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A PBL Experience: Joining Human-Computer Interaction and Mobile Programming

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ABSTRACT

This paper presents a project-based learning approach based on the combination of Human-Computer Interaction (HCI) and Mobile Programming. This approach aims to develop and implement a graphical user interface and respective interaction of an application. The project was implemented in the HCI and Mobile Programming courses located in the 2nd and 3rd years of an Informatics Engineering Degree at a Portuguese Higher Institution. The objectives of this project were to specify, prototype, and implement an interactive system containing the following topics: (i) user and task analysis, (ii) problem-solving, and (iii) Gamified activity in a Problem-Solving Scenario where students must identify user needs and design tasks to address those needs were done. This proposal could be embodied in the form of a theoretical study or practical implementation on a form of connection with hardware that allows an alternative or innovative form of communication/interaction. In the presented study, the students went through four distinct phases: Ideation, User and Task Analysis, Prototyping, and Exploring New Forms of Interaction. In summary, the teacher expressed dissatisfaction with the students' work. Many tasks were completed last minute, and collaboration within groups was lacking. The students showed irresponsibility in their work distribution. The proposals lacked reflection and research on technical aspects, which is expected in engineering. Students demonstrated low curiosity about new technologies and proposed uncreative solutions. Students were also disappointed with their grades, and they preferred more closed and focused problems over open-ended ones.

Keywords: Project based learning, Human-computer interaction, Mobile programming

INTRODUCTION

It is our responsibility as teachers, educators and engineers to guide students to excel in a highly complex and competitive society. An engineer is required not only to have technical skills based on science and technology but also another set of skills that allows them to carry out interdisciplinary and multidisciplinary projects.

Mills and Treagus (2003), Saleh (2009), Aleksandrov et al. (2015), Becerra (2020) or Fowler et al. (2023) summarized some of the key common challenges in engineering education, which include the content-driven nature of many courses, the lack of focus on industrial impact, societal implications, and the need for teaching to be more student-centered.

Today's engineering education faces a number of pertinent concerns. The first challenge facing engineering education is the rapid advancement of technology. Keeping engineering curricula updated with the newest technology advancements is challenging. Engineering is also becoming more and more interdisciplinary, which makes it difficult to create curricula that appropriately cover a wide range of knowledge. Another concern is related to the promotion of gender equality and the participation of underrepresented minorities in engineering courses to ensure diversity.

In order to address societal and environmental issues, it is important to prepare students for global and international engineering challenges, opportunities, and collaboration while also taking sustainability and ethical engineering education into account. The students should also be well-prepared for engineering careers and for rapidly evolving in the job market, being able to adapt and learn during lifelong.

It is also needed to strengthen the collaboration between academia and industry to bridge the gap between theory and practice. But it is not just technical skills that are necessary, soft skills such as communication, teamwork, and leadership, creativity, critical thinking, and problem-solving are increasingly required. And how to achieve all this while maintaining mental health and well-being?

But the demands are increasingly on the side of teachers and institutions, it is mandatory to support faculty in adopting innovative teaching methods, technologies, and pedagogical approaches.

However, on top of all these requirements, retention rates are high. How to motivate students and teachers to face these challenges? We think the solution goes through the use of practical, hands-on experience and implementing effective project-based learning approaches to prepare students for real-world engineering challenges. These activities could integrate online and blended learning, effectively integrating educational technologies, such as simulation tools and virtual laboratories, into engineering curricula.

Learning strategies such as project-based learning and problem-based learning (Sukackė et al., 2022) have the ability to give students transferrable abilities that aid in the acquisition and application of domain-specific knowledge.

Project-based learning (PjBL), which has its roots in constructivism, is the philosophy and method of using real-world work assignments on time-limited projects and structuring the learning around the projects. Projects are challenging assignments that provide students with the chance to work independently for extended periods of time, developing their autonomy while involving them in design, problem-solving, and decision-making (Hmelo-Silver et al., 2007; Perrenet et al., 2000; Ríos et al., 2010; Servant-Miklos and Kolmos, 2022; Wu and Wu, 2020).

The HCI subject is rarely seen by students as a fundamental subject, and Mobile Programming is a course that students find very interesting and relevant. Therefore, the combination of Human-Computer Interaction (HCI) and

Mobile Programming may be particularly suitable for project-based learning for several reasons. This combination could enable: the application to relevant real-world problems, as mobile applications and interfaces are an integral part of our daily lives; the development of interdisciplinary skills, requiring a mix of skills, including design, user research, programming, and usability; a user-centered design, as project-based learning reinforces the importance of designing applications with the user in mind; hands-on experiences, allowing students to apply the theoretical knowledge gained in HCI courses to practical scenarios needed to develop mobile applications; the development of creativity and innovation: in order to develop unique solutions to real-world problems; problem-solving by addressing problems with usability, UI design, and programming, students develop their problem-solving abilities and are exposed to a variety of challenges in the mobile app development industry, usually in teamwork and in a collaborative way.

In summary, the combination of HCI and Mobile Programming offers a well-rounded educational experience that blends theory and practice. Project-based learning in this context empowers students to gain a deeper understanding of these fields and equips them with the skills and knowledge required for successful careers in user interface design and mobile application development.

Faiola (2007) stated that "pedagogical models employed by many HCI and design programs will risk becoming increasingly short-sighted if they do not provide students with knowledge domains that can account for understanding design, social context, and business strategies in addition to computing."

In order to help students work in multidisciplinary teams in "real life" scenarios, several authors also stress the significance of incorporating design thinking into HCI (Culén et al., 2014; Luca and Ulyannikova, 2020; Rahm-Skågeby and Rahm, 2022).

Thus, the students were proposed a project work under a specific theme, but which solved a real-world problem and had a multidisciplinary nature. The following section explains the phases inherent to this project.

CONTEXT

This project was applied in the HCI course located in the 2nd year of an Informatics Engineering Degree at a Portuguese Higher Institution. In this project work, the size of the groups could vary depending on the nature and size of the proposed project. A month and a half were allocated for this project work.

The objective of this project was to specify, prototype and implement the graphical interface and respective interaction of an application. Every year the general theme is different. This year the theme focused on proposing solutions that can respond to situations with a view to prevention, treatment/recovery and promotion of mental health. Although the theme is very generic, each student is expected to propose a different application. It is also a fundamental condition that the developed application considers the inclusion of at least one type of user with special needs (in terms of vision, hearing, cognition, development,...). In this case, concerns also include accessibility aspects. In this way, it was proposed to develop the prototype and respective implementation of an interactive system containing the following topics:

- Phase 1 – *Ideation* – The goal of this phase is to promote discussions among students in order to generate ideas and solutions. Students were told that they could take the opportunity to come up with ideas, within the general proposed theme, that related to their interests or needs that they saw around them. They could use several techniques such as sketching, Prototyping, Brainstorming, Brainwriting, Worst Possible Ideas, and any other ideation techniques. Ideation is also the third stage in the Design Thinking process. Therefore, we suggest students divide ideation into these three stages: generation, selection, and development. However, students were given space, time and freedom to reflect and write their ideas down as they started flowing, shout them out or add them as they came to them. During this stage (2 hour class), a variety of tools (mind mapping, five whys, six thinking hats, SCAMPER (de Villiers, 2022; Wu and Wu, 2020), and so forth) could be used to promote creativity. In this phase, even in an informal way, it was mandatory to discuss the identification of primary users, their tasks, and the required hardware/software adaptations. They have one week (outside classes) to put their ideas in a joint and collaborative mural, using Padlet, where all the other ideas of all the students would be put. The next class was for the idea presentation and key insights, for 5 minutes for presentation and 5 more minutes with teacher or colleagues giving feedback for improvement.
- Phase 2 – *User and Task Analysis* – a week after the Ideation presentation and during the classes, various methods were given for analyzing users and tasks, leaving time in class for each group to ask specific questions about the application of the most appropriate methods for each proposed theme. This phase would have to be subsequently documented and substantiated in a report. In this phase a combination of methods for the presentation of the concepts, principles, and methods of user and task analysis was presented to students to help ensure that students with different learning styles and preferences grasp the concepts of user and task analysis effectively. There was also the presentation of real-world case studies and video demonstrations of the application of user and task analysis in design projects. Online resources, such as articles, videos, and webinars, explaining user and task analysis methods in different contexts were also made available. At the end, a Gamified activity in a Problem-Solving Scenario where students must identify user needs and design tasks to address those needs were done.
- Phase 3 – *Prototyping* – During this phase, which took place in the week following Phase 2 and coincided with classes, the aim was to create a low or high fidelity prototype using tools of the students' choice such as Balsamiq, Axure, JustInMind, Figma or even paper, cardboard, plasticine, 3D printing or other tools for low-fidelity prototypes. Thus, students were told that the prototype should use the tools considered appropriate to the idealized solution, remaining at the student's discretion. The prototype

could be high or low fidelity, but students should justify which best reflects the idealized idea. After demonstrating various types of prototypes for different situations of small examples with tutorials for the different tools, this stage sessions were also held with students so that the teacher could provide feedback about the prototype proposed. The teacher mentioned that the students would have to find out whether the prototype covered all the planned tasks as well as the usability tests carried out on the prototype, with the majority saying that they tested it with a colleague in the group and not with users representing potential users. They were also asked to think about and document the set of metaphors underlying the proposed conceptual model.

- Phase 4 – *Exploring New Forms of Interaction* – later on, it was additionally intended that students would study a new/current form of interaction. This proposal could be embodied in the form of a theoretical study or practical implementation. This implementation could be a mobile application which can take advantage of the various sensors available on mobile devices, but it could also be a regular application connected to some kind of hardware that allows an alternative or innovative form of communication/interaction, using devices such as Kinect, Bitalino, Myo, neural sensors (Mindwave, Muse, ...), Biometric sensors (ECG, EMG, EDG), Virtual Reality Glasses, Arduino, Raspberry Pi, Eye Tracking Systems (Tobii), or others researched by students. In order to force students to investigate the state of the art in similar solutions, it was mandatory to include references to 5 recent papers that summarize the current state of development or application of the new form of interaction mentioned, consulting as an example the scholar source in Google Scholar[1]. With regard to the mobile application, it is intended that it adheres to the principles covered in the UX classes, in particular by opting for intuitive ways of presenting information and interacting with the user. The mobile application can also be connected to various external devices identified as relevant to the subject, in order to use the data generated by them.

It should be noted that when presenting the work to the students, and before completing Phase 1, the teacher showed projects from previous years, so that the students could get an idea of the possibility and variability of possible solutions and thus understand a little of what was expected of them.

RESULTS: ANALYSIS AND DISCUSSION

Phase 1 – *Ideation*

The goal of this phase is to promote discussions among students in order to generate ideas and solutions. Students were told that they could take the opportunity to come up with ideas, within the general proposed theme, that related to their interests or needs that they saw around them.

[1] https://scholar.google.com/

This phase was the most difficult for the students, as they mentioned the difficulty in coming up with ideas. The teacher worked a lot with the students, asking them about interests, hobbies or knowledge of family or other close situations that could indicate needs regarding the topic. The teacher himself exemplified situations based on the ideas presented by the students. In general, the idea presented was one of those suggested by the teacher, with little effort and creativity on the part of the students. The teacher also suggested research so that students could explore existing solutions in light of the idea generated in order to better identify gaps or needs, thus contributing to more creative ideas. The results of this phase were presented to the class the week following it. Each group had 5 minutes to present the idea and the teacher gave feedback on any weaknesses in the idea and difficulties in its implementation, presenting suggestions accordingly. Each group watched the presentation of the others and was able to benefit from both the ideas presented and the feedback generated by the teacher. All students could also give suggestions for improvements.

Phase 2 – User and Task Analysis

After explaining the concepts, methodologies and techniques for the task and user analysis, students had 2 weeks to present the analysis of the user profiles identified during the phase. The teacher questioned the students about the methods used, explaining their relevance and suitability, discussing with each group the relevance of these profiles (including demographic characteristics, behaviors, needs and preferences) for the design of the system and how they impact usability. Most groups chose the personas method, which was not truly applied, with students inventing 5 personas that in most cases could represent plausible user segments, but which were completely invented and rarely researched, observed or interviewed in the literature.

Task analysis is a fundamental step in the interaction and usability design process of systems and products. For task analysis, students were told that they should try to understand how users currently perform the tasks that the new system intends to replace. However, here too little effort was made to collect relevant data either through interviews, observations or documentation analysis. Most students listed most of the tasks that users could perform in the context of the system. It also organized the tasks in a logical sequence, representing the users' workflow through one of the methodologies taught that best adapted to the problem in question. However, they generally did not identify each task in great detail, including the steps needed to complete the task, as well as any necessary data input, output, and interactions with the system. There were also cases in which the objectives of a given task were not clearly defined, or in which it was not clear what the user intended to achieve by performing the task. Almost no group defined the resources (hardware, software, information) necessary to perform each task. Groups rarely thought about the usability of tasks, considering the efficiency, effectiveness and satisfaction of users when carrying them out. No group identified problems (bottlenecks in the process, overly complex tasks or lack of system support for certain steps) that could arise during the task analysis. In some groups, the task description was well documented, with the exception of the previously mentioned problems which, as they were not addressed, were also not documented.

The teacher gave feedback to the students, explaining that task analysis is an iterative process, as such, as the project progresses, it is important to revisit and update the task analysis to incorporate new insights and adjust the system design accordingly. The results of this phase were not presented to the class but resulted from the teacher's meeting with the students. However, in the end, the teacher made a summary of generic aspects that should be improved or addressed.

Phase 3 - Prototyping

Most students created a high-fidelity prototype with the JustinMind tool. The majority of students did not compare the functionalities implemented in the prototype with the task analysis and reported that they tested the prototype with a colleague in the group and not with users representing potential users, but did not report these aspects in the documentation. The few who carried out usability tests did not document how they were conducted, with whom, whether there were new discoveries or the feedback generated. They also did not report the improvements made in successive iterations. There was also no report on the understanding of the metaphors or underlying conceptual model, namely their intuitiveness. The majority of students revealed that the metaphors and icons used were chosen because they were commonly used or based on assumptions that had not been tested or investigated. There were few innovative solutions and few students considered the feasibility of the prototype given the proposed hardware resources.

Phase 4 – Exploring New Forms of Interaction

Although the teacher demonstrated and exemplified in class some of the devices that could be used and how, the students either did not perform this component or did so, generally in a forced manner, having difficulty justifying its integration. Despite their interest in mobile applications and the incorporation of sensors and hardware devices, those who advanced to this phase opt to carry out a theoretical study. This limitation stemmed from their inability to visualize the practical implementation of their proposed integrations. However, they were told that everything would have to be explained and that all the more theoretical situations had to prove to be feasible. As mentioned, they were also asked to search on Google Scholar for the latest trends in literature related to the chosen technologies, having to present 5 recent papers with the summary of the subject and respective references, which very few did.

CONCLUSION

In general, as teachers, we were not satisfied with the work presented by the students. Although students submitted their deliverables within the expected deadlines, it was noted that many tasks were done the day before just to complete them. The collaborative aspects also did not work fully. Despite not having used formal instruments for this assessment, informal conversations revealed different situations, most notably the concentration of work on just a few elements of the group. The different situations denoted different irresponsibility that should be addressed. Most of the proposals presented also showed work with little reflection or at least little research regarding the functioning of the technical aspects of the proposed solutions. As engineering students, they are supposed to investigate how the various elements that make up the proposed solution communicate. Another aspect highlighted was the students' low curiosity regarding new technologies that they could incorporate into their solutions, as well as the proposal of uncreative solutions. This aspect was surprising since, initially, they expressed interest and motivation to utilize various types of devices and interaction methods.

Students were also disappointed with their grades as their self-assessment did not align with the grades they received. Informal opinions indicated that students did not like the open nature of the problem and preferred problems that were more closed and focused.

It was felt that more precise rubrics and assessment criteria should be developed in the future.

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