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Proposal for an innovative framework for teaching ergonomics

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Abstract

Project-Based Learning (PBL) is a teaching and learning approach that has many advantages for students, and it can be applied in ergonomic disciplines since they require a more innovative teaching approach. Thus, following a PBL approach and phases of concepts´ generation from the literature, this work aimed to develop a framework that connects four phases of concepts´ generation with appropriate methods. The result of this work (the framework) was applied in five case studies, with 198 students in ergonomics classes. As conclusions, it can be said that the framework directs professors in a structured way and contributes to a greater fixation of theory by students, as well as a greater understanding of their practice.

Keywords: UCD methods; Ergonomics; Undergraduate course; Product development; PBL

1 Introduction

The experimental education was based on Socrates' methods. All his teaching methods had in common aspects of questioning and inquiry, where all answers can be considered as new questions [1]. However, it is believed that the great milestone of experimental education occurred during the second world war, with Dewey's "learning by doing" theory and Hahn's "Outward Bound" education program [2], [3].

As the theme evolved, other theories were developed. Among them, Kolb [4] states that learning is a multi-dimensional process that starts with concrete experience, goes through observation and reflection, then through the formation of abstract concepts and generalizations, and then comes to the test of new concepts in new situations. Montessori, in turn, states a theory of observation and empirical learning (apud [3]). In any case, experimental education addresses specific methods, and Project-Based Learning (PBL) is one of them [3].

PBL is defined as a teaching and learning approach that enable students to engage in solving authentic problems through a realistic project [5]. One of the advantages of PBL is that students learn more effectively and are more motivated to learn [6]. In undergraduate courses, where students are expected to develop communication, creative, and critical thinking skills, among others [7], teachers must teach effectively and motivationally.

Ergonomics, specifically, is one of the disciplines that require the greatest commitment from teachers. Hands [8] argues that ergonomics in its traditional education leaves a gap between what companies look for and what students learn. Woodcock and Flyte [9] emphasize that it is necessary to approach ergonomics innovatively.

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With this in mind, Astolfi et al. [10] developed a framework based on PBL principles for ergonomics professors to follow. The framework consists of a systemic set of iterative phases, mediated by interactions with employees and users of a real company, teacher, teaching assistants, and monitors. The activities that are the responsibility of the teacher are: to present theoretical content through readings, to make theoretical discussions in the classroom, to apply daily tests, and to present instructions of methods directed to the user (User-Centred Design - UCD methods) so that students able to put theory into practice. Although the authors specify the concept phases that are applied in the discipline (problem definition, user profiling, concepts generation, and usability evaluation), only methods for "user profiling" (persona and empathy map) are mentioned - the methods that students can use in the other phases are not presented. In the literature, many UCD methods are available that could be applied by students, but which ones should the professor choose? Which of them would present a better result for the discipline and the project, since the students work with concepts and not product projects in advanced stages of development?

Thus, this work aims to present a framework for a proposed sequence of methods to be applied by students of product ergonomics in real cases of concept development.

2 Methodology

The framework of this work was developed based on the experiences of five case studies. Each case study took place in a class in the discipline of ergonomics offered to undergraduate courses in production engineering and materials engineering at the University of São Paulo, city of São Carlos, Brazil, between the years 2017 and 2020. Table 1 presents the list of project themes for each course, which year applied, and the number of students in each class.

Table 1 Case studies details

# Case study	Project themes	Undergraduate course	Year of application	Number of students
1	Household inhalers	Materials engineering	2017	42
2	Products for hospital use	Production engineering	2017	43
3	Products for pet line	Production engineering	2018	26
4	Bins for the university	Materials engineering	2019	53
5	Products with anti-covid technology	Materials engineering	2020	34

Although each class had a different project theme to be worked on, all classes followed the same concept development phases: problem identification, user profiling, concepts generation, and usability testing. For the first phase, in all classes, the project theme and the problem identification were presented by partner companies. From then on to the second phase, the students worked with the application of methods suggested by the professor and the monitors of the discipline. The methods applied were: Users Broadening Map (UB Map) [11], pyramidal map, concept map, and concept test [12], [13]. Throughout the application of the methods, in all classes, the professor and the monitors conducted informal observations and interviews with students, and informal interviews with representatives of partner companies. Besides, they discussed among themselves to discuss the benefits achieved, from a didactic point of view.

3 Results and discussion

As a result of this work, a framework (Figure 1) was elaborated for the sequence of concept generation phases related to methods to be applied in each one. This framework can serve as a basis and guidance for professors in the area of ergonomics and product projects.

With the problem defined (first phase - problem definition), students began to identify who would be the users of the product to be developed (second phase - user profiling). To do so, they applied the Users Broadening Map (UB Map). As students identified the different users, they entered into discussions and reflections and realized that, indeed, one user would have a different need than another, since the use of the product was different, or even that the interest in the product was different. From the point of view of the representatives of the partner companies, the application of the method was a great differential, since the developers in the companies themselves did not see that this wide identification was so important. From a didactic point of view, it was observed that students were able to understand the theory of diversification of needs in a clearer and easier way with the application of the UB Map.

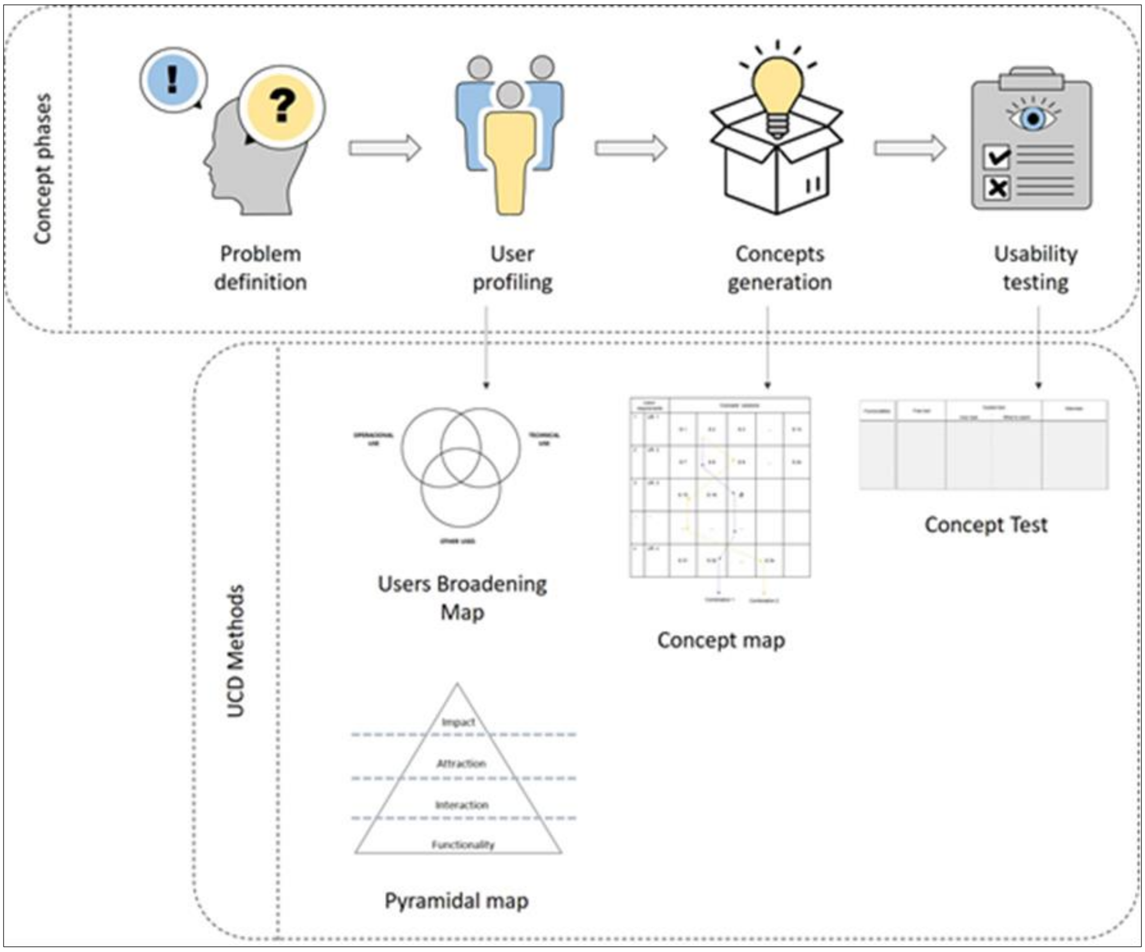

Figure 1 Framework of the concept phases followed correlated with applied methods

After identifying the users, the students contacted some of them to raise their needs. They applied methods such as empathy map, user stories, and personas, and then applied the pyramidal map. This method contributed to an excellent organization of collected information, helping students when searching for specific data.

For the third phase, concepts generation, students applied the conceptual map. With such a method, students were able to list functions and solutions for each user requirement, contributing so that students do not lose the user's focus on generating concepts. From the didactic point of view, it was possible to perceive how students used theories from other disciplines to aggregate in the concept development. This phase then allowed the consolidation of knowledge with other disciplines.

In the last phase, usability testing, the concept test was applied. As it is a method with which the developer can check whether the users' needs were met or not in his project, students did not need to develop high-fidelity prototypes [14], that is, many of the prototypes developed were not functional, they were not produced with the final materials of the project and in some cases, they were just digital (3D drawings). For students, working with this method and with low-fidelity prototypes made it easier to obtain feedback from users. The members of the companies were positively impressed with the method since they thought it was not possible to do usability tests with users with low-fidelity prototypes. Such a practice can help both in decreasing time in product development and decreasing costs.

4 Conclusion

This work presents a framework to guide professors of the ergonomics discipline to follow, with their students, a PBL approach with four concept phases and specific methods for three of them. Starting with the problem definition, which will be presented by a partner company, students become familiar with the design/redesign opportunities in the company's complaining product. Then, students identify potential users of the product using the UB Map, conduct interviews and observations to identify their needs and organize the data obtained with the Pyramidal Map. After that, students create concepts with the help of the concept map, thinking about product functions that meet each user's requirements. After selecting a combination of functions, students develop low-fidelity prototypes to test their concepts with users through the concept test. With the results of this test, the students identify whether it is necessary to change any concept, whether functional or aesthetic, for further detailing of the project.

With the application of this framework in five ergonomics classes (a total of 198 students), it was possible to identify many benefits both from a didactic and a professional point of view (for partner companies). Following a PBL approach, students can put the content of the framework into practice in a structured and guided way. In all phases, with the application of methods, students discuss theoretical concepts, which contributes to a greater fixation of the theory and a greater understanding of its practice.

It can be concluded that the application of the framework of this work, together with the PBL approach, contributes to greater student learning, better results for the discipline's partner companies, and an organized structure for professors. For future work, the framework can also be applied in product development disciplines.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declares that there is no conflict of interest in their research study.

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