Software Engineering and Human-Computer Interaction: Students' Perception of a Project-based Approach in a Postgraduate Course

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Abstract

This work in progress presents how students perceive the incorporation of Human-Computer Interaction (HCI) as content in an advanced Software Engineering (SE) course. This innovation was carried out in a postgraduate course during one semester at a large private university in Chile. The investigation adopted some qualitative, interpretative research using semi-structured interviews. The data was obtained from end-of-term interviews, surveys, and academic records. We focused on academic and professional training, personal evaluation of learning outcomes, utility of the course content and methodology, self-management, desire for learning, self-control, and time spent on core project activities. For this presentation, we concentrated on the analysis of the personal perceptions of utility content and learning. Preliminary results indicate that the incorporation of HCI into the course was highly valued by the students. They all recognized it as a benefit for the software development process. It was also noticed that the activities proposed were good triggers for the self-regulated learning of the expected course content, both SE and HCI. The authors are interested in receiving feedback about the continuity of this work, particularly in the understanding of how the content of HCI interacts with a proposal based on project-based learning (PBL).

1. Introduction

Currently, universities are being asked to train professionals, who are capable of acting in a changing world with new emerging problems. A scenario of these characteristics requires a type of training, in which creative and innovative processes, teamwork skills, tolerance to failure, durable and flexible learning, critical and innovative thinking and ability to learn every day should be reinforced [1]. Self-Directed Learning Readiness (SDLR) is defined as the continuous engagement in acquiring, applying, and creating knowledge and skills in the context of an individual learner's unique problem [2]. SDLR is critical for professionals working in complex scenarios. However, even nowadays, the teaching of engineering continues to be lecturer-centered [3]. In this direction, highly structured activities in Software Engineering (SE) education are gradually abandoning current learning approaches that are being replaced by self-directed learning. These activities are predominantly problem or project-based, where students are required to follow a self-discovery path. Specifically, Project-Based Learning (PBL) has proven to be useful to engage students in addressing real problems and tasks [4]. For this reason, PBL approaches are frequently incorporated into the SE curricula, with a focus on the traditional activities of a software development workflow: analysis, design and formal development. Human-Computer Interaction (HCI) techniques are usually included in this workflow, but as an additional and sometimes isolated activity [5]. This hinders the integrated vision of what a quality and usable software product means.

The current undergraduate training in Computer Engineering at Universidad Andres Bello in Chile (UNAB) does not include HCI content. However, the labor sphere is demanding professionals capable of developing quality software products. It would be useful to know how it is possible to incorporate such content as part of the SE courses. Based on the drawbacks previously described, we define the following general question to conduct our research: How do students perceive the incorporation of HCI as content in an advanced SE course?

The modified course is aimed at students from the Master of Science in Computer Science at the UNAB. The main objective of this innovation was to provide advanced knowledge of the SE (analysis, design and formal development of an interactive software, using HCI methods) through PBL. Data was collected through personal interviews, academic records, and course documents. The interviews, based on a survey proposed by Stewart [2], were aimed at providing information about some relevant factors: academic and professional training, personal evaluation of learning outcomes, utility of the course content and methodology, self-management, desire for learning, self-control, and time spent on core project activities.

This paper is organized as follows. Section 2 presents some related works on PBL and HCI in SE. Section 3 describes the innovation proposal. Section 4 presents the methodology used. Section 5 reports the data analysis and results. Section 6 presents a discussion of the results. Finally, Section 7 presents conclusions and future work.

2. Related Work

HCI applied to SE education considers an outline and the teaching methods related to active learning techniques, which are focused on how students learn SE topics. Particularly, HCI concepts are taught using project and problem-based learning approaches, considering concepts, the application in software development experiences, and in-situ expert support [6]. Projects in Software Engineering education are core activities, simulating and/or incorporating real clients [7]. Consequently, HCI contributes to the improvement of the interaction model and the user experiences, complementing classical requirements elicitation tasks [8], such as needs identification, design alternatives, building of interactive models, and design evaluation. Some findings in project-driven HCI-SE courses have shown that students are motivated by a self-regulating approach, developing initiative to acquire, use and find knowledge [6]. Problem driven strategies focus on analyzing real-world problems to motivate and to facilitate the learning of concepts, procedures, and attitudes of a professional software engineer [9]. This approach considers a set of problems, carefully selected and designed, and self-regulating tools to teach how to collaborate for a solution formulation. These strategies are often mixed with other strategies, such as role playing with a simulated client or played by the instructor, maintaining the role of the learning tutor, focusing on model sketching, and prototyping [10]. Regarding the evaluation of the learning outcomes, the students' perception and attitudes about their own learning must be analyzed to achieve an effective collaborative work, self-regulation, and proactivity [11]. Findings on HCI-SE show how reflection tasks impact on self-regulation (e.g. in [12]); and how a project teaches about iterative and user-centered design [13]. Instruments for data collecting are focused on student feedback monitoring, success in the learning perception by students, and how much the students are self-aware of their learning process [14]. Some results show that learners perceive software development activities as useful and relevant elements for their own learning when HCI foundations are taught through real-world projects [15].

3. Innovation Proposal

Figure 1 illustrates the key elements of the innovation proposal. As observed, the advanced SE course has been restructured using the principles of PBL. The main objective is to provide advanced knowledge of the SE, using HCI methods. Likewise, rubrics were defined to guide the learning objectives and to introduce fundamental aspects of HCI through evaluation criteria. These criteria refer to the requirement to conduct the software development process through a User-Centered Design (UCD) and to formally evaluate the usability / UX of the

developed software. Formal course checkpoints were established to provide feedback to students by both, the instructor and peer-assessment. Furthermore, master lectures were organized to provide advanced knowledge on the essential components of the project. The content provided formally in these instances were only triggers of knowledge. The specific knowledge associated with HCI and SE was expected to be self-directed, and generated implicitly by the requirements of using a user-centered software development methodology.

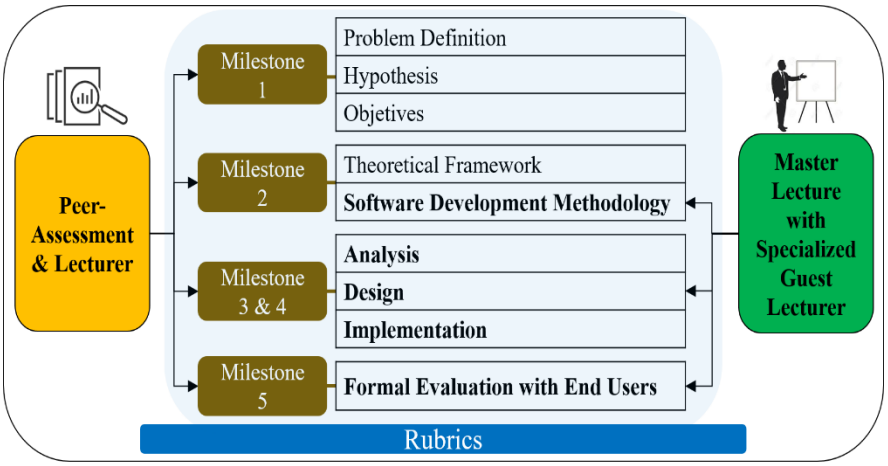

Figure 1: Innovation proposal. Software Project-Based Learning-Driven Rubrics and HCI.

The software project is organized into four main sections. The first section is aimed at defining the main guidelines of the software project (problem, hypothesis, and objectives), highlighting its relevance and impact in a specific field. The second section describes the theoretical foundations of the project and the selection of a software development methodology that would involve end users throughout the development process model, while complying with the principles of ISO 9241-210 [16]. The third section consists of carrying out the formal phases of software development (analysis, design and implementation) by ensuring that the end users' perspective is discussed, described, and considered throughout the process, as suggested in [17]. The last section formally evaluates the final software product with the participation of real users.

The sections of the software project have associated assessment milestones (AM). These milestones are related to the learning outcomes that are expected from the course. Most of the expected learning from the course (see Table 2) is centered on AM3 and AM4, associated with SE itself. Additionally, AM2 and AM5 are associated with two key aspects of HCI (user-centered software development methodologies and formal evaluations of the software product with end users). With regards to the time distribution of the milestones, most of the time it was allocated to tasks related to AM3 and AM4 since these milestones involved the majority of the learning objectives. The AM1 required the least time to be accomplished as it only involved the definition of the problem. Each AM was composed of an oral presentation and a written report of the work. In the oral presentation, formal grades were given through peer-assessment, one by the instructor and two by the students (randomly defined in advance) so as to develop multidisciplinary skills, such as abstraction, the development of arguments, and the ability to describe, evaluate, criticize, analyze, and review.

4. Methodology

As previously mentioned, the primary objective of this study was to provide information

about some relevant factors that, all together, help evaluate the course results: academic and professional training, personal evaluation of learning outcomes, utility of the course content and methodology, self-management, desire for learning, self-control, and time spent on core project activities. This study presents preliminary findings related to perceptions on learning outcomes and utility of course content.

As the aim was to understand the point of view of the participants in the context of the course, we designed an interpretative research using semi-structured interviews [18]. To structure the interview, we divided it into four parts. In the first part, we used the main activities of the course combined with the factors used by Stewart (2007) related to characteristics of self-directed learning readiness. For each activity (presentations of experts, student presentations and project development) questions were designed to obtain information regarding self-management and desire for learning and self-control. In the second part, the percentage of the total hours spent on the core course activities was determined by the students. We used a modified version of the activities considered by Stewart (2007) to consider the inclusion of user-centered methodologies. In the third part, the students were asked to talk about the main skills and learnings that they considered they had obtained from the course. The students were asked to choose from a list of selected skills the ones they thought they developed the most in the course and the ones they developed the least. Likewise, they were asked to rate the course learning outcomes from 1 to 7 according to how they perceived their own achievement. Finally, the last part focused on making students reflect on the general experience of the course, the usefulness of the methodology used, the contents worked on (specifically HCI), and their perception of the contribution that this course had on their job readiness.

Different actions were carried out to ensure the validity of our qualitative study. The interviews were conducted by researchers without the participation of the course instructor. The interviews were transcribed and analyzed by three persons independently. The coding for the highlighted extracts was: SDLR (positive / negative), course methodology (positive / negative), and HCI (positive / negative). This classification was also validated independently and cross-checked by the reviewers. Because the instrument is designed and tailored for this study, there are no measures of validity or reliability provided yet. In addition, to characterize each of the students in relation to their SDLR, we used a Spanish version for the self-directed learning readiness survey [2]. The translation was carried out by three experts independently.

We obtained a signed consent to use and release the data of the interviews and any other instrument used to obtain data for this study. Some actions were carried out to protect the respondents' privacy and maintain confidentiality. Participants' personal information was changed or removed from public view, without distortion of data [19]. Although there remained some contextual identifiers in individuals´ life stories, we made some changes to prevent deductive disclosure.

5. Data Analysis and Results

5.1 Profile

The course involved one female and three male students. More details about their profiles can be found in Table 1. It was crucial to acknowledge these profiles in order to modulate the perceptions that the students had about the usefulness of the course, the learning achieved, the perceived difficulties, and even the understanding reached on HCI.

5.2 Utility of the course content and methodology

Students answered six open questions related to the perceived difficulty in developing a project before and after the course, the contributions and the strengths that user-centered methodologies add to the software product, as well as the self-confidence to tackle a software design project before and after the course.

Table 1
Student profiles.

Profiles	Profile			
	A	**B**	**C**	**D**
Engineering	Advanced knowledge of SE	Knowledge oriented to programming	Basic knowledge of programming	Advanced knowledge of SE
Research/work	Oriented to SE	Works as a developer in a company	Experience in methods and techniques of social sciences	Oriented to the programming of advanced algorithms
Comments	Confident of his abilities to develop a SE project	Aware of some deficits in his training in SE	Convinced of the importance of social interactions in SE projects	Thoughtful and critical about what he knows and what he does not know

In general, the students mentioned some advantages and disadvantages when carrying out the project. On the one hand, they mentioned that it was challenging, favored collaboration, and encouraged the search for new knowledge and the systematization of the software development. On the other hand, the time management necessary to meet the assessment milestones was identified as an obstacle.

"It was totally challenging. [...] But since I knew the project could be useful or practical for my profession, I did not lose the motivation and it ended up being something interesting in the end. And to this day I'm using it ... for ... I'm collecting data." (Student 4)
"It was moderately complicated, I would not say it was super complicated but there were times when it obviously became more difficult [...]." (Student 3)

When it comes to the work environment, students mentioned that they would know what needed to be done, but they would be more dependent on time constraints, budget, and requirements of real situations.

"[...] I can say that I already have the basis, I know certain techniques and I can work on that. If what I learned was not enough, I already have the basis to work and I can investigate based on that." (Student 1)
"I would say half. I already understand what I have to do, how to do it, what the steps to take are and ... how I should do it. And I say half because complications can always arise." (Student 2)

The students highlighted the importance of the experts' talks as triggers for searching new knowledge, the possibility of making presentations in front of their peers as organizers of information and the status of the project, the importance of peer and instructor feedback as a

way of making progress in the acquisition of knowledge and development of the project, and the assessment milestones and rubrics as a help to manage time. About the students' presentations they remarked that:

"Then I learned little by little and this course has helped me a lot because there were always presentations [...]. And the interesting thing is that the colleagues also gave their opinion about what was missing, what was good." (Student 1)
"Having presentations like this is useful because it is something that is not widely practiced in general and that it is an important ability to have ... to know how to communicate ... to know how to speak in public ... let's say I have always believed that opportunity adds up." (Student 3)

In the case of the experts' presentations, the students highlighted that:

"They also talked about specific things, like icons that had to be used for the user interface. That also applies to the project. Then, there were punctual things that helped me finish the project of the subject well and that I have not forgotten either." (Student 1)
"[...] there were several things that were focused on design ... there were several things that one ... like I arrived to my house to see things. Then I would say yes." (Student 3)

Likewise, the students were asked to rate between 1 and 7 the level they thought they had gained in each of the course expected learning (see Table 2). The scores demonstrate that in general they perceived that the expected learning was achieved to a fairly large extent. Within the best rated were found to be *identify and analyze the characteristics of the end users of the software product* (AM3 and AM4) and *consider the characteristics of the end users in the design and development of the software product* (AM3 and AM4). *Justify the architectural software design at a technological level* and *use UML as a tool for requirement specification and design* had lower scores. We must bear in mind that this course goes beyond the SE of the undergraduate programs, thus its objective is not focused on those learnings.

One expected learning to keep in mind is the one related to *use formal techniques for evaluating usability / user experience*. It was evaluated with relatively good scores, except for a student who said he did not have enough time to complete it because he had shortcomings in his previous preparation of SE and some problems with time management.

"... I was not able to carry out the feedback with the end user ... or in my case with the students." (Student 2)

All the students showed a high evaluation with respect to the contributions of the user-centered methodology, demonstrating different focuses and understanding.

"The end user is one more component of that compliance with a quality standard ... [...] I think that if one does not take into account the requirements that the end user could have and one only takes into consideration the requirements that the client has... [...] I'm going to start doing the software in my own way and maybe I'm not complying with that and therefore I'm not complying with a quality product." (Student 3)
"If the user is not taken into account for the design, the project will definitely fail. [...] Yes, we have to do it. Otherwise, your project will be as wonderful as you want in terms of programming or visualization, whatever you want, but if the other is not interested they will be ... in the garbage like many computer projects." (Student 4)

"[...] if we are not able to deliver the product to the extent that they want and we do not try to satisfy them in the best way ... it does not make sense for us to do something. I believe that the user feedback is essential." (Student 2)

The level of understanding about the strengths that the user-centered methodologies bring to software design had a lot to do with the student's profiles, as well as with the learning and skills developed.

Table 2
Course expected learning. Achievement perceptions (scale 1-7).

Expected Learning	Content	Assessment Milestone	Students			
			i	ii	iii	iv
Use UML as a tool for the requirement specification and design	SE	3, 4	5	4	5	6
Justify the architectural software design at a technological level	SE	3, 4	6	3	5	5
Work in a software development environment	SE	3, 4	7	6	6	6
Select a software development methodology according to the project needs	SE, HCI	2	7	5	6	6
Justify the selection of the software development model for the execution of the project	SE	3, 4	7	6	5	6
Identify and analyze the characteristics of the end users of the software product	HCI	3, 4	7	7	5	6
Consider the characteristics of the end users in the design and development of the software product	SE, HCI	3, 4	7	7	5	5
Use formal techniques for evaluating usability / user experience	HCI	5	7	6	4	5

6. Discussion

As mentioned in section 5.2, all the students showed a high perception on the utility of the course. In general, the students mentioned more advantages than disadvantages carrying out the project, such as: it was challenging, it favored collaboration, and it encouraged the search for new knowledge and the systematization of the software development. Regarding the difficulty and the confidence for facing a similar project, but in a work environment, they were all concerned about real constraints: time, budget, requirements, etc. We also obtained data on the perception of utility of the methodology of the course. Everyone valued the presentations both of experts and of peers, as well as the presence of assessment milestones as a help to manage time. Each student showed different reasons to give these opinions, but the most important thing is that, regardless of the profile, all students were favored by these activities.

It is very important to highlight that the students focused their understanding of the contribution of HCI in relation to their profile. For example, the advanced programmer saw the strength that could be achieved in the product developed by incorporating methodologies focused on users. The programmer who worked for a company, pointed out the importance in relation to the best possibilities of selling the product. Likewise, the professional with a clear orientation to SE, considered it worthwhile to incorporate the user as a quality attribute of the developed software. Finally, the professional oriented to social sciences emphasized that it was impossible to develop software without considering the end users.

Regarding the content of HCI worked on the course, it is interesting to note that it was achieved to a very good extent. As was previously mentioned, the content provided during the course was only triggered for self-directed learning. Preliminary results allowed to observe that the explicit requirement of using methodologies focused on the users favored the achievement of the expected learning declared for the course. As observed before, these learnings were not only associated with HCI, but also with SE.

From all the obtained data, although the analysis is not yet completed, there are some indications that all students could benefit from the innovation proposal. It is necessary to deepen the analysis of the interviews and the academic records of the course to determine the benefits obtained and the areas of improvement in the relation PBL+HCI.

7. Conclusions, Further Directions and Learning

A Software Engineering (SE) Project-Based Learning (PBL) innovation driven by Human-Computer Interaction (HCI) was conducted in a postgraduate course. The investigation adopted a qualitative, interpretative research using semi-structured interviews, surveys, and academic records.

With respect to our research question, how do students perceive the incorporation of HCI as content in an advanced SE course?, this work presents the analysis of just a part of the obtained data. Preliminary results indicate that the perception of utility of the incorporation of HCI to the course was highly positive. All the students were able to perceive the benefits that a user-centered methodology benefits the software development. All the students highlighted a better training for the real work environment, as well as a know-how within the SE and HCI. Additionally, as expected, the activities developed were good triggers for the self-regulated learning of the expected contents, both SE and HCI.

The continuity of this work is aimed at trying to understand how the contents of HCI interact with a proposal based on PBL. From the interviews, there is data about self-learning capacity, self-encouragement, self- management, interdisciplinary perspective, improvement of social skills, development of specifics skills, and time spent on core project activities.

The interpretative approach of the research allowed the emergence of the profile as a variable that modulates the results that were possible to obtain with each student. There is abundant literature regarding the fact that learning styles modulate the obtained results. However, it is possible to visualize as other future work the construction of an instrument for a proper determination of the students' profile. Determining important characteristics of the students associated with SE and HCI can help to determine the needs that each one may have throughout the course. The idea declared by the user-centered methodologies is to get to know the users in order to offer them a better product. Analogously, we are thinking about getting to know the students' characteristics with the aim of offering learning experiences more adjusted to their needs.

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