is taken into account and addressed entrepreneurship case studies for creating a business plan. Responsible defining a case study associated with a company or an entity in the region each academic course. This scenario arises in the course so that students apply theoretical concepts to practical case execution. To develop the case study the role playing technique is considered, where each of the agents has a specific role:

- Teaching: tracking and monitoring role
- Company or entity client role, is the agent that brings the case study in question
- Students: In groups of four people and the role of designers and developers of solutions

In the academic year 2013/2014 the company / entity is the Library of our center, which facilitates a number of problems associated with optimizing the physical space for group work or individual students, improved physical access for people with disability and reorganizing work of librarians (redesigning the information system and the interaction with the library users).
During the third academic year, there are a set of subjects in user centred design. The subjects are: “Human-System interaction”, “User centred design and inclusive design” and “Usability and accessibility engineering”. The “Human-System Interaction” subject shows the basic methods and tools from the point of view of interaction design. The “User centred design and inclusive design” explains the principles for universal design. Finally, the “Usability and accessibility engineering” subject show methods and tools in order to study the user experience with new product and services.
We have the help of the Accessibility Chair of the Barcelona Tech University and the help of the Specific Research Centre for Dependency Care and Autonomous Living belongs CETpD, both in Vilanova i la Geltrú town and the Spanish Human Computer Association AIPO. This approach between University and entities gives a clear relationship between teaching, research and technological transfer, so that the design student can increase their knowledge of methodology, tools and applications in the field of assistive technology.
At the end of this curriculum the students must develop the final project. One example of final project is the *design beach* project [13]. This project was launched in order to facilitate the ability of entrepreneurship among design students, in the sense of facilitating autonomy to develop consulting activities, facilitate the connection between universities and companies preparing a job and putting together supply and demand.
Finally, during the last academic year, these engineering design students have the possibility to begin the International Design Project Semester beside international students.
The *International Design Project Semester* (IDPS) is an innovative training program which addresses the new professional demands engineers of the future will face. The program focuses on industrial design and

adheres to the learning outcomes established by the European Higher Education Area. The IDPS is a one-semester course designed to train third-year industrial design engineering students to work in international teams. In the IDPS, an international team of students works on a real-life project. The IDPS has two complementary parts:

- **Courses** (12 ECTS): Four core courses are offered during the semester. Each of these is made up of 20 contact hours plus assignments and a final evaluation.
- **Final degree project** (18 ECTS): During the semester and under the guidance of an academic tutor, an international team of four to six students works on a real-life project.

The following courses are included in the IDPS study program: Ecodesign, Social Sustainable Design , Human Centred Design, Visual Business, Graphical Visualization of systems, Minding the gap and Spanish language for Foreigners. The IDPS will enable students to apply technical knowledge acquired during the previous years of their engineering education to real, practical projects. The program also offers the opportunity to learn to work in teams in an international and multicultural atmosphere, similar to that found in many companies today.
In the current edition of the IDPS program, the 14th engineering students came from Europe (Denmark (1), Sweden (2), Ireland (2) and Spain (2)) and Latin-American (Brasil (3) and Mexico (2)).
Next sections show in more detail the relationship between the IDPS program, teamwork and role playing technique.

3 Human centred design subject

The engineering students are spared into three groups attending that they are just arrived to the Technical School and they must work together in the IDPS project along the semester (February to July). The HCD course was developed as a three day intensive subject (February 2013) with a total number of 11 engineering students (Industrial Design, Business Management). The criteria for the group composition are: one HCD group has the same members that a IDPS final degree project; no more than one nationality in the same group; mixing male and female students inside a group; put in the group multidisciplinary engineers.
The previous background of these students in HCI is poor. Some of these students show basic knowledge about human factors and ergonomics, however there is a lack of knowledge in HCI methods, specifically in the concept of model process engineering (software engineering), evaluation methods, user experience and usability. For this reason, the aim of the HCD subject is show the basic methods and tools of HCI and project the relation of HCI and design beyond the subject, in the sense that the future design engineer understand that he can include the human centred design approach, the interaction between the human and the product designed and the HCI methods along their professional activities [14].
The course syllabus:

1 Basic concepts: this first chapter introduces the student into the teaching framework. Key principles of HCD. Methods for HCD. ISO ISO 9241-210 (2010) Human centred design for interactive systems.
2. HCD in engineering curriculum: this chapter explains the idea of a holistic approach and a synergic approach between, human factors, design and engineering taking into account how introduce the basic concepts inside the engineering curriculum.
3. HCD Laboratories: this chapter introduces a set of experimental laboratories in human computer interaction, usability and interaction design related to other classical engineering laboratories.
4. Human-automation systems: this chapter presents safety complex systems in order to establish the levels of interaction between human and automation (manual control, traded control, supervisory control, shared control, full automation).
5. Project Examples: the natural interaction project. In this study case, a natural and advanced interface is presented, trying to show how is possible take into account end users with motor impairments, engineers and human factors experts in the design of new technology.
6. Project Examples: the Avatar-based help project. In this study case, an artificial agent is presented in order to establish a good interaction between the human and a home automation system (scale model inside the Interactive system design laboratory.

The subject has been structured in two methodological lines: theoretical class and role playing approach. In the first part, the teacher explains the basic concepts of human centred design, with exercises and a visit to the Interactive system design laboratory. In the second part, within the use of the role playing technique, the class is divided in groups of 4 members. These groups, plan, develop and execute a

research work in the application of human centred design into a specific social or industrial real case study. Finally, the group propose in a presentation the best methods and proposals.
Next section shows a study case and the teaching group skills.

4 Study case in the classroom: assistive technology

Some case studies were considered in the application of model role playing in the classroom. We show a study case in assistive technology.

4.1 Study case in three steps

This study case has three steps:

- A Discussion topic: Design of a vibrating bracelet for deaf people and hard hearing people. This is a portfolio supplied by the teacher of two pages.

Role assignation: the group 1 in the role of End User. The group 2 in the role of Industrial designer. The group 3 in the role of Services Enterprise.
Before to begin: It is necessary define important aspect of deaf and hard hearing people (group 1), to develop a prototype of a vibrating bracelet (group 2) and make a list of services for deaf people (group 3).
Next: it is necessary to prepare a report and an oral presentation
- B During the role play: The instruction is: Listen the other role players. You can attack and defend (please, be polite) and discuss. Try to use expressions for expressing opinions, interrupting, agreeing: "You're right; I'm afraid, you're wrong, In my opinion, I'm afraid I disagree, Can I add something here?, Whatever you say.
- C Final Assessment. Is well considered the interaction between the other players, the peer assessment and the quality of the final report.

Fig. 1. From left to right: a member of each group (end-user, services, industrial design) writing the features of each role. This is the previous task before to begin the discussion all together within the final cooperative task between groups..

4.2 Satisfaction questionnaire

The vibrating bracelet designed by group 1 allows us to prepare a satisfaction questionnaire. In this work, we are using the System Usability Scale. The SUS system usability scale is a 5 point Likert scale that allow us to measure the user satisfaction and the perceived ease of use of one product [15]. The score (from 0 to 100) show in Figure 2 a clear acceptation of the product designers by our engineering students.

Fig. 2. Application of the System Usability Scale

4.3 Teaching group skills

From the point of view of develop a teaching approach to group skill we are following the Teamwork evaluation form from Lingard and Barkataki [16]. Within a group, the member 1 shows a poor communication with the other group members, however complete individual assignments on time; member 2 share knowledge with others in the relationship between human factors and industrial design; member 3 show ability in the oral presentation with a good synthesis in relevant aspects of end-user role and early feedback to the rest of the class; member four has ability in prototype development. With the aim to define the user requirements, the group 2 shows good interaction with the group 1. In the group 3 we observe a positive attitude to do research and gather relevant information.
At the end of the IDPS courses, the students groups begin the final degree projects. The next section shows the complete final degree projects.

5 Final degree projects

In the current edition of the IDPS program and the European Project semester EPS, the total number of projects is ten. Students have four months to develop the project within a continuous feedback by teacher,

industrial supervisor or research supervisor. "The autonomous acoustic buoy" is focused in the electronic development of an acoustic buoy and is not related to HCI. "The Motorization and improvement of a wheelchair" follows the classical point of view of an engineering project: when the wheelchair prototype is finished then is used by a child with motion impairment. The "Chloride reduction from brackish water by hollow fiber supported liquid membranes (HFSLM) using ionic liquids as a carrier" project is related inside the chemistry domain and it's not related to HCI. "The outboard electric propulsion" project is related to the design of an electric propulsion system for the local fishing industry. This project includes a chapter related to ergonomics (anthropometrics dimensions of arm and hand) related to the use of the outboard system. "The Creating a new urban element to turn Vilanova i la Geltrú into a Smart City" project is focused with the creation of an electronic urban node. The second part of this project is developed for industrial designers and takes into account an user-centred approach (display design, ergonomics considerations related to anthropometric dimensions of Spanish population, meeting with experts, surveys to the citizens). "The WC cubicle" project takes into account the design of a WC cubicle for Indian population within the collaboration of a famous Spanish enterprise leader in this domain. In this sense, the industrial designers analyze cultural aspects, technological aspects and emotional aspects (acceptation of the product, empathy). Finally, "Design of small interfaces" project follows a human-centred approach in the context of improve the relationship between design methods and HCI methods and within the collaboration of teachers from three Catalan Universities. This project has an analysis requirements phase (context, market, trends in the design of small interfaces), a development of a guideline for small interfaces and informal usability studies with Tablet PC trying to understand and find usability problems.
The next section shows in more detail an example of a study case inside this last project.

6 Final project example: the use of tablet PC and design of small interfaces

Informal evaluations can be done with nothing more than the knowledge you have from experience [17]. With the aim to detect usability problems in the use of Tablet PC, in this section the method called five step to a user-centred expert review is applied in the study of three Tablet PC. The Tablet 1 is a low cost 5" Spanish Tablet. The Tablet 2 is a famous and competitive 7" Tablet. The Tablet 3 is a 8" Tablet adapted to the use of e-book readers. The authors of this method are Whitney Quesenbery and Caroline Jarrett [18]. The method follow a sequence of steps for example "Who is using this product" and thinks related to relationship, conversation, interaction and appearance. This informal method is important because is the first step to establish a relationship between the industrial design methods and the HCI methods [19] and allow us to prepare a usability study.
The objective of the test is to study the quality of use of a Tablet PC [20-23]. The focus isn't on the user behavior but on usability problems with the use of new technologies. The users group that was interviewed was a sample of nine EPS students with ages ranging from 19 to 25 years old. Each student had to complete 16 tasks on each tablet, and after answer 7 questions about the hand posture preference, the preferred tablet, finger part used, etc. This experimental test has a duration time of 45 minutes.

The set of tasks are:

1 Turn on

2 Unlock

3 Change the language; put the Tablet in Spanish

4 Change the language: put the Tablet in English, after continuous the test with the Tablet in English

5 Connect on the internet

6 Open Youtube from the browser

7 Search for the video: "IPhone 5 (parody)"

8 Open this video

9 Increase the volume

10 Put it full screen

11 Stop the video and exit internet

12 Access to the rest of applications of your Tablet

13 Take a photo with the camera

14 Access to the gallery folder

15 Close all applications

16 Turn off

From the point of view in the assessment of these devices, here we have the comments of three users:

- The Tablet3 was easy to use and handle with minimal icons and a clear simple interface however it takes time to turn it on;
- With the Tablet1 it's a totally different interface thus was a lot harder to figure out the buttons but once you get used to it quite nice;
- The Tablet2 was very similar to the Tablet3 as I was able to pick out and recognize however they were much smaller and sometimes hard to see and press. This Tablet don't have back camera.

A discussion with users shows that the weight of Tablet 3 is considerable and is difficult to hold the Tablet. For one female user is difficult to hold the Tablet 3 with the two hands and do tasks because she has a little hand and need to do a physical effort with the fingers. So it's important taking into account some human factors aspects related to the use of the Tablets (the fat finger problem, the size of the human hand, the thickness of the index finger).

The 66% of the interviewed users prefer the hand posture "Thumb Extended with Thenar Support", 25% prefer "Thumb Wrap' posture" and 9% prefer "Flat Hand' posture" and 75% of the interviewed users use fingertip, the rest, 25%, use finger pad.
The 50% of the respondents have problems with the size of the targets; the majority think that it is small, against 42% that don't have problems.
The 50% has vision problems with Tablet 1, 17% with Tablet 3 and nobody has with Tablet 2, and also 33% don't have vision problems at all.
One of the questions was about the preference of the tablets, and the respondents have to analyze everything that is involved and justify. 58% sad that prefer Tablet 2, 34% Tablet 3 and only 8% Tablet 1.
Moreover, 33% of them prefer other devices to complete similar tasks.
Half of the respondents didn't have previous knowledge about mobile devices and 75% don't use tablets, but 25% said that depending on the tasks the tablet is not the first choice, for example to work and research the computer is still preferred.
If we compare the average time of the 16 tasks the fastest one is Tablet 3 (3 minutes in total), then Tablet 1 and 2 with a similar time (3,4 minutes).

6.1 Satisfaction questionnaire

The SUS was applied to 9 EPS students after they operated 3 different tablets and some conclusions were made based on the data. All students disagree or strongly disagree with this 3 sentences: 4- I think that I would need the support of a technical person to be able to use this system, 8 - I found the system very cumbersome to use, 10 - I needed to learn a lot of things before I could get going with this system (see Figure 3). All students agree or strongly agree with this sentence: 5 - I found the various functions in this system well integrate.
The users found some difficulties on the operation of the system because sometimes the interface and what they are supposed to do is not so clear, so they agree that they have to get used to the interface first and then they can operate it quite well, but they recognize that the tablets are an excellent tool for business, studying or entertainment. The test shows that the tablets have an average score of 76.94.

Fig. 3. SUS in the use of Tablet PC

For further information about this project, the references [24 and [25] show in more detail the final presentation of this IDPS project with a video where the students explain this learning experience.

6.2 Project assessment

From February to June, we have meetings with the students each fifteen days. In these meetings the aim, the objectives, the plan, and the development of the project are discussed and revisited. The students have a mid-term defense and a final presentation, both with international teaching members in the jury. Each

student explains his contribution to the project, his role and how to contribute to achieve and effective project. The design of small interfaces project has two parts: in the first part the students focused the aim in study the market, the population, trends in the design of future smart interfaces., in the second part the students develop HCI tools (a guideline for the design of small interfaces, usability testing in the laboratory with the use and the comparison between three tablet PC). The Figure 4 shows a smartphone prototype developed with the MockApp tool. This prototype is examples of a high fidelity prototype were the users have full interactivity. The Figure 5 shows an example of application of the small interface guideline into some real smartphones and tablets. The aim is develop research studies in how improve the quality of these interfaces. This aim is out of scope of this paper [25].

Fig. 4. Smartphone prototype

Fig. 5. Application of a prototype of the guideline to four smartphones and three tablets

This is the point of view of the students:

"We found the Design of small interfaces project to be a challenging and rewarding experience. Through it we gained valuable experience in areas such as teamwork, time keeping, work sharing, and responsibility. We learned more about my own skills and strengths throughout the course of the project and learned how we could bring them to the table and benefit the team. We believe it was an excellent experience that allowed us to learn from other people and get an insight into different ways of thinking, cultures and work ethics. We meet many interesting people and feel we gained from their experience and knowledge in different fields and backgrounds.
We felt this project was rewarding as it deals with the current and future rise of smart technology a subject we show great interest in and enjoy learning more about. The project allowed us to dive right into the world of interface design and help us develop our skills as a designer while aiding areas were our strengths do not rest. The project makes us become more competent in areas such as human centred design, an important topic for any designer, and gained not just as a designer and engineers but as a person also."

From the point of view of the teaching, the teamwork is good previous the mid-term defense. The students have positive attitude and initiative. After the mid-term defense the motivation decreases, perhaps because the second part of the project is related in human computer interaction and the students don't have a enough background. They need to discover and it's not ease for degree students begins in HCI research. For this reason, we developed a meeting the 21 th of May with the project supervisor Toni Granollers and two PhD students from the University of Cauca, Colombia, with the aim to help the students in this research .In any case, the final degree project has good level.
We have peer assessment inside the methodology. Students can put a mark from the contribution of the other members of the group in the project. In this case, all the answers are the same: students don't want to say that one member of the group is better to the others.
The final presentation is a problem for two members of the group. These members show a natural attitude as a leader of the group, or as an expert in human factors (we can appreciate this fact along the meetings). However in the final presentation, they have problems to communicate with the audience. After this presentation is finished, the project director has the possibility to talk with the jury, explain his opinion and put a mark for the assessment of each member team.
The final assessment of the IDPS program takes into account the mark of the courses and the mark of the final degree project. With the feedback of this current edition, the IDPS managers, local and international teaching, point of view of students, we are revisiting the methodology with the aim to improve the methodology.

6.3 Soft skills

To sum up the previous section, the next figure show a list of soft skills and the classification of the members of the group. The answer is low, medium or high. In the context of this final degree project the student 1 and student 2 shows a positive attitude, essential to achieve the success of the project. The student 1 show a natural leadership: this student pays attention to the details and tries to improve always the quality of the project. The student 3 has a good attitude, however it's not punctual in all the meetings and the motivation in these meetings is low. Students 1 and 4 came from Brazil and student 3 came from Mexico: they have a good level in communication skill in English Language. Student 2 came from Ireland and has a poor level in Spanish (perhaps it's not important because the official language of the IDPS

program is English). The assessment of soft skills of students 2 and 4 is medium and in many occasions is low. In this context, the teamwork of students 2 and 4 is poor related to the other members of the group. We don't have a correlation study between the soft skills and the academic/technical results in written exams for these students, however all these students have a high score in the final assessment of the IDPS program.

Table 1. Assessment of soft skills

7 Conclusions

An study of professional skills in international multidisciplinary teams is presented. The engineering degree in industrial design and product development engineers is commented in the second section of this paper. This context allow us develop an international mobility program with the aim to share learning experiences. The International Design Project Semester is an academic framework where is possible to link the capacity to reflect on experience and the development of professional skills. Preliminary results in the Human centred design course show that the use of the role playing model and practice in the classroom can be useful for the teaching assessment of group skills.
From the point of view of research projects, the final project presented in this paper show that is possible to establish a relationship between design methodology and HCI materials and methods. With the use of an informal evaluation of small interfaces (Tablet PC) the authors can detect usability problems and prepare a framework for the development of a guideline for small interfaces. As a learning outcome of this project, students have developed a paper for an international conference in HCI [26].
For the next edition of the IDP program we want revise the criteria in the composition group, adding the Belbin team role theory at the beginning, preparing an interview with the students, with the aim to create well balanced teams.

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Fig. 1. From left to right: a member of each group (end-user, services, industrial design) writing the features of each role. This is the previous task before to begin the discussion all together within the final cooperative task between groups..

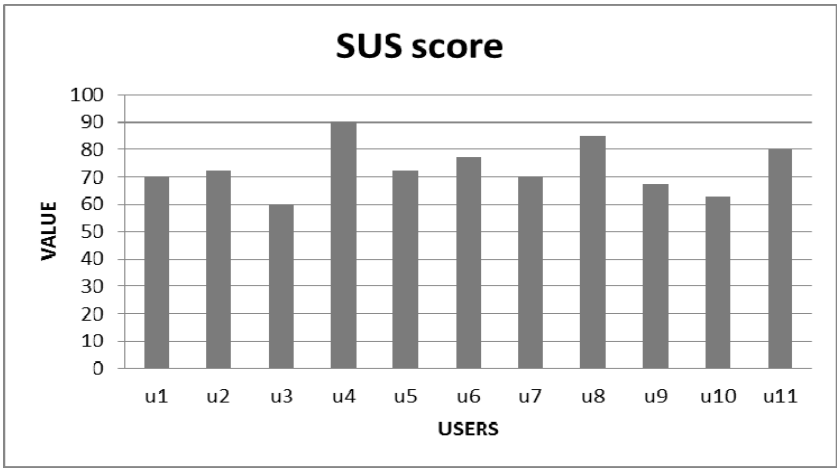

Fig. 2. Application of the System Usability Scale

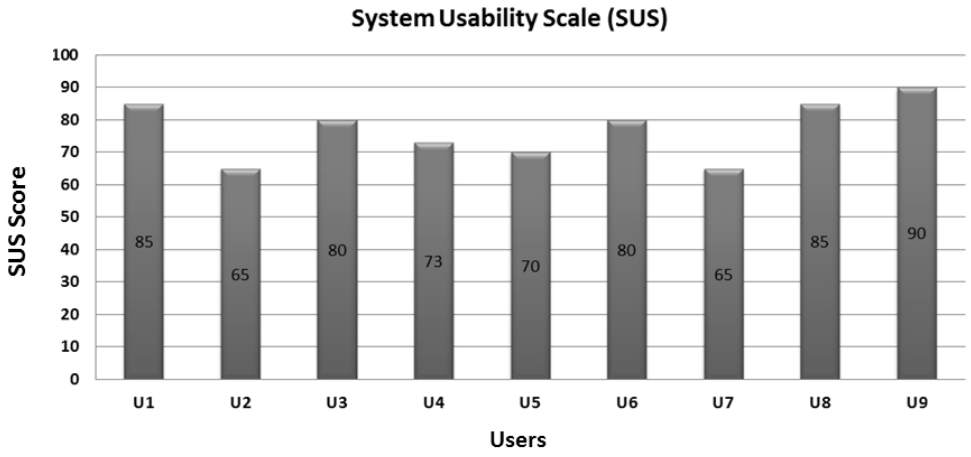

Fig. 3. SUS in the use of Tablet PC

Fig. 4. Smartphone prototype

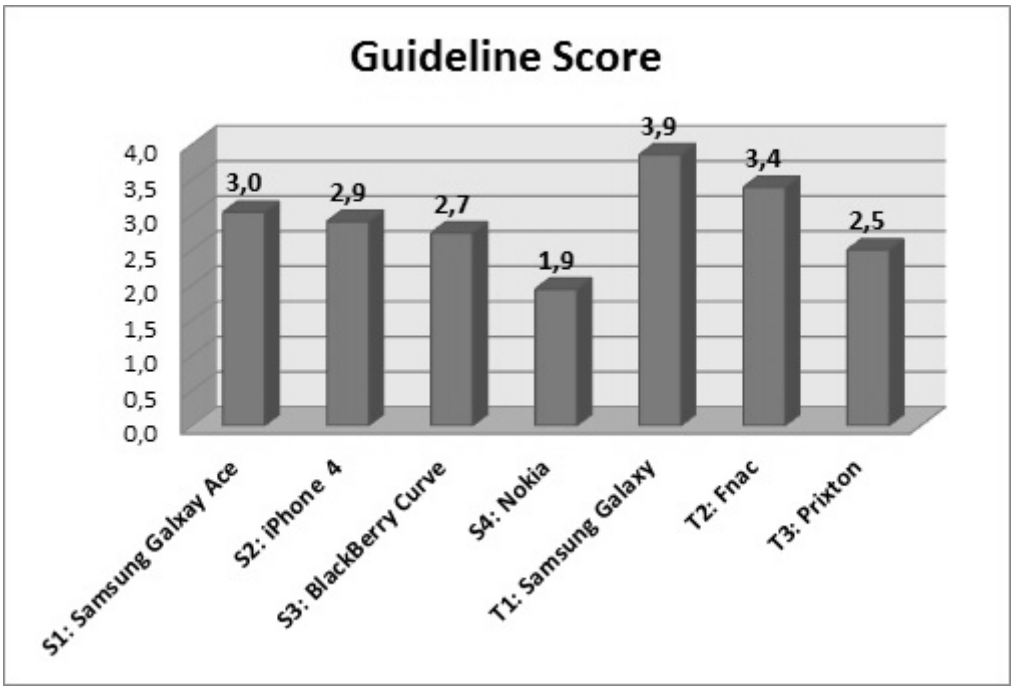

Fig. 5. Application of a prototype of the guideline to four smartphones and three tablets

Soft Skill	**Student1**	**Student2**	**Student3**	**Student4**
Fluency in second language	High	low	high	high
Attitude	High	high	high	medium
Technical writing	medium	medium	medium	medium
Self-supervising	medium	medium	medium	low
Punctual	High	medium	Low	medium
Interpersonal skills	High	medium	high	medium
Willingness to take instructions	High	medium	medium	low
Communications skills in public	medium	medium	medium	medium
Team integration	medium	medium	medium	medium
Team management	High	medium	high	medium
Persevering	High	medium	high	medium
Leading	High	low	medium	low
Problem solving	High	low	high	low

Table 1. Assessment of soft skills