Virtual 3D Support Contents Oriented to Interactive Self-Learning

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Abstract: *In the educational project described in this paper, new virtual 3D didactical contents have been developed to achieve specific outcomes, within the frame of a new methodology oriented to objectives of the European Higher Education Area directives. The motivation of the project was to serve as a new assessment method, to create a link between new programs of study with the older ones. In this project, new rubrics have been developed to be employed as an objective method of evaluation of specific and transversal outcomes, to accomplish the certification criteria of institutions like ABET (Accreditation Board for Engineering and Technology).*

Introduction

Currently, students of the Mechanical Engineering program in ETSII-UPM (Escuela Tecnica Superior de Ingenieros Industriales – Universidad Politecnica de Madrid), develop main part of their class-work in accordance with the European Space for Higher Education (ESHE) principles [1]. The application of innovation initiatives based, for instance, in Project Based Learning (PBL), together with the implementation of new methodologies as collaborative team work and the employment of Information Technologies, have contributed to the improvement of specific outcomes, as it is established in ESHE directives. However, some deficiencies have been detected, particularly related with outcomes assessment [2].

In the project described in this paper, two aspects have been introduced to improve the observed deficiencies. First, new virtual contents have been created in PDF format with three-dimensional models enrichment [3-5]. Second, new rubrics for outcomes assessment have been developed and applied [6,7]. The main objective of the project is centred in demonstrating the viability of the new methodology for the transition to the new ESHE programs

Methodology

The project has been developed in the subject “Design and Manufacturing in Plastics”. This subject is imparted in the 10th semester of the current program at ETSII-UPM. Two outcomes were selected, one specific “Ability to use techniques, procedures and modern engineering tools necessary for engineering practice”, which is in ABET (Accreditation Board for Engineering and Technology) outcomes accreditation list [2,8]. This institution has recently certified titles imparted on ETSII-UPM. The other selected outcome has been “Creativity”, which represents an innovative point of view, because it is still moderately considered in engineering education institutions. Creativity is a learning outcome for the Universidad Politecnica de Madrid (UPM).

Preliminary Study

Students made a preliminary test to evaluate the previous knowledge in relation with the specific outcome; four blocks were evaluated with different amount of questions:

- Plastic parts validation in terms of manufacturability by injection molding process
- Mold size estimation
- Mold sub-systems pre-design
- Workshop manufacturing documentation

Initial test results demonstrated that more than a 50% does not respond correctly to the different blocks separately, what clearly identifies a weak in the outcome achievement. In the following the procedure to improve the outcome achievement will be described.

Virtual 3D didactical support

A combined method for knowledge development has been employed in the area of injection moulding design. Five additional sessions of class were imparted; the classes were supported with the employment of self-learning three-dimensional (3D) files, in Adobe PDF format. Usually, theoretical information for Injection Mould design is represented in classical two-dimensional (2D) cross-section views. Figure 1 depicts a core-cooling device 2D representation as usually is shown in workshop documentation.

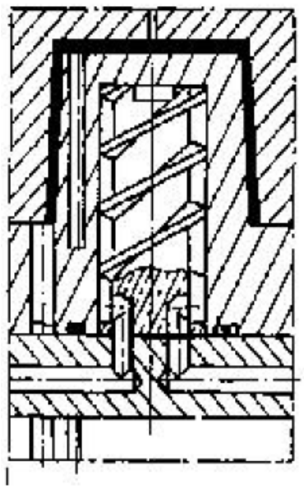

Figure 1: Core-cooling device representation

However this kind of representation is difficult to understand for the student without previous background, and has to be complemented with the 3D representation that could be found in the Acrobat files made for this subject as it is shown in Figure 2.

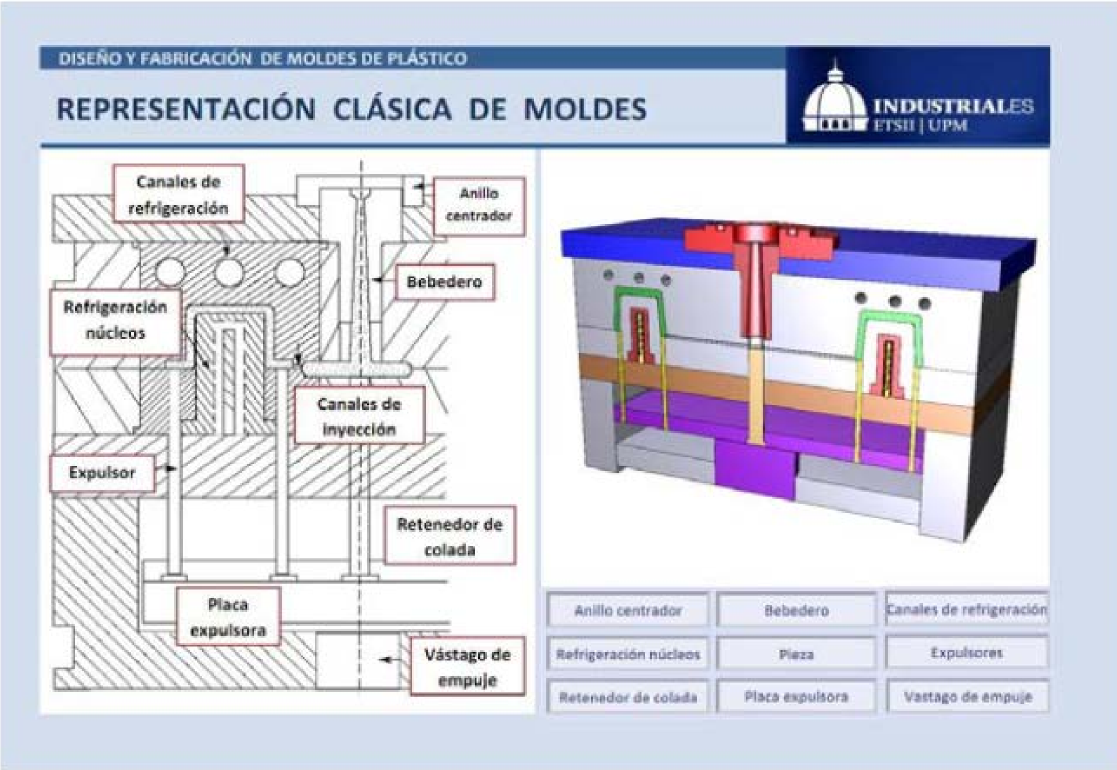

Figure 2: Acrobat file for core-cooling device representation

Students can interact with the 3D representation, and obtain the most suitable view of details to understand the component functionality. Students can zoom, pan or rotate the 3D models. This type of file also supports layer visibility, video and animation possibilities. They only need acrobat reader 8.0 or higher so they are independent of the web browser.

Student assignments

During the development of the subject, students have to accomplish weekly personal assignments that can be described as follows:

Assignment 1

Manufacturability. The student should justify the selected part geometry to be injected, providing the design phase information, and carrying out a manufacturability study to verify the gate location, moulding window, confidence of filling, cooling quality, sink marks and air traps predictions.

Assignment 2

Mould size estimation. The student should determine the number of cavities and the proper injection moulding machine size to employ. With a cycle time estimation and applying economical data, as lot size, mould initial cost and maintenance cost, together with part weight and part surface, a detailed estimation of optimal number of cavities can be done.

Assignment 3

Conceptual mould design. The student should design a preliminary creative solution for the injection mould, providing a 2D cross-sectional view of the conceptual mould where can be identified the feeding, ejection and refrigeration systems adopted for the mould.

Assignment 4

Final validation of proposed solution. The student should carry out a multicavity analysis to cover the following aspects in the design proposal:

1. Feeding system validation. Creation of a feeding system to make a preliminary study of runner and gates, runner balance and runner optimization.
2. Refrigeration system design optimization in terms of cycle time and cooling quality
3. Cycle time optimization and quality prediction with a study of filling and packing, adjusting the packing profile, and analyzing the shrinkage and warpage in injected components

Project Based Learning

Last part in course consists in a project oriented collaborative work, to develop the detailed design in the injection mould. The students form groups of three people that will collaborate in the 3D complete design of core and cavity of the mould, and normalized components selection for a production kit. The work could be divided in three phases:

1. Three-dimensional design of core and cavity of the mould (assessment of the use the CAD tools, number of solutions and originality criteria)
2. Normalized components selection and integration (viability criteria)
3. 3.Manufacturing workshop documentation generation

With this work we can evaluate the achievement in the use of CAD tools as part of the ABET outcome. They have to design the mould using a 3D CAD program of their choice.

For the development of the creativity, additional information has been thought to students. They have learnt basic creativity techniques, and specially brainstorming in a one hour session. The assessment of this achievement has been done using a rubric with two performance criteria: number of solutions, originality and viability.

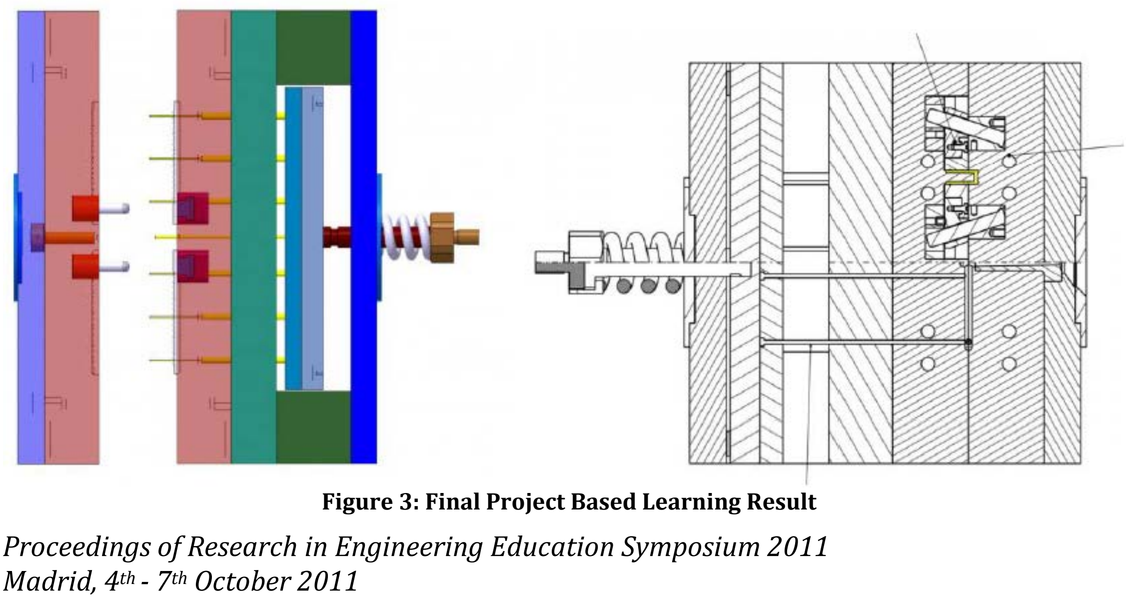

Figure 3: Final Project Based Learning Result

Results

Table I shows the comparative results of the initial vs. final outcome assessments. The figures represent the percentage of the mean value of correct answers on each block of questions, associated with their correspondent rubric indicator. From these data can be deduced the following conclusions:

1. There is a significant improvement over all the indicators
2. Improvements in indicators “Design validation” and “Detailed Design”, although remain significant, are not very remarkable and can be due to the practical work developed in the subject. On the other hand, these indicators measure abilities that are not exclusively developed in this topic.
3. The improvements obtained in “Conceptual Design” and “Pre-Design” highlight the success of the introduced methodology, and they are the abilities more specific for the outcome considered. The results obtained support that use of active learning techniques improves the outcome achievement in students.

Rubric indicator	Initial Test	Final Test	Improvement
Design Validation	36	42	6
Conceptual Design	32,33	56,1	23,77
Pre-Design	36	78	42
Detailed Design	41	48	7

Table I: Performance results for the specific outcome “Design of Moulds”

Conclusions

In the project described on this paper, a new methodology has been applied in order to get an outcome improvement on students. For the first phase of it, an important amount of virtual 3D didactical support material has been developed. The overall objective has been to adapt the programs of study to the new directives of ESHE, but what is more important to highlight the usability and efficiency for student formation. New rubrics have been also developed for the objective assessment of the outcomes, to fulfil the evaluation criteria of institutions like ABET that certifies programs of studies in engineering universities.

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