ERGONOMICS AND DESIGN EDUCATION: EXPERIENCES FROM THE DEVELOPMENT AND APPLICATION OF A WORKSPACE DESIGN WORKSHOP

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SUMMATIVE STATEMENT
Ergonomics and design education poses a series of challenges to educators and students. A workspace design workshop was developed and held in several contexts. This experience highlights benefits of a practical approach to ergonomics and design education.

Formation en ergonomie et conception : une expérience axée sur l'élaboration et l'application d'un atelier portant sur la conception d'un espace de travail

MOTS-CLÉS
Formation en ergonomie, conception technique, apprentissage par le jeu

SOMMAIRE
La formation en ergonomie et en conception présente divers défis pour les éducateurs et les étudiants. Un atelier de conception de l'espace de travail a été élaboré et organisé dans plusieurs contextes. Cette expérience souligne les avantages d'une approche pratique à l'égard de la formation en ergonomie et en conception.

INTRODUCTION
Ergonomics is an essential element to the formation of production engineers. Production Engineering in Brazil is a very popular career due to its broad field of activities, ranging from finance and economics, to production planning and control. Among the various subject areas regarded in the production engineering education, the area of Design and Technology congregates disciplines as product design, factories planning and design, work design and, of course, ergonomics.

Historically, the human factors and ergonomics field in Brazil has been strongly influenced by the Francophone ergonomics research, centered on the concept on activity (Daniellou & Rabardel, 2005). Topics covered on an ergonomics course in higher education usually follow the ergonomic work analysis methodology (EWA) (Wisner, 1995), which culminates in the ergonomic action.

In this context, ergonomics is regarded as a design discipline, which must be accounted for in the design processes of products, workspaces and facilities, focusing in two closely related outcomes: health, safety and well-being of workers and users and systems' operational performance (Dul et al., 2012).
However, challenges arise in the ergonomics teaching and learning processes in higher education. In a survey performed by (Eroglu, Cifter, & Ozcan, 2013) with 79 students of industrial design related higher education courses, students’ dissatisfaction with their ergonomics education mainly related to the insufficiency of applied studies during the course. As noted by (Tempelman & Pilot, 2011) students in design courses struggle to bridge the gap between theory and practice, which can also be seen in ergonomics courses. Nonetheless, the theoretical concepts are paramount for a solid understanding of ergonomics and its development but they may seem elusive for students when they are asked to put them into practice. Furthermore, differences among students’ interests, motivation and maturity levels must also be overcome as pointed by (Jones, 1999).

The closer interweaving of theory and practice suggested by (Tempelman & Pilot, 2011) is one of the possible strategies deployed to make the learning process more effective and engaging. The experience described by (MacKie, 2011) shows how a practical assignment (designing a personal vehicle) could help students assimilate concepts of anthropometry and at the same time apply them to a concrete challenge. The hands-on approach reported by (Jones, 1999) allowed students enrolled in an introductory course in human factors and ergonomics to experience the concepts presented in the lectures in a fun and engaging environment.

Recent developments in education research and practice specially those related to the use of games and game-like applications and activities present yet another alternative to bring meaningful experiences, linking concepts and practice, to the classroom. The game-based learning (Kirriemuir & McFarlane, 2004) initiative aims to create environments where games and game-like content can be used by educators to enhance knowledge acquisition and skills’ practice, involving students in problem-solving activities while making the learning process fun and engaging. Considering the ubiquity of technology and the ever-growing exposure of students to it, since their young years, and the substantial differences in thinking and information processing of this “digital natives” generation (Prensky, 2001), this idea becomes even more relevant and worth further investigation.

RESEARCH OBJECTIVE
In this paper, we present and discuss the experience of developing and employing a workspace design workshop to support ergonomics and design learning in higher education and specialization courses. Bridging the apparent distance between the abstract and conceptual underlying issues discussed in ergonomics theory and the pragmatic, empiric and objective nature of design practice, is one of the most salient challenges faced in ergonomics education. In this context, we explore the benefits and shortcomings of employing the workspace design workshop pointing to potential future development paths to improve ergonomics education.

METHODOLOGY
The creation of the workshop was guided through the game-based-learning (GBL) theory, incorporating mechanics such as competition, rounds, feedback, cooperation and points. The activity aims to consolidate concepts related to ergonomic work analysis and workspace design.

The development process of the workspace design workshop (WDW) initiated with the adaption of a real-life ergonomics intervention experienced by one of the authors during his work at an oil refinery in Brazil as an ergonomics consultant. The creation process of the activity span for more than three-years in an iterative and interactive process, with several intermediary versions and pilot tests that culminated in the consolidated version of the WDW that is reported here.
The main goal of the activity is to simulate the role of an engineer in the process of analysis and conception of a local control room (LCR) in a large scale continuous process industry. Based on the information available the participants must propose a redesign of the LCR to contemplate operators needs in terms of health, safety and well-being as well as their operational performance. The participants are divided in groups (up to 5 people) which compete to achieve better solutions while attaining to the stipulated budget goal.

Participants receive a “design kit” composed by a game board (where they will sketch their new layout proposals), a budget spreadsheet (listing all available furniture and equipment they may buy to incorporate in their proposals) and additional textual information (in the form of a synthesis of the ergonomic work analysis performed by an ergonomist in the area).

In total, three sessions of the consolidated version of the WDW were held, with a total of 82 participants. Workshop session 1 was held in the context of the ergonomics course in a professional master program on Production Management, with 39 participants. Sessions 2 and 3, were held with undergrad students in the Production Engineering education, with respectively 20 and 23 participants each. All sessions were essentially identical and were held in the first semester of 2016.

The WDW session takes 4 hours, requiring two facilitators. The workshop is divided in three main phases, namely “Levelling”, “Designing” and “Reflecting”. In the first stage, the facilitators briefly present the context and current situation of the area, and explain to the groups the workshop dynamics. After this initial step, the teams receive their “design kits” and then discuss among the team members the issues and improvements that can be proposed. This stage has 3 rounds, at each round the teams consolidate a layout proposal and the correspondent budget spreadsheet and submit them to the facilitators’ evaluation. The facilitators evaluate the layout proposals quantitatively and qualitatively in terms of their resolution of the issues highlighted in the presentation of the case and support materials, following a systematic evaluation guideline, assigning points to the teams’ proposals. After this evaluation and the feedback to the groups regarding their score and position compared to the other groups, another round starts and the groups have a chance to improve their proposals and reflect about what aspects of workers’ activity must be considered when redesigning their workplace. After the last round, the facilitators guide a discussion about the design process experienced by the participants, the concepts involved and how they related to the actual design proposals.

After the workshop, participants were asked to answer a feedback questionnaire comprised of seven closed questions and one open question to assess how they perceived the experience in terms of learning and applying the ergonomics concepts. Data was collected from the workshops (scores achieved by each group in each rounds).

RESULTS
The scores achieved by each group during the rounds of the workshop were plotted in a box-plot diagram an are shown in Figure 1. The three main vertical sections of the diagram correspond to the workshop session analyzed. In each workshop section, there are three subdivisions: the 3 rounds. Each point corresponds to a group in its respective workshop.
Figure 1. Box-plot diagram of the performance of each group at each round of their respective workshop sessions

It is possible to verify a consistent increase of groups points during the rounds of the workshop. The iterative and interactive nature of design itself is incorporated in the WDW through the rounds system allowing for the groups to progress over time, forcing them to try to better understand the situation presented and to construct links from theory to practice that allowed them to propose new layouts of the area.

The feedback questionnaire was composed of two main parts: the first one focusing on the participant profile and previous knowledge on the topics and the second one regarding their perception on the effectiveness of the activity as a learning instrument in the ergonomics education. The total number of responses of the questionnaire was n=82.

The participants average age was 25.6 ± 4.9 years. Regarding their level of instruction, the majority of the participants 50.0% (n=41) were undergrad students, 48.8% (n=40) were enrolled in a professional masters program and 1 person had already completed graduate school. The participants’ background education was mainly related to engineering (production engineering had 62%, n=51 and other engineering another 14%, n=11). Completing the first part of the questionnaire, three questions aimed to the determine the previous knowledge and involvement of the participants with the EWA methodology, engineering design projects and gamified learning activities. The questions and their answers’ analysis are shown in figure 2.
As expected, considering the activity was embedded in the ergonomics course which contemplated the theory of the EWA methodology and topics on engineering design, a substantial proportion of the participants answered they had some knowledge on the topics. However, the format of a game-like workshop was relatively new to most participants (55% had only a low degree of experience with such activities and 5% had never experienced one).

The second part of the feedback questionnaire inquired participants of their perception on the contribution of the activity to their understanding of the ergonomics concepts and how to apply them to a practical situation. Two questions specifically asked about the workshop structure and its competitive nature, to see if participants felt more motivated by it. The questions and the answers can be seen in Figure 3.
Participants’ answers to these questions were mainly positive, especially questions 4, 6 and 10 which only received concordance answers. It’s interesting to note that question 7 was the one with the lowest proportion of “strongly agree” answers. This question asked if participants understood the key concepts of task and activity better after the workshop. Overall, the feedback analysis highlights participants’ perception that the workshop helped with the understanding of the main concepts approached and that the dynamic and practical nature of the activity was more engaging to learn.

Finally, the comment section of the questionnaire was open for the participants to share what they most liked or disliked about the activity. A total of 66% of the participants (n=54) commented. The comments were read and 74 relevant segments were identified and coded to three categories: “positive comment”, “negative comment” and “suggestion”. Most comments were positive 66% (n=49), 24% (n=18) were negative and the other 10% (n=7) suggestions. Figure 4 shows a subset of the comments and their categorization and Figure 5 synthesizes the overall distribution of comment types in a pie chart.
The practical nature of the activity was interesting to me and I liked to participate in it. The competitive aspect of the activity was important because it made my group to be more committed to it.

I liked a lot the activity. I suggest adding some variation from one round to another, so the groups have to adjust to it.

The activity was very interesting, it made us think about the concepts, the design process and the role of ergonomics, and the competitive factor was a nice touch to the activity. Maybe we could have more time in the first round, once we have drafts to start from in the following rounds, but not in the first.

Figure 4. Example of participants’ comments and classification

DISCUSSION
The workshop divided participants in groups that competed against each other to propose a “better” solution for the case presented. Competition in this sense, may be an engagement factor that motivates participants to better understand the concepts and case and thus propose better designs. Additionally, interaction within the “design groups” revealed many familiar aspects of ergonomics and design practice such as difficulties for communication, usage of intermediary objects, cooperation and so forth, giving participants a sense of how an ergonomic-guided design process may unfold.

The role of the facilitators varies during the workshop. At times, they must play the operators, giving participants details and insights about the analyzed situation. It’s also up to the facilitators to keep track of time and to manage conflicts; depending on the degree of engagement of the participants, they may get too excited or lose track of time, which could lead to delays on the workshop schedule. However, as the workshop has the premise of simulating a real-world scenario, time is a constraint and participants must learn to manage it efficiently. The “design kit” helped the participants in simulating scenarios and estimating their budget expenditures. The gameboard was a physical artefact that congregated efforts and facilitated the discussion on current and future activities and implications derived from the proposed changes in the layout.

The evolution of the groups in the workshops’ rounds point toward a better understanding of the issues present in the current situation presented and how they could solve them to better
accommodate operators’ needs and assure the reliable performance of the activities that take place in the LCR. The rounds configuration is essential to give participants’ room for experimentation, trying different configuration and seeing the scores achieved. Once again, the facilitators can assist groups, pointing them towards the need to understand the problems and trying to solve them through the new proposal.

Participants’ feedback was mostly positive. The practical nature of the task at hand gave participants a taste of what a real-life design project can feel like. The key concepts of the activity appeared to be passed on to participants with success. An instrument to evaluate participants’ actual comprehension of the concepts could be developed and applied before and after the workshop to directly measure to which extent it helps participants on understanding and linking theory and practice.

Conflicts regarding the interpretation of scoring that each group constructed are significant in the sense that they tend to question what is the logic behind the scoring. However, the rounds system also helped with this when they see that proposing changes that positively impact operators’ work has greater value, leading back to the understanding of the situation to transform it.

Challenges remain to incorporate other concepts and mechanics into the workshop to continuously improve its potential. The incorporation of virtual environments developed using game engines is a feasible path we are already pursuing, aiming to enable participants to explore the situation virtually, interacting with the workers and the environment itself. The use of 3D printed models of the furniture and equipment also helps participants to visualize their design proposals and could be employed in future applications. Replacing the budget spreadsheet for a web-based application that could run on smartphones as well as computers makes it easier and more flexible to have workshop sessions in different locations.

CONCLUSIONS
The current evolution in learning styles and attitudes of contemporary students and their close relationship with technology and digital tools are crucial drivers for searching for new tools and methods for teaching and learning practice across all knowledge domains. The ergonomics and human factors education can also benefit from such initiatives, especially considering the inherent design-driven characteristic of the field, which requires a practical focus without neglecting the underlying theoretical concepts.

The workshop presented had a beneficial impact on participants understanding of some core concepts of francophone ergonomics and in how to apply those concepts in a workspace design simulation setting. Further developments are needed however to continuously improve the efficacy of the workshop as a teaching tool and to make its experience meaningful to participants. The incorporation of 3D virtual environments, virtual reality applications, 3D printed models of the furniture and equipment are some of the developments that could help achieving improvements in participants’ engagement and understanding in the workshop.

REFERENCES


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