Simultaneous Usage of Methods for the Development of Experimental Competences

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ABSTRACT

This work reports a didactical implementation addressing the development of students’ competences on DC circuits. Teacher’ approach focus on the use of simultaneous teaching/learning/assessment resources and methods in order to improve students’ abilities of adapting and dealing with available tools to solve real practical problems. The impact this didactical implementation was measure in terms of students’ perception, usage and learning results. The results indicate that students clearly benefit from the use of virtual resources, in developing their skills, including the associated calculus, although the majority of students do not immediately understand it. This design represents a long-term vision, and, with some adjustments, some identified in this work, this course may become more effective in improving students’ learning.

KEYWORDS

Competence Development, Computer Simulation, DC Circuit Calculus, Engineering Education, Hands-on Laboratory, Learning Strategies, Remote Laboratory

INTRODUCTION

Engineering education has solid needs of experimental competence developments, regardless the area (Jara, Candelas, Puente & Torres, 2011; García-Peñalvo, F.J., & Colomo-Palacios, R., 2015). In order to become experts when dealing with complex problems in which high competence level relations have to be applied, students have to become fluent in the language of nature and a successful designer, and for that engineering students must perform numerous experiments practice laboratory work (Gustavsson et al., 2011a). These competences they develop along their education, will help them deal with more complex problems in their professional life. Traditionally this experimental work was developed in laboratories. But in the last decades, with the general growth of the number of students attending higher education, the physical resources were no longer sufficient. Simultaneously other scientists started developing computer simulations and remote labs, allowing students to practice some experimental skills in a different manner. With the laboratory time reduced in most European Engineering Schools, this became a complementary way of trying to bridge this gap (Gustavsson et al., 2011a; Nickerson, Corter, Esche & Chassapis, 2007). On the other hand, it also allowed students to extended access to learning resources and improved their freedom to organize their own learning activities according to their perception of their learning needs. This factor potentiates students’ autonomy, which was also one of the main objectives of the Bologna Process (Gustavsson et al., 2011a). The actual economic restrictions and pressure also contributes to the development of these
new technologies decreasing the cost associated with classroom and laboratory spaces (Nickerson, Corter, Esche & Chassapis, 2007). It also increments the possibility of mature students return to university to update their current skills or even develop new ones, as they can access these resources from other places, minimizing the distance factor.

This poses new trends regarding didactical and pedagogical issues. One of the major differences is the type of measurements that can be obtained from these different resources. As Gustavsson and colleagues (2011a) state, engineers must be able to find relevant imperfections of the models embedded in the simulators they use to design prototypes by experimenting. Students also need to understand the difference between model results (simulations) and real experimental results (when dealing with real apparatus, which influence the measurements). Remote laboratories allow students the advantages of simulations (while being accessed virtually) and the advantages of working with real things (the obtained results are not simulated). This way it seems like the perfect solution... nonetheless some studies show that this issue requires much more reflection, with some authors viewing these methods as inhibitors of students’ learning (Ma & Nickerson, 2006). The underlying technology of the laboratory (for instance the interface to the equipment) is one of many possible factors that could influence learning effectiveness (Nickerson, Corter, Esche & Chassapis, 2007), among other factors such as motivation, peer collaboration, error-corrective feedback and richness of the media (Ma & Nickerson, 2006). While the critical role played by Laboratory-based courses in science education (in general) is consensual, some disagreement emerges between science and engineering educators regarding the choice of technology-mediated labs. As Lustigova and Novotna (2012) point out, there is still an on-going discussion about which one promotes better conceptual understanding, design skills and/or professional skills. Still, some studies present evidences that computer simulations and remote labs can be effective in students learning but teachers must realize that the educational objectives associated with each one may be different (Ma & Nickerson, 2006). For instance in 2007, Corter and colleagues presented a study in which they showed that students performed equally or even better while working with remote and simulated laboratories versus performing hands-on laboratories. Many students also stated that they saw advantages to technology-enabled lab formats (stating attributes such as convenience and reliability), even though they still expressed preference for hands-on labs (Corter, Nickerson, Esche & Chapassis, 2007).

So, even though in the last decades these other resources (computer simulations or the access to remote laboratories) were gradually introduced in classes, and several technical studies exist, pedagogically and didactically they are still understudied, especially remote laboratories. Some efforts have been made in the last years in order to address this gap (Lindsay, 2005; Hennessy et al., 2007; Marques et al., 2014).

More recently Corter and colleagues (2011) stressed the importance the designing of the tasks have on student performance, being the learning results higher with group activities rather than individual ones. Some authors also call attention for the competences each method allows developing (related to different learning objectives) (Ma & Nickerson, 2006). Teachers should take this in consideration when deciding which methods or which combination of methods to use. As Ma and Nickerson (2006) states, what really matters might not be the type of laboratory (the technology used), but the weight each type has in a given situation, as a mixture of elements/resources. So, it becomes essential to look for some harmony between these resources. Even though some attempts in combining these experimental different approaches can already be identified in literature (Ma & Nickerson, 2006; Abdulwahed & Nagy, 2011) these comparative studies are relatively small-scaled and no significant and consistent difference between hands-on, simulation and remote labs stand out (Ma & Nickerson, 2006). Additionally, it is well studied in literature that while diversifying methods and techniques in classroom, teachers can in fact reach more students due to their different learning styles (Felder
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