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PROJECT-BASED LEARNING: A NEW WAY TO TEACH ERGONOMICS

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1. Introduction

Ergonomics applied knowledge is believed to being capable, when introduced with other disciplines, to solve systemic problems and seeking for understanding human behaviour in even broader scales – from individuals to groups and societies [Moray 2000]. Human factors or Ergonomics can be defined as the science applied in favour of comprehending environments, tasks, organizations, products and even jobs regarding three main disciplines: understanding the human's physical relation with systems; cognitive factors for interacting with them and the optimization of sociotechnical systems [IEA 2015].

Since every artefact designed is going to, in one way or another, interact with humans, understanding these relations is a key factor for succeeding. Ergonomics may be taken as a guiding principle in product development, avoiding facing human as a post-design feature [Woodcock and Flyte 1998], [Burns and Vicente 2000].

In order to insert Human Factors improving the odds of attending users' needs, some practices may be of importance as proposed by Norman [2013]: deeply understanding the goals of people while they use the products, generating potential solutions, building quick prototypes and mock-ups and testing them with users through many iterations.

It may be a fact that both individuals and organizations are failing to support Human Factors when facing other project constraints [Woodcock 2007]. The author also stresses that the teaching and designing of environments to provide ergonomics related education have been neglected, influencing on the narrower adoption of Human Factors. Education of design engineers may be critical towards the development of more usable systems.

In addition, it seems that current engineering programs are not encouraging students to develop the skills they are expected to obtain and education remains disconnected to what real life looks like [Mills and Treagust 2003].

The necessity of approaching Ergonomics differently [Woodcock and Flyte 1998] allied to Hands' [1983] argue that traditional education leaves a gap between what industries seek and what students are prepared for, provides an opportunity to redesigning the learning of Human Factors to undertake the global market demand. The mentioned author also states that closing this existing gap may require a partnership between the academy and companies, in which students must be encouraged to mind real projects, having the opportunity to plan, gather data, make decisions and communicate their work in a reasoned manner.

As an attempt to contribute to the education of Ergonomics, a Framework is proposed in order to enable students to learn this discipline from a different perspective: as a belonging constraint of the design process. However, breaking up with the idea of Ergonomics as a post-design feature would not be sufficient to change its role at designing products. Using a design methodology may facilitate the path

of developing a new product as well as it may enable teaching of other disciplines [Dunne and Martin 2006].
Therefore, this research aims to empower the future engineers by providing a Project-Based Learning whereas realistic experiences are set to encourage user involvement, problem-solving, team working, use of CAD modelling and 3D printing, decision-making and pitching. Certifying that once these students are inserted in a company's environment and face designing of complex systems, they will not only be able to create concepts based on Human Factors but also to defend their importance and maintenance in the project.
Concisely, a review on project-based learning is presented to give support for the proposition of a Student-Centred Course (SCC) Framework to assist teaching Ergonomics. In this, PBL relies the sine qua non condition of an intense participation of a partner company and that students anticipate studies when going to class. The SCC framework was applied twice in semesters of Engineering Classes at the University of São Paulo and this paper will describe one of them. The main outcomes indicate that the framework helped the students on introducing Human Factors' concepts to solve the problem presented to them and that the realistic environment created improved both the outcomes of the project and students' personal skills.

Project-Based Learning

Project-Based Learning (PBL) may be seen as a tool for changing the traditional education paradigm, as a learning approach that provides the students with a proper realistic environment to solving authentic problems [Blumenfeld et al. 1991]. The acronym PBL may also refer and be interpreted as Problem-Based Learning however many differences may be seen among these two approaches. Five criteria were identified to arbitrate if a certain approach is Project-Based or not, as following:

- Projects are central to the curriculum – The project is the main teaching strategy and students should be able to learn the curriculum content through it [Thomas 2000], [Mills and Treagust 2003];
- Problems and discipline content must be linked – PBL must focus on problems whose solving must guide the learning discipline's content and stimulating students on looking for solving them [Thomas 2000], [Blumenfeld and Krajcik 2006];
- An investigation process is inherent – PBL must encourage students to engage in a constructive investigation process including inquiry, knowledge building and resolution [Thomas 2000];
- Goals and outcomes must be well defined – Defining goals and outcomes of the project are of complete responsibility of the professor even though students are allowed to direct themselves to this goals however they see fit [Savery and Duffy 1995]; and
- Projects must be realistic – Differently from scenario and academic challenges, PBL may engage into real life challenges and provide authentic problems whose solution could be implemented [Thomas 2000]. Such criterion can be achieved with the help of authentic features such as tasks, roles that students play, working context, artefacts developed, the users of artefacts being created and/or judging criteria [Thomas 2000].

Blumenfeld and Krajcik [2006] have set the theoretical backgrounds of this learning model as active construction, situated inquiry, social interaction and implementation of cognitive tools. According to Blumenfeld and Krajick [2006], Project-Based Learning's advantages rely on the facts that students:

- Earn a deeper understanding when encouraged to actively construct meaning through the process of anchoring previous experiences and acquiring new ones;
- Learn more effectively when situated in a realistic context, since a real-like process helps motivating students, enhancing their performance;
- Show better outcomes when learning is constructed based on sharing information with others and discussing ideas and concepts; and
- May have their learning maximised by the use of tools on gathering and analysing data, sharing information, visualizing, planning, building and testing models and registering students' progress.

Although Project-Based Learning presents many advantages for the students, a wider adoption of this approach will not happen unless careful attention is given to the way teachers and students are supported

[Blumenfeld and Krajick 2006]. Besides, it is worthwhile to mention that its implementation is arduous and success might rely on a prudent scaffolding of instruction and assessments, a wise choice of the driving problem, commitment to stimulate student's motivation, the creation of a proper realistic context, amongst other challenges. The lack of a structured PBL model has the convenience of providing more freedom to creating a framework and consequently, the one here proposed is aimed for teaching Ergonomics by developing concepts of products through a PBL approach, endeavouring to address these previous concerns.

2. Student-Centred Course framework

The Student-Centred Course (SCC) is based on PBL principles and is intended to enhance the students' experience while learning Ergonomics. The SCC Framework consists in a systemic set of iterative project phases, permeated by interactions with a real company`s personnel and users and assisted by the teacher, teaching assistants (TAs) and monitors.

The partner company presents a challenge for the students solve that is one of their current ergonomics problems demands. In order to solve the problem, the students have to accomplish the project phases presented above, resulting in a concept. At the beginning of every phase, the students are instructed regarding the Ergonomics theoretical content through mandatory readings, class discussions and methods introductions and these curriculum matters are assessed in the Weekly Preparatory Tests and at the end of the semester, in a Final Exam. In addition, at the end of every phase the students must release a Project individual Logbook and a Team Deliverable, to be assessed. The framework is illustrated on Figure 1 along with its composing elements.

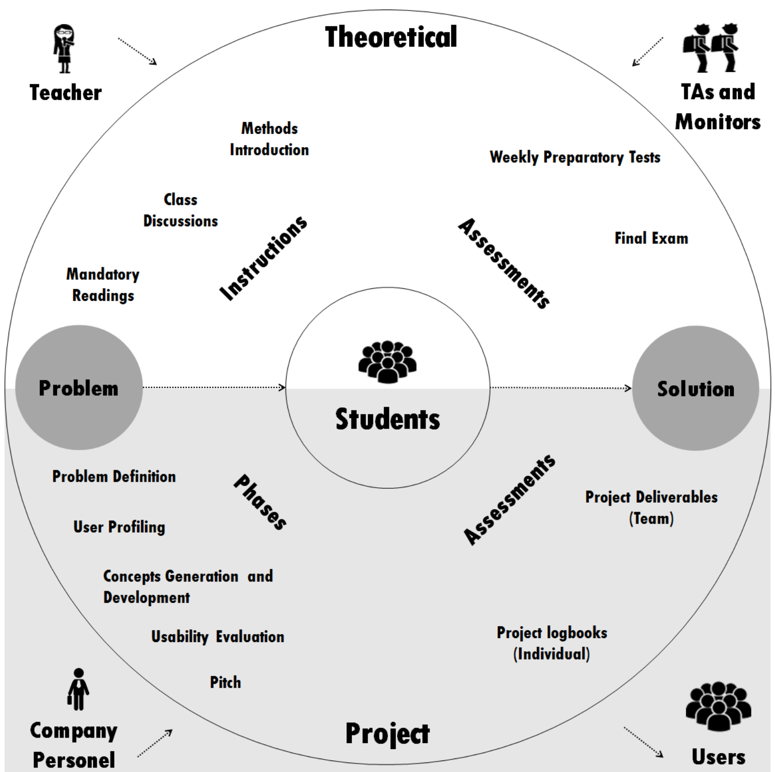

Figure 1. Framework for teaching Ergonomics through Project-Based Learning

2.1 People and technology

Project-Based Learning provides a unique opportunity for both teachers and students to immerse in a problem, exploring and learning concepts through it. However, it assumes that teacher fulfils many requirements that are not easily met and consequently, many PBL do not reach the expected outcomes

[Blumenfeld et al. 1991]. Also concerned with the enhancement of PBL's practice, this framework suggests that the professor forms a team, composed by company personnel, monitors and teaching assistants (TAs). Blumenfeld et al. [1991] stressed the importance of technology use in PBL by supporting learning and sustaining students' motivation.

Company personnel

The company personnel's role extents to presenting the challenge and maximising the realistic feature of the project by facilitating the access to end-users to whom concepts are designed for, providing students with a real work environment and with feedbacks according to the company's project judgement criteria.

According to Prince [2004], becoming an expert requires depth and width in factual knowledge in their fields and when this is not true for the PBL's tutors, a significant issue in PBL's implementation is established. Therefore, the company personnel, as they are experts, evaluate the concepts and social skills evident during the presentations, increasing the assertiveness of the approach by assisting the students and sharing with the teacher the responsibility for teams' project assessments.

TAs and monitors

TAs are graduate students pursuing either a master's or doctorate degree. These students are selected from the Teaching Enhancement Program, joint effort of the University of São Paulo and a research fomenting institution to train future professors in their interest areas. In addition, monitors are undergraduate students which apply for the position and are selected by the University if they attend to specific requisites of the Program. While teacher assistants help on guiding the implementation of methods and on correcting the assessments, monitors are involved on operational issues such as keeping the instructions and files up to date for the students. In addition, as the monitors' experiences baggage is closer to the students', they can help the teacher by telling which activities are too easy or too difficult to be accomplished, increasing assertiveness and students' motivation.

Technology

An open-source learning platform with the discipline's content and mandatory readings is provided as a mean for uploading deliverables, helping the teacher in organisation and allowing students to see their previous works. Communication, however, between students and the teacher, TAs and monitors is held by emailing and the design process is registered through photographs posted in a blog.

Moreover, the classroom is set in a way each team have access to a computer, allowing the use of cognitive tools. The technology support to the students in this case comprehends gathering and analysing data; enhancing visualization of the concepts features and enabling betterment in its interrelationships through CAD designing; allowing the manufacture of mock-ups by 3D printing; developing multimedia registers of the activities; and facilitating the communication of instructions via emailing.

2.2 Theoretical instructions

In order to allow an active construction of learning, instructions must be structured and the teaching must provide an encouraging environment for the students to strive for answers themselves and learn in situated context [Blumenfeld et al. 1991]. Previous experiments showed that the highest scored PBL programs were also the most directive ones [Prince 2004], reinforcing the need of instructions even on self-directed approaches.

Another point in which PBL differs from traditional education regarding instructions is that the lecture must consist in a brief introduction of content instead of pushing theoretical content as much as possible in a same class, given that students remember more in the first way [Prince 2004]. Therefore, students must be prepared in advance about fundamental discipline's content.

The three sub-elements of theoretical instructions proposed are mandatory reading, class discussion, methods introduction.

Mandatory readings

Students are required to study in advance the mandatory readings containing the Human Factors' theoretical content related to the project phases. The texts are available at the course platform along with a list of reflection points to be discussed at class.

Class discussion

Class discussion mediated by the teacher is intended to students sharing and discussing their acquired knowledge, opinions, and express and solve their doubts. The teacher encourages critical thinking by asking students to relate the theory they learned in the previous class to the theory being discussed. It is also encouraged in students to ideate how the theory might be applied in real cases. The classroom layout dedicated for teamwork also motivates students to discuss the theory reflecting on the implementation in their own current projects.

Methods introduction

Ergonomics methods are introduced in order to support the teams on the development of project's concept. It is important to point out that the instruction of the methods should differ from the traditional teaching approach that generally specifies a sequence of steps that students should take towards reaching an outcome. In turn, the teacher reflects with students the desired results with the application of methods. Thus, students will have the opportunity to learn how to use or even customize methods and practices according to each real case. Concisely, the Teacher instructs the basic of the methods and let the students free to implement them, helping when requested. By proposing this model of instruction, it is believed that the assimilation of concepts by anchoring experiences and situating learning provides deeper understanding and allows students to make correlations with other matters, maximising learning.

2.3 Assessments

Since the project students engage in is the main teaching strategy and must be treated as the curriculum itself [Thomas 2000], a lot of attention must be given to the way assessment is taken. It must be certified that the students are learning the theory and applying it properly and that the process of acquiring valuable skills for professional life are being achieved.

It is noteworthy to state the most desired abilities students must fulfil in order to succeed in work environment are to interpret, to evaluate, to be proactive and to communicate well verbally and through writing [Hands 1983]. Given that, the assessment task becomes even more challenging and feedback from the enterprise addressing these aspects become essential in their evaluation.

Regarding academic achievements, evaluating by traditional exams is not an issue even in PBL and instead, it might be helpful in directing students, enhancing performance [Prince 2004]. The problem related to traditional assessment and its negatives effects on students' learning process does not reside on the exams themselves but on the fact that more attention is given to performance rather than knowledge acquisition [Blumenfeld et al. 1991].

Another concern related to assessments is how to promote individual responsibilities in cooperative environments. Prince [2004] then, emphasizes that the course shall not be team-based only, but also to demand individual efforts.

Based on all these previous concerns addressed in the literature, the SCC framework proposes a combination of formative and summative assessments regarding theory and project acquirements, seeking to provide in-process and overall feedback (respectively) to the students and measuring individual and team achievements (see Appendices for the Course Program).

Formative theoretical assessments

A preparatory test is held individually at the beginning of every weekly class meeting consisting in one or two conceptual questions in order to check students' understanding of the mandatory readings. The tests are followed by a class discussion in which students are encouraged to actively participate given that good performance could imply in upgrading the test for the highest score.

Formative project assessments

Individual project assessments are taken at the end of each project phase in which students are required to deliver a one-page logbook with the reasoning that occurred during the development of the phase. The evaluation considers the presence of elements from Ergonomics' theory, interdisciplinary content and depth of the registered thoughts. The score is given within a feedback from the professor or the TAs. For the team's assessments, the project deliverables are graded considering their content, structure and presentation. Some deliverables are not graded but have the purpose of assessing the progress of the project and providing in-process feedback for the groups. Along with the team deliverables, in specific phases the students have the opportunity to present their work to the experts of the partner company and to the potential users of their concepts, resulting in a sum of feedbacks with different points of view, enriching the development of the teams.

Summative theoretical assessments

Consists in a final individual exam following the traditional education's format regarding the Ergonomics content and it was only applied to the ones that did not performed well in the weekly preparatory tests.

Summative project assessments

At the end of the semester, the teams are expected to pitch their concepts to an audience and they are judged by a committee formed with personnel from the partner company and from the university using the same criteria that the company adopts in their projects. The assessment consists in the evaluation of the final concepts and professional skills, then, feedback is given.

2.4 Project phases

Bloom et al. [1956] proposed a hierarchy of six levels on cognitive domain (in ascending order): Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation and teaching must cover all levels. After analysing thousands of engineering programs, however, Felder et al. [2000] observed that the majority of them fit level three or lower. In fomenting the learning of Ergonomics content by inquiry, its study must start with a problem to be unfolded by the cycle of understanding, proposing, realizing and evaluating [Scrivener 1999], [Woodcock 2007] and moving from a stage to another imply in a solution as well as in reaching major levels of Bloom's Taxonomy [Bloom et al. 1956]. The path however should not look like a liner process of validating hypothesis but like a complex trajectory filled in with surprises brought through action-on and reflection-in [Schon 1983], [Woodcock and Flyte 1998]. Considering that, the phases are designed for the students to attain high cognitive domains and to experience the most of a real company product development process. However, given the lead-time of a semester and the main purpose of the discipline, the design process the students perform does not concern to the manufacture of the product, only testing the prototype. In general lines, the design process proposed is leaded until the Concept Development presented by Ulrich and Eppinger [2012].

The goals of the phases along with the project deliverables are following presented, keeping in mind that the individual project logbooks and formal project deliverables are constants of the process and are released by the end of every phase.

Problem definition

The first phase's aim is to introduce the ergonomics challenge to the students. They must also understand the ergonomic problem presented by the company`s personnel, being able to identify and elaborate, re-framing constraints and criteria related implicitly and explicitly to the project case.

User profiling

This stage aims to teach students regarding the value of understanding the user in the design process. Although observing users demands a lot of work and time, they are extremely important to produce pleasant and ergonomic products for consumers. Secondary objectives of this stage are familiarisation with observation and interviewing good practices (designing guideline and implementing user

investigation), application of user profiling methods, and ability to identify users' needs through translating users' profiling information into ergonomic requisites.
The required project deliverables of this stage are: an open questionnaire and observation guidelines to be applied with the users, a user profile report (persona or empathy map) containing the information gathered with the potential users and a list of ergonomics needs.
Finally, the company`s personnel must arrange opportunities for the students interact with real product users. It is worth mentioning the importance of respecting the ethical issues in research. Besides taking appropriate care concerning the users' rights, it is recommended to the responsible for the task to plan in advance the meetings as the acceptance of the research permissions can be very bureaucratic and time consuming.

Concepts generation and development

Students must brainstorm their ideas regarding how to attend the ergonomic needs identified. Secondly, listening to peers and being able to understand and value their contributions are social skills valued in team working and therefore stimulated in this stage. Besides, when the team starts converging to one concept, students are instructed to construct and reconstruct understanding (what provides deeper learning) while reflecting regarding its features and convincing others by the use of interdisciplinary matters [Blumenfeld and Krajcik 2006]. Moreover, dealing with an amount of constraints and trade-offs, decision-making and giving and receiving feedback are some skills that can be practiced at this stage.
Once a set of concepts are created, the teams present it to the company's experts in a formal gate meeting. During the gate meeting, the company`s personnel and the teacher recommend one of the presented solutions to be developed by the team. The students following develop CAD modelling and produce a prototype with a 3D printer available for use. It is noteworthy that CAD modelling and familiarization with additive manufacture are required for this stage.

Usability evaluation

The main objective for the students is to evaluate the usability of the solution developed by testing with real users. The company again is asked to provide the interaction with real users. The project deliverables are a usability test script to be used in fieldwork and a usability evaluation report.

Pitch

According to prior research, students have difficulties on articulating and defending their claims, on understanding what the evidences are, also, on using the appropriated ones instead of relying on their personal views [Blumenfeld and Krajcik 2006]. Given that, this phase previews exercising argumentation and even communication skills through pitching.
The challenge is that students must persuade stakeholders from the partner company to provide the continuity of their concept's development, as well as convincing an audience. The groups must deliver to assessment the presentation used to support the pitch in digital form and a final project report.

3. SCC application case

The case followed presented was given to the 2nd year of the Manufacturing and Materials Engineering Program during the second term of 2015. One faculty member, two TAs, a master student and a PhD student composed the course team. Besides the TAs, three senior undergraduate students assisted the course being monitors.
A partnership was established with a multinational company (hereafter called Company A), producer of office consumer goods. The company presented an ergonomic challenge (case) to the students that indeed was one of their real current problems to be solved. In addition, the company was requested to provide student interactions with real users, and to judge the project deliverables with the same criteria they applied in their projects. In this way, the students could experience the delivery and evaluation of a project in an environment as realistic as possible.

The 60 undergraduate students enrolled in the course and were grouped into 9 teams. Students were free to form their groups, the only limitation imposed by the teacher was a maximum of 8 students per team. The TAs and monitors were assigned to assist specific groups throughout the entire project's progress.
In order to solve the case, fifteen formal class meetings were held weekly in an average of four hours each, resulting in approximately 60 hours of work in class. Besides, the students were required to work outside for 4 hours per week however they could manage these work hours as they see fit. The open-source learning platform allowed the students to access the theoretical content of the mandatory readings and to upload the project deliverables throughout the stages of the project and a blog was created to register the project activities by multimedia documents. The case will be described according to its projects phases and the syllabus along with the course program are provided as appendices to illustrate the theoretical and project assessments and instructions occurred during the SCC.

3.1 Problem definition

At the present phase, Company A challenged the students for designing an innovative white glue package considering use of non-toxic materials, possibly eco-friendly materials; that the product must be recycled or reused; and that the white glue composition must not be altered. They also provided material and guidance to the students experiment the use of white glue in activities directed to the target audience, children 4-11 years old. While accomplishing the dynamic with commercial products, the students were asked to start to pose questions regarding the problem scoping.
After the dynamic, the experts from the enterprise showed some short videos of fieldworks they made testing products with the target audience and designated some time to clarify the students' doubts, related to commercial and technical issues.
To conclude the phase, it was requested for the students add their first reasoning about the project challenge in their individual logbooks.

3.2 User profiling

On demonstrating to students the importance of user identification, the principles of User-Centred Design and Biomechanics where discussed in classroom. Afterwards a practical exercise was conducted to familiarize students with two user-profiling methods: Persona and Empathy map.
The teams were asked to select and apply in their projects one of the user profiling methods they learned in class. To apply the methods, the students were advised to plan a set of activities to be performed with the users of the glue tube and create an interview script and observation guidelines to assist them during observations. The TAs and monitors stimulated students to think over user's ambitions, interests, realities, hopes, desires and other aspects that fit the user profiling methods. It is noteworthy to point out that the teams were, at the start of this activity, focused on information regarding the technical performance of the product rather than worrying about the profile and the needs of users. This typical tendency of engineering students enhances the important coaching role of TAs in this regard.
Company A arranged for the teams go to public schools to perform their planned activities. The teams immersed in the children's environment to observe and interview students and teachers (were available approximately 20 students and 1 professor per team). The following activity was to build up the user profiling with the information they gather at the field, and thereafter elaborate a table containing the ergonomics needs, in which they should state for each need: nickname, description, justification, and level of importance (desirable, optional or essential). The teams started this activity at the classroom where they received assistance of the teacher, TAs and monitors. They were requested to upload at the platform a formal User Report to be assessed by the teacher and Company A.
To finalize this phase, the students submitted the second part of their logbook. The recommendation was for them to express their concerns about the project regarding the users and their needs, possible solutions and register relevant aspects for the best development of their projects.

3.3 Concepts generation and development

The purpose of this phase is to create a physical concept of the solution, as the solution itself has been constructed in a continuous process since the beginning of the project. To allow students to produce high level solutions for the ergonomics problems, discussions of theoretical content regarding

Anthropometry, Cognitive Ergonomics, Human Variability in Product and Rapid Prototyping in Industry served to input more constraints to the problem and instigate inquiry.
The students at this stage drew sketches and refined ideas to present to Company A three concepts at most and in turn, the company's personnel gave feedback to the teams including which of the concepts they think would produce better outcomes.
After a process of incrementing and refining the chosen concept, the teams designed in CAD the solution and on prototyped the concept, using additive manufacture.

3.4 Usability evaluation

The students were required to test their concepts performing an evaluation of the usability of their prototype. For performing the usability test, the teams designed a script in order to maximise their time with the users and to obtain consistent usability's information to evaluate their concepts.

3.5 Pitch

To help students practicing argumentation, objectiveness and public speaking, the final deliver of the project was a pitch presentation in which the students had seven minutes to persuade an audience and a judgement committee to invest in their concept.
The judgment committee was formed by professors from the University of São Paulo and personnel from Company A and they elected a winner as well as 2nd and 3rd places considering pitching performance, level of innovation presented, quality of the solution proposed and understanding of users' needs. Besides, the audience formed by students from the university and related also had a chance to vote and they elected an audience finalist.
It was observed that the quality of the works considering this four aspect was high in the opinion of the judgment committee. The company`s personnel stated that the process of development of the concepts was very similar to the company's, differing in the lead time, and they were amazed by the conceptions regarding the users' needs and quality of the pitch presentation. They also said the solutions presented features already discussed by them and that it reveals deep understanding of ergonomic matters and ability to solve problems.

4. Conclusions

Discussing with professionals in the area might be a path for evaluating teaching [Wankat and Oreovics 2015]. Qualitative surveys involving the company personnel were performed in order to measure the performance of the students and the benefits for the company.
After interviewing three professionals from the partner company that were highly involved during the whole process, it became clear that students presented a profound comprehension of users' needs and relevant solutions for the given problem.
Comparing the two gates the company personnel is responsible for evaluating the concepts, the interviewees pointed evolution on both the project deliverables and students' social and professional skills throughout the project.
As the proposal of the Ergonomics course is student-centred, success is considered to be achieved when students are able to understand and apply Ergonomic related knowledge on solving systematic problems and achieve personal developments.
The realistic environment created using the framework called the attention of the company personnel. This atmosphere may help obtain better project and personal outcomes and facilitate the introduction of Human Factors in the resolution of the problem. Nevertheless, it's important to keep the learning environment in first place.
Despite the mentioned evidences, there are still open points to compare this Student-Centred Course Framework to the traditional approaches. The development of metrics to evaluate and eventually endorse Blumenfeld and Krajiciks' [2006] mentioned benefits from applying PBL is a concern and will be performed in future work.
Finally, feedback obtained from the students indicates the problem presented motivated them towards a solution. This may imply that success on the application of the proposed SCC framework heavily relies on the choice of the driving problem, as the outcomes probably depend on a wise proposition of the

challenge. Yet, another future concern is to further understand the role of the driving question in order to adapt the framework to provide a PBL course for teaching different subjects.

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SEP0451 – Design of work systems and ergonomics

Goal:

Present basic concepts regarding design of work systems and product ergnomics. Offer conceptual knowledge and methods to investigate ergonomic aspects of products and work stations. The student is expected to define the ergonomics field, its goals and main intervention areas. He/she may be capable of applying techniques presented throughout the course.

Program outlines:

Ergonomic theories and practical concepts are presented. Thus, the course is partitioned in theoretical and practical sections. Theoretical sections cover physical, cognitive and educational ergonomics. Applications and goals related to these sections are developed.

Program:

Introduction to work workstation;
Introduction to product ergonomics;
User-Centred Design;
Users observation methods;
Biomechanics;
Anthropometry;
Human variability;
Rapid prototyping;
Cognitive Ergonomics;
Practical classes.

Evaluation:

Minimum grade of 5.0 evaluated according to:
Tests (50%): 8 Preparatory tests (30%) + 1 Final Exam (70%)*;
Team (25%): project deliverables and activities (group);
Individual (25%): individual deliverables.

- *Only the student that do not achieve 7.5 on preparation tests and individual deliverables together must take the Final Exam.

C#	Classes Date	Theoretical Content	Project Activity	Reading Material	Prep. Test	Group Deliverables (Moodle)	Individual Deliverables (Prototyping Room)	Delivery Date
C01	8/7	Workstation project	Warm-up: paper plane construction - Define Groups	MR 1 - What is ergonomics (ergonomics.org.uk)		Activity 1 - Paper planes manufacturing report		8/12
C02	8/14	Product ergonomics	Project introduction Logbook definition	MR 2 - Ergonomics and work analysis (Daniellou 2004) OR 3 - Ergonomics & Product - 7.1 (Pequini 2005)	PT 1		LB 1 - Problem understanding	8/19
C03	8/21	Users	Observation methods definition	MR 4 - User-Centered Design (Abras 2004)	PT 2	PD 1 - Observation protocol		8/26
C04	8/28	--- Project --- (School visiting)	Users observation				LB 2 - Eliciting users' necessites	9/2
C05	9/4	Biomechanics	Users observation	MR 5 - Occupational Biomechanics (Iida 1997)	PT 3	PD 2 - Definition of users and ergonomics requirements		9/16
	9/11	Feriado						
C06	9/18	Antropometry	Solution concepts proposition	MR 6 - Antropometry (Masculo 2011)	PT 4	PD 3 - Solution concepts		9/23
C07	9/25	--- Project ---- (Company - Gate 1)	Solution concepts proposition				LB 3 - Solutions proposition	9/30
C08	10/2	Improper use of products	Solution development	MR 07 - Human variability in product use (Peacock 2012)	PT 5			
C09	10/9	Rapid prototyping	Solution prototyping	MR 8 - The role of rapid prototyping in the product development process (Lopez 2002)		PD 4 - Concept description (CAD)	LB 4 - Solution development	10/14
C10	10/16	Cognitive ergonomics	Solution prototyping	MR 9 - Ergonomics at work - chap.5 (Abrahao 2009)	PT 6	PD 5 - Prototype photos		10/22
C11	10/23	Follow up **(Schedule meeting with professor !)**	User testing					
C12	10/30	--- Project ---- (Company - Gate 2)	User testing					
	11/6	Holiday						
C13	11/13	Pitch	Pitch preparation			PD 6 - Pitch	LB 5 - Stakeholders testing	11/18
C14	11/19	--- Project ---- (Amphitheater)	Pitch presentation			PD 7 - Technical report - final version		11/24
C15	11/27	--- Test ---						

MR- Mandatory Reading   PT - Preparatory Test   PD - Project Deliverable   LB - Logbook