1st International Conference on Higher Education Advances, HEAd'15
Universitat Politècnica de València, València, 2015
DOI: http://dx.doi.org/10.4995/HEAd15.2015.336

Microproject-based teaching/learning methodology focused on emerging technologies and international entities cooperation.

J. Fernández-Ceniceros*, A. Sanz-García, F. Antoñanzas-Torres*, M. Alía-Martínez*, A. Pernía-Espinoza***

* EDMANS Research Group, Department of Mechanical Engineering, University of La Rioja, C/ San Jose de Calasanz 31, Logroño 26004, Spain.
** Faculty of Pharmacy, Centre of Drug Research (CDR), University of Helsinki, Viikinkaari 5 E (P.O. Box 56), 00014, Helsinki, Finland.

Abstract: This paper deals with the implementation of an educational methodology based on microprojects into the subject 'Manufacturing Technology' of the EHEA (European Space of Higher Education) engineering degrees. The main idea is to consolidate the theoretical background by working on microprojects ordered by foreign entities. Under this approach students implement the theoretical knowledge acquired in the classroom facing real world problems, such as scope definition, planning and team work, while promoting the use of English and information and communication technologies (ICTs). Results show higher motivation and level of interest among students as well as an improvement on their scores when compared with traditional teaching/learning methods.

Keywords: Microproject; PBL; English; Engineering; Manufacturing Technology.

Introduction

The European Space of Higher Education or EHEA (EEES in Spanish) (http://www.eees.es/) promotes educational models that focus on student's autonomous workload and learning activities based on projects (Project Based Learning, PBL) (Buck Institute for Education, 2002). Besides this, a growing demand for professionals with greater leadership skills, international experience and adaptation capabilities for changing environments boosts the updating of traditional teaching methods to meet the needs of companies.

Traditional teaching methods have shown the lack of promoting interactions among students and between teachers and students. Student become passive characters who in some cases are overwhelmed by the theoretical contents and consequently, they, find serious difficulties to apply these concepts in real world problems. Moreover, the jump onto working life makes a huge change on the student's life, whose role must turn to an active attitude. The student has to show personal skills, such as leadership, communication capacity, integration in multidisciplinary groups, problem solving capacity and, the last but not the least, mastering English as a universal language within the engineering circle. For these reasons, it is necessary to introduce some changes in the traditional teaching methods enhancing the student's personal work, the interpersonal relationships, the use of a second language and the use of Information and Communication Technologies (ICTs).

The PBL model includes some of these points, and its use is widely spread in technical studies. Particularly, PBL promotes student's active work throughout the planning, development and evaluation of different projects with a real application beyond educational purposes (Marti et al., 2010). Several experiences have been reported up to date in this field (Garcia-Almiñana & Amante, 2006; Labra et al., 2006; Aliane & Bemposta, 2008; Villalba et al., 2009) and all of them reveal multiple advantages: it fosters cooperation and creativity, stimulates autonomous learning and provides learnings on a higher cognitive level.

The methodology herein presented has been implemented through a Teaching Innovative Project during two consecutive academic years: 2013/2014 (Fernandez-Ceniceros et al., 2014) and 2014/2015, adding some upgrades in the last year. Along these two courses the methodology has shown to lead to substantial improvements in the teaching methods. It is clear that student's motivation for the subject increased and also average scores and success rates raised when comparing to the traditional teaching used during previous years (years 2007-2008 and 2009-2010).

Objectives

The general objective of the methodology proposed herein is to foster the students' motivation when learning a specific applied subject such as 'Manufacturing Technology'. It is crucial for their academic training to acquire information about industry through the contact with several companies, research centres and other universities. In this sense, the student can assimilate better the theoretical concepts presented in the classroom. Moreover, in a globalized world, it is very motivating to collaborate with international entities/companies, promoting the use of the English as a second language and pointing out the barriers and difficulties a different culture and working habits, at the same time that fosters the use of ICTs as an interchange platform among the agents.

The specific objectives are the following:

- Establish communication networks between University of La Rioja and other international entities from both the teaching and the industrial world, with the aim of bringing the professional environment closer to the student. Specifically, 'microprojects' are presented, where foreign institutions act as petitioners.
- Promote the use of a second language. This is addressed through the use of English in scientific articles and multimedia content to develop issues related to the manufacturing processes that lie under the microprojects, and as the interchange language between the foreign collaborators and the students. The petitioner establishes the tasks to be developed also in English. Previously, the student is provided with all the information translated to its mother language and a glossary with the most important terms. It must be highlighted that our aim is not to implement English as the main language in this subject, but to familiarise the student with the key concepts presented in English due to its great importance for his future working life.
- Boost the use of ICTs through the use of new communication and teleworking environments. Relating microprojects to foreign entities represents a great opportunity to make use of different ICTs resources such as: a web environment to exchange information between petitioners/professors and students, videoconference and digital blackboard to state projects scope and objectives between the involved parts.
- Provide the student a state of the art about the current manufacturing technologies. The collaboration with technologically advanced institutions brings novel manufacturing techniques closer to students. One of these new techniques is the *additive manufacturing*, implemented in 3D printers. Along one of the microprojects, students have to learn how to use these printers to make 3D prototypes and elaborate tangible pieces. Besides, following the open-source-RepRap-philosophy (http://reprap.org), the student can contribute with ideas that improve designs, materials and software, putting into practice the

contents learnt in the subject. The most innovative designs can be manufactured in the 3D printer available.

- Improve educational techniques by including seminars given by experts from the industry or institutional world to provide another professional point of view of the concepts applied in the microprojects. Also, improve educational assessment by providing the student with an evaluation sheet for each microproject. In this way, the student can objectively know what and how is going to be evaluated. In addition to these, in order to improve continuous evaluation, guided discussions and small tests are driven after the seminars, promoting the student participation.
- Track the experience and evaluate how students' motivation evolves along the course and how the execution of the microprojects influences on that. To this end, several anonymous questionnaires are addressed. In addition, different written tests after ending the microprojects are carried out to evaluate how these practical experiences help to acquire theoretical knowledge.

Material and Methods

Methodology

The methodology is based on the PBL model and problem solving of study cases from the real world. It is all complemented with seminars given by experts in the three areas selected for the microprojects. The methodology is as follows:

- Theoretical classes to address basic knowledge along with resolution of real cases related to the topic of the particular microproject.
- Microproject presentations.
- Seminars given by an expert on the topic related to the same topic.
- Short tests about basic concepts that will be developed further.
- A platform to integrate everyone involved in the microproject, also useful to exchange information (text, glossaries, videos, etc.). This platform will be based on Moodle (http://moodle.org/, Rivas, 2006), an educational resource management platform, which also allows groups to have a forum to discuss about different topics and questions.
- Generate and show the students the evaluation record that will be use to assess the microprojects. Not only the knowledge applied in solving technical issues will be evaluated but also the quality and clarity in the reports as well as the degree of cooperation of each member in the groups (by a survey to the other group members).
- Work groups are created, which will involve 4 people per group (this number is related to the total of student in the classroom, normally is around 60). The 'Group Constitution' is signed, which compromise the student to do the assigned tasks on time. It also incorporates the concept of 'expulsion rules'. Since three degrees (Electrical, Electronic and Mechanical Engineering) are involved, the groups will be created as much multidisciplinary as possible.
- The international entity (along with the Innovation Group) defines the objectives, tasks, time and costs. This is done through a video and documents in English, which are found in *Moodle.* Reports can be written in Spanish or in English, as students prefer.

- Each group distribute their tasks to each group member, with the deadlines. The Innovation Group coach this assignment. Besides, each group will name a coordinator which will be in charge of supervising the activities and organising meetings to put in common the works and solve doubts. The coordinator will be the link between the group and the members of the innovation group.
- Problems stated in microprojects are solved according to the distribution of abovementioned tasks. Therefore, everyone should understand the particular problem studied, search for useful information and make hypotheses in order to solve the problems.
- Clarify doubts through forums or tutoring with the members of the Innovation Group. Professors have to supervise work on a systematic and periodic basis.
- Each group reports the solutions for the problems outlined in the microproject through a report, paying attention to the evaluation sheet previously presented.
- The members of the Innovation Group proceed to the final evaluation of the microproject by using the same evaluation sheet abovementioned.
- Surveys will be carried out along the whole course to track students' evolution and then elaborate statistics. Partial results will be taken into account for the approach of the next microproject. At the end of the experience, a final report will be performed with the complete statistical analyses.

Implementation into the subject 'Manufacturing Technology'

The methodology explained above was implemented in the subject 'Manufacturing Technology', which is studied in the second year. It is offered in three engineering degrees at the University of La Rioja: *Mechanical Engineering*, *Electrical Engineering* and *Industrial Electronic and Automation Engineering*. The professors of the Innovation Group involved in this project belong to the Department of Mechanical Engineering and, more precisely, to the areas of *Manufacturing Processes* and *Engineering Projects*. Moreover, taking advantage of the post-doctoral period of one of the member of the Innovation Group, who is in the *Division of Biopharmaceutics* of the University of Helsinki and currently researching at the *Tokyo Women's Medical University*, that institution (University of Helsinki) acted as the petitioner for the microprojects.

Currently, the subject 'Manufacturing Technology' combines a variety of teaching/learning methods along with the learning through microprojects. Three of the seven topics are under the microproject modality. The remaining four topics use several teaching/learning techniques like real case solving problems, forum discussions, oral presentations, workshop practices and quizzes. The three microprojects are described as follows:

- *Microproject 1: Filling process analysis of the plastic injection of a piece*. The objective of the project is to analyse the plastic injection of a part under different process conditions, using the specific software Simulation Moldflow Adviser Ultimate 2014®, which is available for free downloading for students. Students have to learn about plastic injection molding and simulate the process, using one or two gates for injection. They are asked to report about some issues, such as the filling time, injection pressure, surface orientation of molecules, weld lines, possible defects, etc. This microproject is linked to the seminar 'CAE (CAD) tools for modelling polymers in the automotive industry' given by an expert from the automotive industry.

- *Microproject 2: Metal forming processes*. Forging, cold rolling, blanking and deep-drawing are presented as sequential processes involved in the manufacturing of a cylindrical cup. Students are asked to analyse each process and define their main parameters, such as the press power, rolling force, appropriate punch and die diameters or the holding force. This microproject is linked to the seminar 'Mould and die design for sheet metal plastic forming' given by a mould-maker expert.
- *Microproject 3: 3D Printer*. This project introduces additive manufacturing in the shape of 3D printing to students, from CAD modelling to G-code generation and the communication with the 3D printer. The project makes extensive use of University of Helsinki expertise in this manufacturing technique, which is used for cell bioprinting in tissue regeneration. The software used was *Repetier-host* (http://www.repetier.com), which allows to complete all the steps necessary for 3D printing and is available for free download. In this project, students were asked to import the CAD model from the piece to be printed to the software *Repetier*, varying the parameters in the *Repetier* to meet requirements, print the piece and report about the process, time and cost required for printing. This microproject is linked to the seminar 'The future of 3D printing in regenerative medicine and tissue engineering' given by two experts on additive manufacturing applied to regenerative medicine.

Results and Discussion

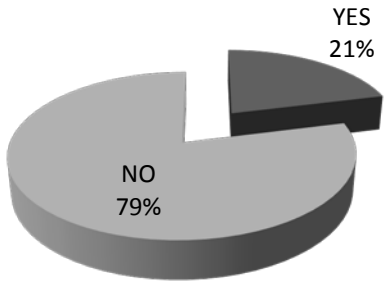
After conducting this teaching/learning experience several observations might be extracted:

- Students complement the theoretic and practical knowledge acquired during the lessons and the practical classes with a realistic vision of working by projects. Working by projects involves many tasks, such as information research, self-learning and self-management, along with team working competences. Moreover, students must confront situations where the definition of the scope, the correct understanding of the proposed requirements or the deadlines must match with the correct resolution of the proposed project.
- Collaboration with international organizations, in this case, with the *Division of Biopharmaceutics* of the University of Helsinki, provides an open vision that enriches the student learning through different technics such as the use of ICTs as communication and contact methods. The student must overcome the language barrier and use English as an international and scientific language. Moreover, the student must confront the cultural differences and problems due to different working hours.
- The collaboration with the University of Helsinki provides students the possibility to access to modern fabrication methods such as *additive manufacturing* or more particularly 3D bioprinting. The possibility of using these innovative methods is a great motivating experience for students.
- The interrelation between the fabrication methods, traditionally linked to the industry, and a specific area of knowledge drastically different such as biomedicine, can give the student an innovative vision of the wide spectrum of applications in which fabrication methods can be involved. Additionally, students have to cope with an unknown discipline.

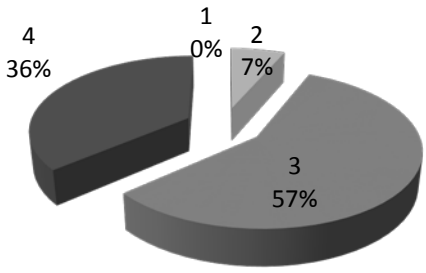
- Seminars provided an interaction tool for students with expert from the industry and institutions that also motivates the knowledge acquisition.

Once the semester has already finished, students filled a survey to canvass the interest in the teaching/learning methodology based in microprojects, compared to the traditional method. Figure 1 depicts the results from the survey. It shows that the use of English does not suppose an important barrier to properly develop the objectives stated. Besides, the percentage of students that consider of high or very high interest learning through microprojects raised from 82 to 93% with respect to last year. This can be explained by the improvements introduced, such as glossaries, evaluation sheet, the 3D printing of the pieces and seminars given by experts (86% of the students considered them of high or very high interest), which make the subject more complete. It is also derived from Figure 1 the importance of 3D printing the piece designed to motivate the students along the process.

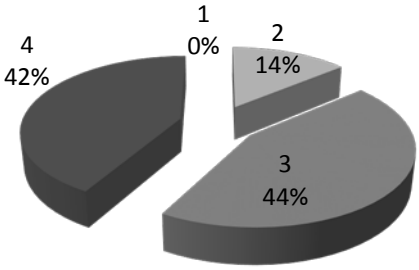
1. Do you consider the use of English a great language barrier to develop the tasks along the microprojects?



2. From 1 to 4 (where 1 represents 'low' and 4 'very high'), how interesting did you find the microprojects based teaching/learning methodology compared to traditional teaching model?



3. From 1 to 4 (where 1 represents 'low' and 4 'very high'), how important was the possibility of printing the piece in a 3D printer?



4. From 1 to 4 (where 1 represents 'low' and 4 'very high'), How interesting were the seminars given by experts during the course?

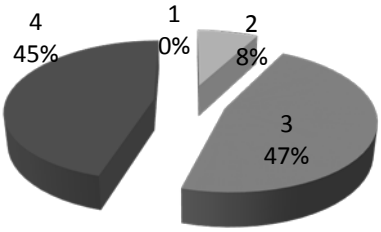


Figure 1. Results obtained from survey at the end of the semester, year 2014/2015.

Finally, Figure 2 shows average score and success rates of the subject studied during previous semesters (from year 2007 to year 2014), i.e. before and after implementing microproject teaching/learning methodology: during years 2007-208 and 2009-2010 traditional teaching model was used, and in years 2013-2014 and 2014-2015, microproject methodology was adopted.

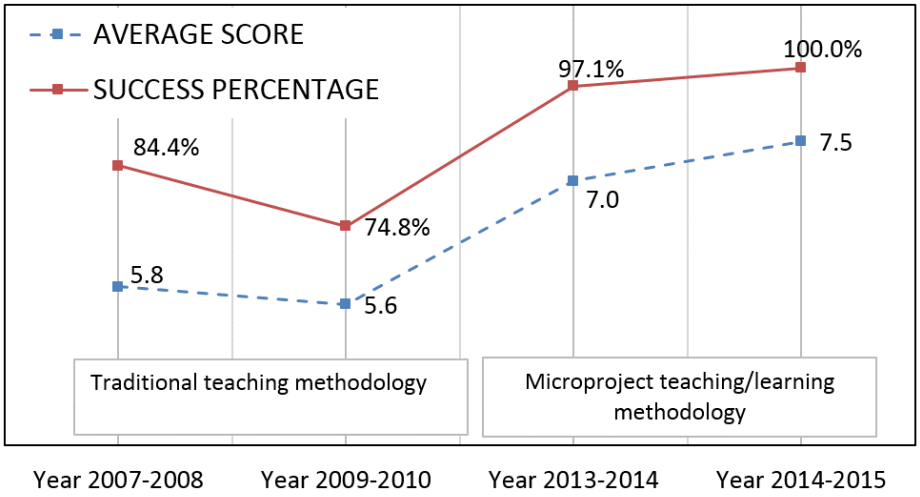


Figure 2. "Manufacturing Technology" subject average score and success rate for years from 2007 to 2014.

The results obtained, both this course (2014-2015) and the previous one (2013-2014), sustain the convenience of the microproject teaching/learning model herein proposed for technical subject.

Conclusions

This paper deals with the application of small projects or microprojects requested by foreign institutions, with the goal of bringing the working life close to undergraduate students. They must deliver reports in which they combine the appropriate technical solution of a problem under a strict deadline, following specific scopes and using teamwork. One of the main characteristic of the proposed project is the use of English as a means of communication as well as the use of ICTs as a working tool. All of this was additionally complemented by seminars with experts and assessment tool provided to the students.

The methodology explained herein was applied to the subject 'Manufacturing Technology', in cooperation with the *Division of Biopharmaceutics* of the University of Helsinki. Students showed a higher level of satisfaction with this educational method in comparison to the traditional one. Collaborating with real petitioners gave students an extra motivation as they could make use of their gained knowledge in real applications.

Finally, although the methodology was just applied to the subject 'Manufacturing Technology', it might be extendable to other subjects in technical careers. International mobility of researchers can play an important role to connect universities, companies and research centres and act as foreign petitioners in this kind of experiences.

Acknowledgements

The authors would like to acknowledge University of La Rioja for the financial support received through the program '*Proyectos de Innovación Docente 2014/2015*', as well as for the fellowships *FPI-UR* to train researchers (J. Fernandez-Ceniceros and F. Antoñanzas-Torres). The authors also want to express their gratitude to the *Instituto de Estudios Riojanos* (IER), to the *Banco Santander* for the project *PROFAI 13/06* and to the *Agencia de Desarrollo Económico de La Rioja* for the project *ADER-2012-I-IDD-00126* (CONOBUILD). One of the authors, A.S.G., would also like to acknowledge the financial support with the grant No. 273689 (*FINSKIN*) and the mobility grant No. 276371 (*VATURP*) by the Academy of Finland.

Finally we would like to thank to the special collaboration of all student involved in this experience. Their comments and suggestions enriched the methodology proposed in this communication.

References

Aliane, N. & Bemposta, S. (2008). A learning experience based on projects for Robotics. *Ibero-American Magazine of Learning Technologies*, 3(2), 71.

Buck Institute for Education, An overview of Project Based Learning (2002). http://www.bie.org/pbl

European Space of Higher Education. http://www.eees.es/

Fernandez-Ceniceros, J., Sanz-Garcia, A., Urraca-Valle, R., Martinez-de-Pison-Ascacibar, F. J. & Pernia-Espinoza, A. V. (2014). Teaching-learning model based on micro-projects for the subject 'Manufacturing Technology'. *XXII University Congress on Educational Innovation on Technical Studies*, Almaden (Spain).

Garcia-Almiñana, D. & Amante, B. (2006). Experiences of implementation of cooperative learning and learning based of projects. *I Seminar on Educational Innovation*, Zamora (Spain).

Labra, J. E., Fernandez, D., Clavo, J. & Cernuda, A. (2006). A learning experience based on projects using open-source software development collaborative tools. *XII Seminar on University Education of Informatics*, Bilbao (Spain).

Marti, J. A., Heydrich, M., Rojas, M. & Hernandez, A. (2010). Learning based on projects: an educational innovation experience. *University EAFIT Magazine*, 46(158), 11.

Moodle: Open-source Learning Platform. http://moodle.org/

Repetier: the software driving your 3D printer. http://www.repetier.com

Rivas, F.C. (2006). Learning platform Moodle as a tool for social work in the European Space of Higher Education context. *Social Actions and Research*, 1, 367.

Villalba, G., Zamora, M. A., Santa, J. & Herrero, D. (2009). Experiences on learning implementation based on projects to develop creativity in domotics subjects. *IX Seminar on Cooperative Learning and II Seminar on Educational Innovation*, Almeria (Spain).