INTERNATIONAL SYMPOSIUM ON PROJECT APPROACHES IN ENGINEERING EDUCATION

Aligning Engineering Education with Engineering Challenges

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Hands-on simulation in the classroom to teach new concepts and to prepare future industrial engineers as operator´s instructors

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Abstract

This paper presents a hands-on simulation approach developed in a Curricular Unit of the 5th year of the Industrial Management and Engineering (IME) Integrated Master degree of University of Minho. The students, working in teams, were invited to prepare a potential training session to instruct operators in a work environment about cell operating modes (specific thematic in the Curricular Unit contents, defined by the teacher). The teams had freedom to prepare this session as they desired and to use all kind of concepts, tools, techniques they already know or acquire. All teams decided to use a torches kit, available by the teacher, with a product to assembly (the torch), in a different cell operating mode. With the hands-on simulation, the students learn how to prepare a training session, learn new concepts, and apply concepts and tools learned in previous classes. Student's opinions and results of this hands-on simulation are presented.

Keywords: student-centred learning methodologies; hands-on simulation approaches.

1 Introduction

The Bologna process (Eurydice, 2010) puts some challenges to the academic community. Some of these challenges come from the need to change teaching methodologies. Traditional lecture based teaching methodologies are being replaced by active learning methodologies, that involve the student in his own learning. Either based on technology, like the Technology Enabled Active Learning (TEAL) project in MIT (Dori, 2008) or on projects/problem, the objective is the same, engage students deeply in their learning process. At the School of Engineering of University of Minho, some projects based on *Project Led Education* (PLE) (Powell & Weenk, 2003; Powell, 2004; Lima et al., 2007) have been developed for students of the 1st and 4th year of the Industrial Management and Engineering (IME) Integrated Master degree (Lima et al., 2009a; Lima et al., 2009b). The 5th and last year implies for the students an individual project, normally, in a company (Alves et al., 2009b) so, these students do not have any PLE project. In spite of that, each Curricular Unit (CU) gives teamwork assignments that involve active learning methodologies. This paper presents and explains an experience developed in CU of the 5th year in an active learning context. The students were invited to prepare a potential training session to instruct operators in a work environment about operating modes (specific thematic in the CU contents, defined by the teacher). All students in different teams were supposed to simulate a different operating mode, using the same product – a torches kit, to assembly in a hands-on simulation. Additionally, the students learn new concepts and compare the different operating modes. Hands-on simulations have been explored to promote understanding of complex subjects in a deep and intuitive way (McManus et al., 2007).

2 Student-centred learning methodologies

The Bologna Declaration is said to promote a shift from traditional, teacher-centred approach to a student-centred approach to learning, taking the learning outcomes as a starting point, instead of content-driven. Using methods that are centred on the students, instead of on the teachers, implies three fundamental shifts in thinking about learning (Jonassen & Land, 2000). The first shift is from knowledge transmission to a process of making meaning. Learners try to resolve the dissonance between what they know for sure and what they perceive or believe that others know. Secondly, the social nature of the construction of meaning increases the focus of learning as a process of social interaction, rather than an individual process. The third shift in assumptions relates to the communities in which the process of making meaning is taking place. The locus of meaning making is not only in the head of the learner, but also in the discourse among individuals, the social relationships that bind them and the physical artefacts, models, theories and methods they are involved in (Jonassen & Land, 2000). In a student-centred approach to learning, students need social interaction to construct meaning. This means a learning environment in which students are engaged in activities that provide opportunities to interact with other and with the world around them. Shifting responsibilities from teachers to students makes students more active in the learning process and increases interaction between students and the teacher and between the students and their peers. Weimer (2002) identifies five key elements of change towards a learner-centred practice, starting with the balance of power that is, traditionally, with the teacher. Student-centred learning means a shift of power from the teacher to the student and confidence in the ability of the student to make decisions about his learning. It does not imply a complete transfer of power, but rather a share of power. The function of content is the second key element of student-centred learning. Weimer (2002) argues that a too strong orientation on content can hinder learning. On the other hand, learning about learning and learning content simultaneously is a different way of looking at content in learning. The role of the teacher is a third key element in student-centred learning. The focus of faculty needs to be on learning to become aware of how teaching influences learning. Faculty facilitates learning and is no longer the centre of attention. The responsibility for learning needs to be accepted by students, as a fourth key element of student-centred learning. Teachers can create conditions and help students to be willing to learn, but, in the end, the students have to do the learning. Weimer (2002) argues that discipline is not the key to student learning, but that logical consequences are necessary to change unfavourable behaviour. There must be consistency in word and deed with regard to students. The purpose and process of evaluation is the last key element identified by Weimer (2002).

In this study, students are involved in a specific activity that aimed to construct as many torches as possible with a specific operating mode. Students have to work in teams and carry out an open-ended assignment. T

3 The teamwork assignment

The teamwork assignment was carried out by teams of 3 students and consisted in developing a plan to operationalise a session to train operators in working operating modes (Alves et al., 2003; Alves & Carmo-Silva, 2006) adopted for cells (Hyer & Wemmerlöv, 2002). A cell is a production system layout that could be projected as a *"…small organizational units which complete all the set (or family) of products or components which they make, through one or a few major processing stages, such as metal founding, machining and assembly, and are equipped with all the machines and other processing equipment they need to do so."* (Burbidge, 1989). An extended definition points to a production system that groups and organizes the manufacturing resources (e.g., people, machines, tools, buffers, and handling devices) necessary to manufacture a family of parts and/or assemble a family of products, with identical or similar manufacturing requirements.

Seven teams were formed (21 students), each team approaching a different operation mode: Baton Touch; Bucket Brigades in line and in cell; Rabbit Chase; Working Balance, Toyota Sewing System and Assembly Line (Figure 1).

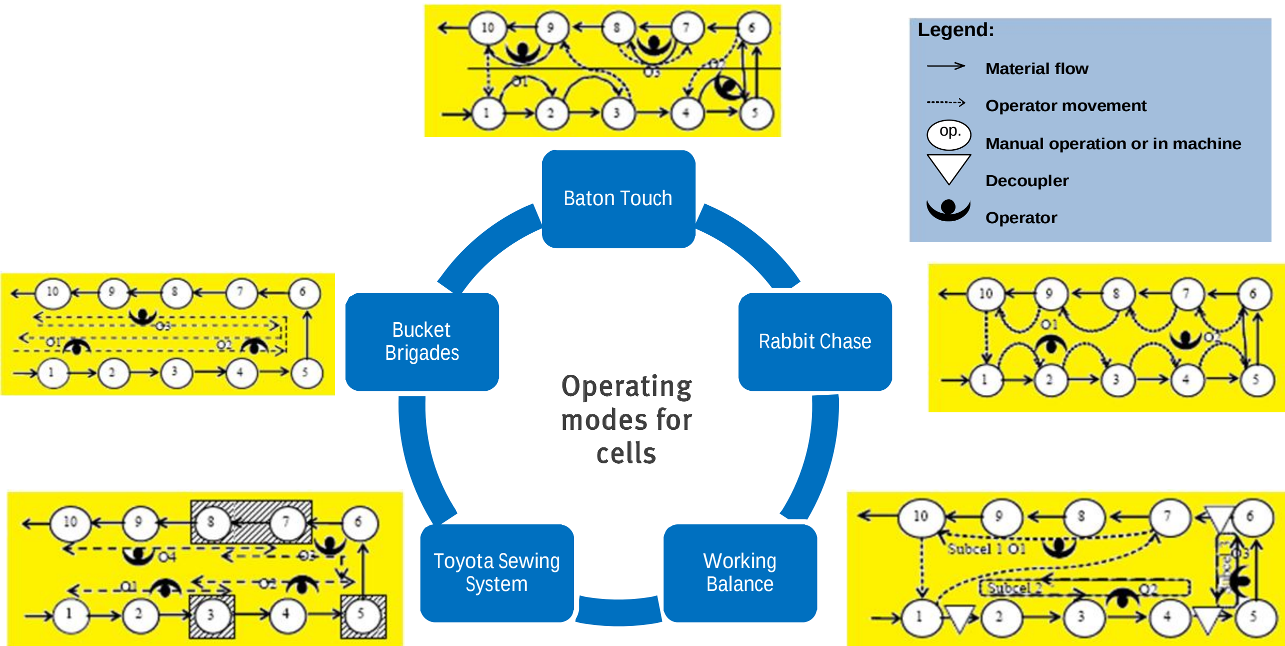

Figure 1: Schematic representation of operating modes for cells (Alves, 2007)

In simple terms, working operating modes mean the internal organisation and distribution of the operators by the workstations related with how people work and flow within a cell (Oliveira & Alves, 2009). Each operating mode has some characteristics distinguishable and each team had to study these characteristics in order to present to the teacher and colleagues how works the mode allocated to the team. All teams receive a document with a basic description about the operating modes with the Figure 1. They also had access to operating modes literature and a review already done in Alves (2007).

The teams had totally free choice to do the plan how they wanted and used tools available or others they found out. They had available a torch kit (Figure 2) for the hands-on simulation with a very simple manual (Lean Games, 2006) which describe the operations to assembly a torch.

Figure 2: Torches kit (Lean Games, 2006)

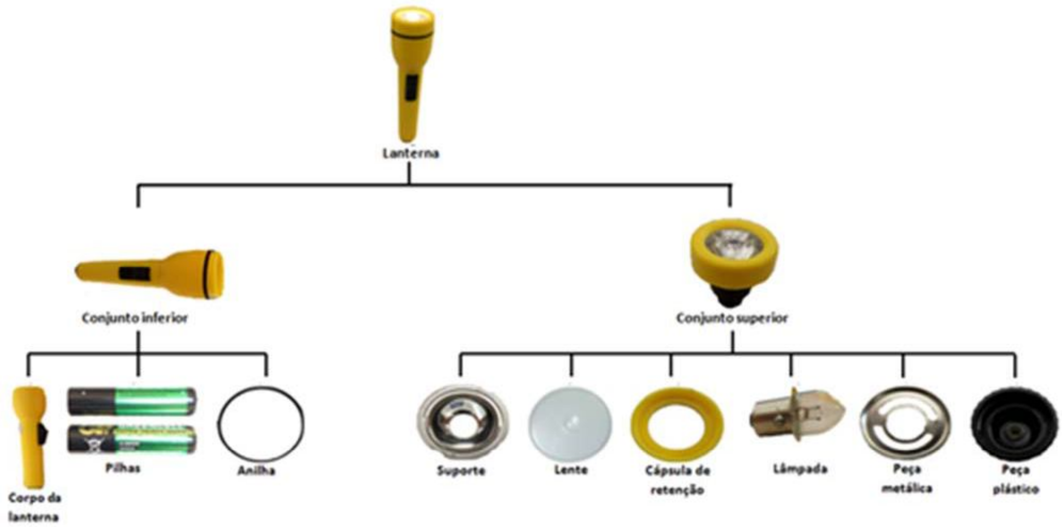

Figure 3: The torch and torch components (Bills of materials)

All teams decided to use this kit to do the hands-on simulation. The product to assembly in the cells was torches with different colours. Each team has to prepare the layout for the cell, attending to the operating mode allocated and all material (documents, presentations, …) that they consider for the operating mode formation plan.

This work assignment was one of the assessment components (25%). Other components were the written test (40%) and an individual project in a company (35%), resulting in a technical report. This individual project is what Peter (2010) calls a hands-on case study, a teaching methodology that helped students to assimilate the CU contents and engage them in a work industrial environment. The opinions students on that experience were collected by email in the end of the semester.

4 The sessions preparation

The first task was to standardize the operation times for all assemblies operations, defined by the teacher and students before the simulation sessions. Having these common operations times, each team made some experiences, and then sent the results to the teacher that found out an average that all teams could use in order to compare results. The common material to be used by all teams was the torch kit, the torch kit manual, the operation and operation times. In class, a simulation time of 5 minutes was defined to demonstrate the operating mode. Knowing this time and the longest operation time, the demand and the theoretical operators' number were defined.

So, the initial data for simulation was 5 minutes for simulation, chronometric time, longest operation time was 5,7 seconds, expected demand was 53 torches and the initial number of operators was 5. This number puts some challenges to the teams since they had 3 members and need more people than this number. When the first session took place, the team needed 5 operators and even with the volunteers called by the teacher the students did not offer help other teams. The teacher had to interfere to make students help each other out to run the simulation.

These simulations took place in three sessions with a total time per group of 10 minutes. Each team simulation had three parts: the preparation (introduction by the team of the operating mode), the hands-on simulation (involving team members and others colleagues) and the conclusion (the findings). All sessions were video-taped and became available to the teams in the end of the sessions. There were not restrictions to the tools, documents or figures they could use. Each part demanded different approaches and they could use whatever they want.

5 The results

The outputs from each team were diverse since they used different approaches to "train the operators"; the Table 1 resumes these approaches. Some introduce the theme with a presentation, others with posters. One team used a simulation model using the software ARENA to show the layout and the operating mode (Figure 4).

Table 1. Approaches used by the teams to present (conclude) the operating modes

Teams	G1	G2	G3	G4	G5	G6	G7
Operating modes	BT (5 op)	RC (4 op.)	WB (5 op.)	TSS (5 op.)	BBline (4 op.)	BBcell (4 op.)	LP "L" (5 op.)
Reports			X				X
Presentations	X	X		X	X	X	X
Posters			X				
Video					X		
ARENA simulation							X
Hands-on simulation	X	X	X	X	X	X	X

It is important notice that the manual provided to the students was simple, without pictures, except for the torch picture, so all the pictures, including the pictures components in figure 3, were photographed by the teams. In order to demonstrate how the operating mode worked, the teams created many documents, tools used in the hands-on simulation, applied concepts learned in others previous CU (bills of materials – BOM-, balancing methods, process flow diagrams, Activity On Node – AON - Networks to represent operations sequence,...).

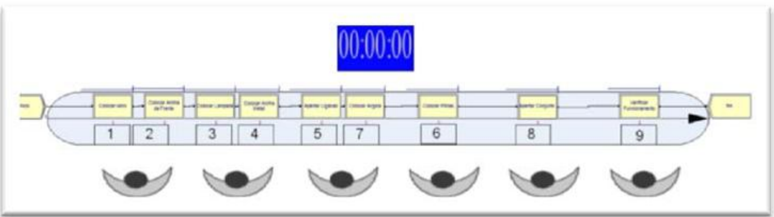

Figure 4: ARENA simulation of the Torches Assembly Line by G7

The Table 2 summarizes these technical documents; in brackets it is the operators number simulated in each operating mode.

Table 2. Tools, documents and mechanisms developed by the teams

Teams	G1	G2	G3	G4	G5	G6	G7
Operating modes	BT (5 op)	RC (4 op.)	WB (5 op.)	TSS (5 op.)	BBline (4 op.)	BBcell (4 op.)	LP "L" (5 op.)
Standards work sheets	X					X	
Work instructions written		X	X		X		X
Work instructions oral		X		X			
Balancing sheets			X			X	X
Process flow diagrams			X				
Work combination chart			X				
Mechanisms Poka-yoke	X						
Box to serve as contentors			X				
Kanban cards						X	
Activity on Node diagrams			X				

Figure 5 and Figure 6 shows examples of one work combination chart and work instruction written to put in the workstations.

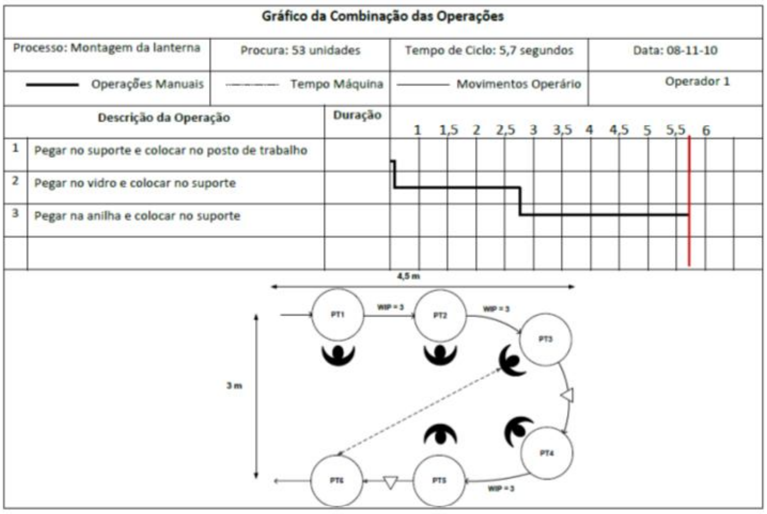

Figure 5: Example of work combination chart by G3

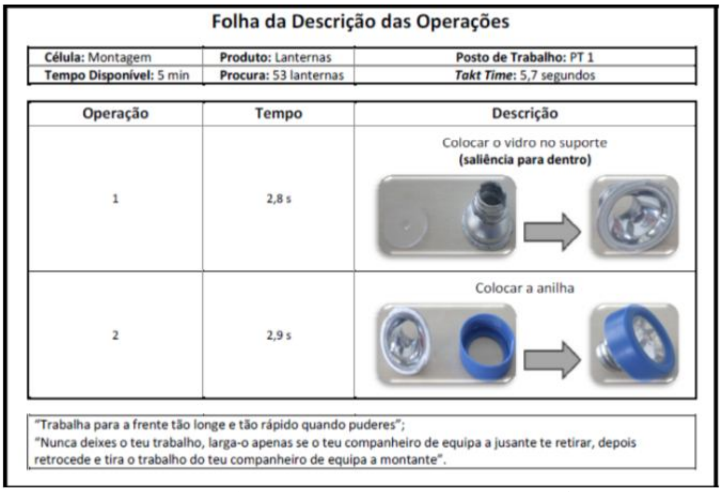

Figure 6: Example of work instruction written by G5

6 Students perceptions and opinions

In the final experience the students were asked, as a team or as an individually, to share their perceptions and give their opinions about this hands-on simulation. The opinions and feedback were very positive and encouraging. One team opinion was: *"Our team enjoys the experience because it was something more practical and motivator comparing with the typical research work. We think it was positive because when we train we debate some ideas with other colleagues and this help us knowing better other operating modes."* This opinion was shared by others members: "*very interesting*"; "*more practical*"; "*more reality approach*";

"*more easy to retain the knowledge*". One student say *"In my opinion you should maintain this assessment form and incentive the team students to participate in others operating modes."*

Other team point out the positive aspects and aspects to improve. The positives aspects were *"This experience helps us to understand and assimilate concepts from different operating modes and the functioning mode on the industrial practice. The fact of the teams help each other contribute to our knowledge of the other operating modes. Additionally we have to think in details about to train operators and force us to review all CU contents. This assignment contributes to a deep learning of all members of the team. This hands-on simulation could teach us that, in practice, some operating modes are adapting, not following strict the author definition."* This team considered as aspects to improve the criteria used in simulation evaluation. They referred the clarification of these criteria because they were not sufficiently enlightened about these.

And another team perception was: *"These activities are always more interesting than an expositive work. The team feels more motivated and think this could be extended to other subjects because promote more understandable. Being a formation type it is very important since we have to do something like this when we have to present something new in companies. We hope that others colleagues from the next years have these kind of opportunities."*

7 Final remarks

This paper described a hands-on simulation in a final year course of the IME Master´s degree programme. The different outputs of teams work, resulting from their motivation and dedication exceeded the expectations. Their free choice promotes their creativity and problem solving in a way not expected. This experience revealed that students when properly stimulated are capable of amazing things. The students learn how to prepare a training session, learn new concepts, and apply concepts and tools learned in previous classes. Of course, this experience had some pitfalls as pointed out by the students, for example, the evaluation process was not very well clarified in the beginning. This was one first experience and not knowing what to expect from the students, makes it difficult to plan the assessment process in detail. Furthermore, two technical objectives were focused on at the beginning and this becomes difficult to control. These objectives were the cell operating modes compare and the training session learning. Future editions must detail better the evaluation process and focus only one objective, in this case the training session preparation it reveals to be the most important.

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References

Alves, A. C. (2007) *Projecto Dinâmico de Sistemas de Produção Orientados ao Produto*. Doctoral dissertation, University of Minho, Guimarães, Portugal.

Alves, A.C., Silva, S.C., & Lima, R.M. (2003). Sistemas de Produção Orientados ao Produto – integrando células e pessoas. *Revista de Inovação Organizacional*, *1*, 109-145.

Alves, A., Moreira, F., Sousa, R. & Lima, R.M. (2009) Projectos para a Aprendizagem na Engenharia e Gestão Industrial" In: Livro de Actas do X Congresso Internacional Galego-Português de Psicopedagogia., (Eds.) Cied-Universidade do Minho, Braga-Portugal, 9-11 Setembro 2009, Universidade do Minho, pp. 3360-3375.

Burbidge, J.L. (1989) *Production Flow Analysis for planning Group Technology*. Clarendon Press, Oxford.

Carmo-Silva, S. & Alves, A. C. (2006). Detailed Design of Product Oriented Manufacturing Systems. " Proceedings of Group Technology / Cellular Manufacturing 3rd International conference – 2006, Eds. J. Riezebos and J. Slomp, University of Groningen, Holland, Julho, cap.44, pp. 260-269.

Dori, Y. (19 de November de 2008). Long-term cognitive and affective impact of the Technology Enabled Active Learning (TEAL) studio physics for on learning outcomes of MIT students. School of Engineering, University of Minho.

Eurydice. (2010). *Focus on Higher Education in Europe 2010: The impact of the Bologna Process*. Education, Audiovisual Culture Executive Agency (EACEA P9 Eurydice).

Hyer, N., & Wemmerlöv, U. (2002) *Reorganizing the factory: competing through cellular manufacturing*. New York: Productivity Press.

Jonassen, D., & Land, S. (2000). *Theoretical foundations of learning environments*. Mahwah, NJ: Lawrence Erlbaum.

Lean games (2006). *Torch factory Simulation - assembly game*. Lean Games.

Lima, R.M., Carvalho, D., Sousa, R. M., & Alves, A. (2009a). Management of interdisciplinary project approaches in engineering education: a case study. In D. Carvalho, N. van Hattum-Janssen and R.M. Lima (Eds.) *Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE2009)* (pp. 149-156). Guimarães: University of Minho.

Lima, R.M., Fernandes, S., Mesquita, D. & Sousa, R. M. (2009b). Learning Industrial Management and Engineering in Interaction with Industry. In D. Carvalho, N. van Hattum-Janssen and R.M. Lima (Eds.) *Proceedings of the First Ibero-American Symposium on Project Approaches in Engineering Education (PAEE2009)* (pp. 219-227). Guimarães: University of Minho.

Lima, R., Carvalho, D., Flores, M.A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education, 32*(3), 337–347.

McManus, H. L., Rebentisch, E., Murman, E. M. and Stanke, A. (2007) Teaching Lean Thinking principles through hands-on simulations. *Proceedings of the 3rd International CDIO Conference, MIT, Cambridge, Massachusetts,* June 11-14, 2007.

Oliveira, A.R., & Alves, A.C. (2009). Operating modes in manufacturing cells – An Action Research study. In M. Gen, G.A. Suer, H. Hwang, K. H. Kim, K. Ohno & S. Fujimara (Eds.), *Proceedings of the 5th International Conference on Intelligent Manufacturing & Logistics Systems and Symposium on Group Technology and Cellular Manufacturing (GT/CM 2009)* (pp. 107-115) Kitakyushu, Japan.

Peter, G. J. (2010), Hands-On Graduate Courses in Lean Manufacturing (LM) Emphasizing Green and Total Productive Maintenance (TPM). Proceedings of the ASME 2010 International Mechanical Engineering Congress & Exposition IMECE2010, November 12-18, 2010, Vancouver, British Columbia, Canada

Powell, P. C. (2004). Assessment of team-based projects in project-led education. *European Journal of Engineering Education, 29*(2), 221-230.

Weimer, M. (2002). *Learner-centered teaching. Five key changes to practice*. San Francisco, CA: Jossey-Bass.