Development and Application of a New Interactive Model for the Teaching of Manufacturing Engineering Technology*

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The object of this paper is to outline the interactive teaching model developed by the education innovation group 'New Teaching Methodologies in Mechanical and Manufacturing Engineering Technology' of the Polytechnic University of Madrid. The aim of the model is to teach the subject of Manufacturing Engineering Technology for the Mechanical Technical Engineering degree course. It is based on a new face-to-face methodology that we have called DE-learning (driven electronic learning) in which theoretical teaching and laboratory teaching are combined in a collaborative environment, managed through the developed software that combines: theoretical lessons, solved practical examples, exercises, bibliographical references, Webpage links and self-assessment tests. [Here the term 'collaborative' is used to describe the teaching methodology whereby student-to-student and student-to-teacher relationships take place in the learning process and not exclusively through a one way teacher-to-student relationship.] The teaching of this new model is 'driven' under the guidance and supervision of a professor, in an educational environment with no formally taught classes. Students themselves can decide on the pace at which they learn, the resources used, the definition and carrying out of practical exercises and whether they wish to form collaborations among themselves during study time. The fundamental advantage of this model is its efficiency in optimising learning time, given that: (a) all the necessary resources are accessible to the student through electronic teaching support, (b) the laboratory practical classes take place in the same environment, as they are combined and connected to the theoretical concepts without any break in continuity, and (c) students' problems can be resolved in a personal and immediate way by the professor. In addition to this, other advantages have emerged that are equally relevant in the engineering training of the students: the development of better communication skills as well as their skills and abilities, motivation, creativity and increase in confidence and confidence in their decisions. The efficacy of this new teaching model has been confirmed through the academic results attained by the students during the 2006/07 academic year, which are presented in this paper.

Keywords: driven electronic learning; manufacturing engineering; games; learning styles

INTRODUCTION

THE 2002 STUDY PLAN [1] leading to the Mechanical Technical Engineering degree from the Polytechnic University of Madrid (UPM) has 255 credits for face-to-face teaching attendance hours (approximately equivalent to 306 ECTS), structured in six semesters with the hours distributed between: core, compulsory, specialist and electives/free choice subjects, as shown in Table 1.

Once the common subjects —both core and compulsory—have been completed, students can choose between four specialist subjects: Industrial Construction, Industrial Installations, Machine Construction and Industrial Production. Those who elect to study Industrial Production must study the following specialist elements:

1. Manufacturing and Assembly Lines (7 ECTS),
2. Machine-tools (5.5 ECTS),

3. Engineering of Productive Processes and Quality Control (9 ECTS) and
4. Manufacturing Technology (5.5 ECTS).

The subject contents of the Manufacturing Engineering Technology course, collected in the study plan published in the Official State Bulletin (BOE) [1] are: Manufacturing processes and equipment; Geometrical modelling of surfaces and solids; and Programming of machine tools and CAD/CAM.

Using these descriptions as well as the academic plan established by the UPM for the undergraduates on this degree course, the vocational training contents of the course have been developed and are ordered in four sections:

1. Introduction to CAD/CAM systems.
2. Computer-aided design. 3D modelling. Generation of ISO codes for numerical control machines. Simulation environments.
3. Manual programming of numerical control (NC) machine tools. Assisted programming of NC machine tools. Planning and graphic simu-

Table 1. Distribution of total semester hours for Mechanical Technical Engineering studies at the UPM

ECTS Core subjects	ECTS Compulsory	ECTS Specialist	ECTS Electives	ECTS Total

lation of machining operations. Determination of machining parameters.
4. Flexibility overview. Components of a flexible manufacturing system: manipulation, transport, storage. Robot programming. Programming of flexible manufacturing cells.

TRADITIONAL TEACHING METHODOLOGY

The Manufacturing Engineering Technology degree was taught using traditional teaching methods up until the 2004/05 academic year: with theory in the form of formal teaching classes and laboratory practical classes in groups of 10 students. The formal teaching classes were taught with the support of a digital projector, slide projector and a blackboard. The practical classes were taught in a laboratory equipped with a flexible manufacturing cell made up of a store, a machining centre, a parallel lathe and a robot to feed the machine tools and manipulate the pieces.

Two changes in methodology were introduced during the 2005/06 academic year, with the intention of making the formative process more efficient. First, a decision was made to remove the division between the theory and the practical laboratory classes; since then all theoretical and practical classes have taken place in the Manufacturing Engineering Laboratory, enabling a direct and immediate relationship between theoretical abstractions, numerical calculation exercises and practical applications using the simulators and/or real machine tools. Teaching models with similar aims have been successfully implemented in a number of universities and have proven to improve students' creative ability, their academic performance and their scientific and technical communication skills [2–9] as well as providing other advantages.

The main objective of the second decision was to promote greater student participation throughout the whole learning processes, favouring educational development in a co-operative environment and fundamentally solving practical cases. Studies like those developed by Aleven and Foedinger [10] clarify the benefits of this type of learning as a metacognitive strategy.

These two decisions, which were adopted in the 2005/06 academic year, gave rise to important improvements in the formative results of the students and their attitudes. Namely:

- The combined working of simple practical exercises, with the students providing the solutions themselves, made it possible to continuously evaluate their knowledge, with the result that the final exam became almost unnecessary.
- The mixed theory/practical teaching method allowed a better use of time and ideal sequencing for both teaching functions.
- The moving of all the teaching to the Manufacturing Engineering laboratory allowed intense collaborative work between students, in addition to active learning. That is to say, it favoured students' individual decisions in the determined aspects of the learning process, for example in the definition of determined practical exercises and in the strategies involved in resolving these.
- The students could apply their training activity immediately, rather than through practical sessions of the theory, which were sometimes separated by a number of days due to the academic calendar.

This proposal entailed an important qualitative change and showed evident improvement relating to the methodology used compared with that of
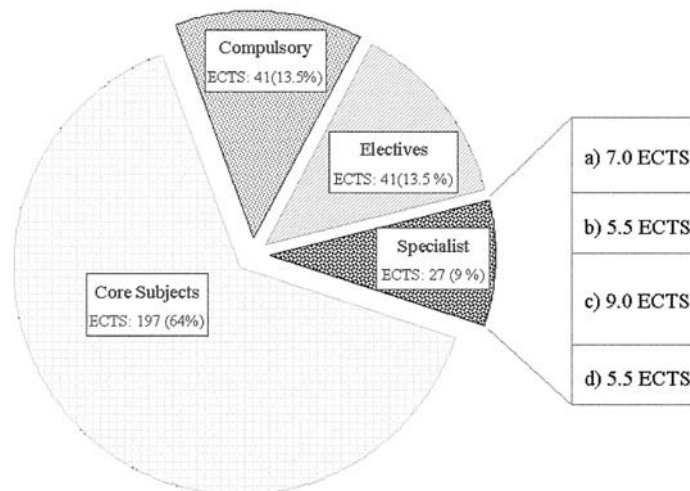

Fig. 1. Distribution of ECTS credits with Industrial Production as the specialist subject.

previous academic years (2004/05 and before); however its implementation caused some difficulties and imposed some limitations, as listed below.

- If an active and collaborative teaching method in a practical environment as previously described is to be achieved, the level of attention and dedication that the professor needs limits the group to a maximum of 10 students. Larger groups would prevent the professor from responding appropriately to student initiatives and the teaching would consequently be closer to a traditional formal teaching class model.
- The pace of work and learning tends to be adjusted to the lowest performing students.
- Students with a greater leading capacity tend to propose actions and make decisions on behalf of their colleagues, limiting the initiative of others.
- The time dedicated to conveying theoretical knowledge is reduced and there is a risk that the students learn only the most evident elements or those essential for solving the assigned practical exercises.
- The absence of a final exam could result in some students relaxing to such an extent that the subject could eventually be devalued.

SYSTEMATIC APPROACH TO THE CURRICULAR REFORM OF THE SUBJECT

After analysing the teaching experiences of the 2004/05 and 2005/06 academic years, the possibility of tackling a serious curricular reform of the subject was considered. The professors involved unanimously expressed their wish that this reform must maintain or even improve on the advantages already obtained by the changes introduced in previous academic years, while also reducing or even eliminating the disadvantages that had been identified, as indicated above.

The curriculum reform was tackled, following a systematic methodology that was divided into six stages, with an additional seventh stage for feedback. The steps followed are shown graphically and schematically in Fig. 2.

Each stage is linked to an action that must be carried out and is associated with a question. The three initial actions correspond with many other questions relating to traditional teaching methodology: 'What do we have?' 'What can we change?' and 'How are we going to change it?' The three actions that follow these refer to the new methodology: 'What have we changed?' 'How have we done it?' 'What results have we obtained?' The seventh stage is tackled once the results are known and have been analysed, which is the point at which the question, 'What can be improved?' is considered so that the appropriate corrective actions can be immediately implemented.

The initial situation had already been analysed, which led to slight changes in the 2005/06 academic year as was stated in the previous section. Consequently, the answer to the first question, 'What do we have?' had already been tackled and solved. The possible improvements were analysed at the end of the 2005/06 academic year, arriving at the conclusion that changes to five areas were necessary.

1. Develop a teaching tool capable of integrating theoretical knowledge, practical examples and interactive simulations.
2. Facilitate autonomy in the learning pace of each student.
3. Find an objective evaluation model of the acquired knowledge, without placing exclusive emphasis on a final exam.
4. Promote collaborative and active work.
5. Implement a primarily learning-orientated teaching model.

The analysis of the third stage and the answer to the associated question, 'How are we going to change it?' took up the most time and effort.
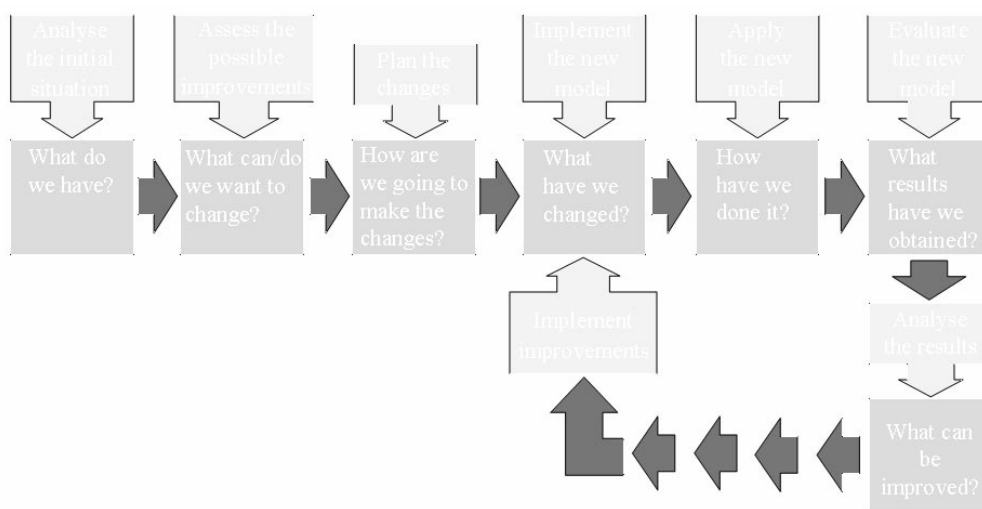

Fig. 2. Stages of curricular changes.

From the beginning, the solution was directed towards a methodology centred on an Information Technology (I.T.) solution capable of integrating: basic theoretical concepts, solved exercises and self-evaluation exercises, through a learning model that allowed student autonomy. This was a good initial plan but it had to be clarified as the intention was not to replace a face-to-face class with an e-learning model. According to the American Society of Training and Development (ASTD), e-learning is: 'everything that is distributed and supported by electronic means for the explicit purpose of learning' [11]. If e-learning is also understood to be 'carried out in a non face-to-face environment', then our proposal cannot be sustained in this type of model. A b-learning model does not appear to be appropriate either, if it combines face-to-face and non-face-to-face teaching through some electronic support.

Our methodology must contain the versatility provided by electronic support in a face-to-face environment, allowing the student a certain amount of autonomy and creativity but under the supervision of a professor, making co-operative work possible, but evaluating the individual student's work, centring a significant part of the teaching function on simulations, and also carrying out practical work on real equipment. This is a cognitive learning model that is radically new to Manufacturing Engineering Technology, although similar in concept to other known teaching experiences [12]. In short, this is face-to-face teaching with the aid of laboratory equipment, the support of an electronic environment and under a professor's supervision: an environment that we have called 'driven electronic learning' (DE-learning).

Characteristics of the DE-learning methodology

The new DE-learning teaching model is based on the idea of placing the student in an optimum learning environment for learning Manufacturing Engineering Technology, an environment that allows the greatest teaching efficiency. In this model, the student is at the centre of the action, and is the body around which all the resources revolve, as shown graphically in Fig. 3. The resources on the right-hand side of the diagram (collaborative works, manufacturing cell, measuring equipment, books and manuals, and detailed explanations) are offered as a complement and comparison to the electronically supported training activity, provided with the resources that are shown on the left-hand side of the diagram (notes, Web, solved examples, exercises and simulations). The professor forms part of the model as an additional 'resource' available to the students and undertakes the following main tasks: to advise, to direct and to guide. The individual evaluation tests

Fig. 3. DE-learning environment.

are proposed as a control function, adjustment and for knowledge reinforcement.

The defined environment enables tangible resources to be set apart (located on the right of Fig. 3) from those that are electronically supported and distributed online (located on the left). The former were already available and had been employed in previous teaching sessions; conversely the 'online' environment was then non-existent. First, the possibility of the MOODLE® environment was analysed. This is an open code platform used by the Tele-Education office (GATE) of the Polytechnic University of Madrid, through which continuing formative training courses and study subjects regulated by the UPM via e-learning and b-learning systems have been implemented. [Moodle is a learning management system, that is to say, an application designed to help educators create online courses. The word Moodle originated from the acronym of Modular Object-Oriented Dynamic Learning Environment, which is a basic utility for programmers and education theorists. It is also a verb that describes the process of wandering lazily through something and doing things 'as and when you think about doing them'. The two meanings are applied to the way in which Moodle is developed and the way in which the student or professor can approach the study or teaching of an online course. Anyone who uses Moodle is a 'Moodler'.]

This platform has proven to be useful for the publication of content, news, exams, links and chats, among other things, but has not turned out to be an appropriate environment when the theoretical/practical integration of interactive content is intended. With no other tool available, the solution is orientated towards a self-developed interactive application. For this purpose, different general studies relating to cognitive human abilities were analysed (Newel and Simon [13], Anderson [14] and Sternberg [15], among others). The analysis of the study developed by Felder and Spurlin [16] was of great interest; it showed the learning preferences of students at different universities, revealing their preference for an active, visual and sequential teaching method, in which various senses are used and attention is paid to the ILS (Index of Learning Styles) [17] classification, which we assumed as a reference of unquestionable value. Likewise, some studies specifically carried out in the area of production and manufacturing engineering suggest the use of interactive tutorials in the teaching of these types of technological subjects [18, 19]. Another area of unquestionable teaching interest and necessary examination is focuses on how to proceed in order to include practical cases capable of reproducing situations similar to those that take place in the development of the professional performance of an engineer. Different studies have shown the advantages of this type of teaching tool, for example publications by Vivas and Allada [20], Liu and Schonwetter [21], Dutta et al. [22] and Diegel et al. [23]. Finally,

the statement by Zaremsky [24], an expert in computer training environments, turned out to be especially relevant. He states, 'The true interactivity of developing the content, lies in the designer's ability of being able to put themselves in the place of the other, the one who is going to learn'.

Consequently, work was focused on the development of an application that was capable of encompassing the characteristics of our teaching model, with the fundamental premise being that such an application had to be: user-friendly and easy to use, systematic, and capable of integrating all the resources that we were going to employ in the training activity. Its implementation was scheduled in four stages:

1. Defining the general structure and contents by lessons
2. Devising the user interface
3. Implementing the contents and resources
4. Testing and refinement.

Definition of structure and contents

Following the Manufacturing Engineering Technology course keywords and the general objectives of the specialist subjects that the course is made up of, it was decided to divide the application into twelve lessons. Their content was balance in such a way that all lessons could be reasonably expected to be completed by the students within three and five hours in the laboratory class, without taking into account the study time that each individual must have to prepare for the subject. [In this context the expression '*completed [. . .] within three and five hours*' means that within this time the students must get to understand the theoretical concepts of the 'notes' section; they must understand the solutions of the practical examples; and they must solve the self-evaluation exercises as well as developing and completing the evaluation practical. Individual study time away from the classroom is estimated to be between 1.5 and 2 times greater than previously.] The subject titles are as follows.

1. General concepts of programming machine-tools with numeric control (NC)
2. Introduction to NC turning lathe programming
3. NC fixed cycle turning lathe programming
4. NC parametric turning lathe programming
5. Introduction to NC milling machine programming
6. NC fixed cycle milling machine programming.
7. NC parametric milling machine programming
8. Introduction to CAD/CAM systems.
9. Automated programming in a CAD environment: revolution pieces
10. Automated programming in a CAD environment: 3D pieces
11. Automated programming in a CAD environment: pieces with warped surfaces
12. Flexible manufacturing: robot and cell programming

Devising the user interface

The adoption of a game-based learning environment is presented as the most reasonable option to satisfy the objectives of: (a) developing a more efficient learning model than the traditional one (Petti *et al.* [25]; Kumar and Labib [26]); (b) increasing student motivation (Snell-Siddle and Toki [27]; Burn [28]) and (c) helping students to understand the theoretical and practical content of the subject in the most efficient way (Klassen and Willoughby [29]).

It was decided that the programming language to be used in the development of the application would be Visual Basic®, primarily due to its versatility and ease of programming. It was also decided to maintain a common structure for all lessons; thus all the application windows remain the same. All contain the following sections: Objectives, Notes, Examples, Exercises, Bibliography, Links, Syllabus and Evaluation. Access to the different lessons is restricted and sequential: students can only access the next lesson once they have completed all exercises in the current lesson and have passed the practical test. They will also be able to access the previous lessons if they need to revise any content. This has all been implemented in a simple model containing interactive teaching modules with a structure similar to many applications of this type. Some examples in the field of mechanical and manufacturing engineering have been studied and/or developed by McCarthy *et al.* [30], Holzer and Andruet [31], Gurbuz [32], Xu and Duhovic [33], Fidan and Elsawy [34] and Kumar and Labib [26]. Teaching models supported by interactive computer simula-tions in other engineering areas have also been developed and experimented with with success: thermal [35], quality [36], basic sciences [37], mate-rials [38].

Implementation of contents and resources

The implementation of each lesson's content was carried out using the resources described in Table 2.

TRAINING SEQUENCE AND LEARNING ENVIRONMENT

Each lesson starts with a short presentation by the professor of no longer than 15 minutes. Each student then accesses the computer application (Fig 4) and starts the process of self-training. The professor is present in the laboratory and can be consulted by the students at any point. In addition, the students can talk among themselves.

The 'Objectives' option gives a precise idea of the abilities, skills and knowledge that the student should acquire, that is to say, the purpose of the lesson. The objectives are formulated concisely in a direct, precise and summarised way in which that they can be understood without any ambiguity. The 'Notes' option integrates the basic theoretical contents of each lesson in HTML format. It contains a single document equipped with hyper-texts. The 'Examples' option contains different solved numerical problems and mathematical workings that complement and clarify the theore-tical content. Figure 5 relates to an example within lesson 2: 'Introduction to lathe programming' as

Table 2. Resources used in the application

Section	Description	Resource
Objectives	Basic information about what is going to be learned in each lesson.	Application window
Notes	Text with links and simple examples where the corresponding concepts to each lesson are explained and the contents that are essential to know and understand are developed.	HTML and PDF Documents
Examples	Solved exercises that include explanations about the basic concepts of each lesson.	Application window
Exercises	Problems that each student must solve individually, which the application corrects automatically. This section has a restricted implementation system: the second exercise can only be accessed when the first has been completed and so forth.	Application window
Bibliography	List of bibliographical references that expands on the information contained in each lesson. The books are found in the laboratory and available to the students. In each case the chapter or section is indicated and the pages to be consulted are clarified.	Application window
Links	(a) Access to different I.T. simulation and calculation programs used in each lesson.	WinUnisoft®, CAD, Matlab®
	(b) Access to a selection of Webpages related to the contents of each lesson.	Internet
Syllabus	Access to different lessons. Only the current lesson is activated and those that have been passed.	Application window
Evaluation	Control test of each lesson. These are only accessible when the designated exercises have been passed.	Multiples*

*Control tests can be of a different orientation and scope: a similar exercise to the contents in the same lesson, a theory/practice combined exercise, a simulation, a complete project (design, programming, manufacturing and dimensional control of a piece or mechanical assembly) a comparative study of costs, an internet search. In addition, depending on the scope and difficulty of the test, these can be carried out individually or in groups.

| Objectives | Notes | Examples | Exercises | Bibliography | Links | Syllabus | Evaluation |

Fig. 4. Access buttons to the application's resources.

Lesson 2: Introduction to NC turning lathe programming

Objectives
Notes
Examples
Exercises
Evaluation

Bibliography
Links
Syllabus

Exit

Example 3:

A turning operation in a grinder must be carried out complying with the following conditions:
• Programming in absolute co-ordinates
• Speed of advance: 140 mm/min
• Turning speed: 1000 rpm
• Tool to be used: number 1
Write the necessary instruction in a program line using the Fagor 8050 language

Result:
Following the directions of the statement, the functions to implement are:
• Programming in absolute co-ordinates: G90
• Constant speed of advance, expressed in mm/min: G94
• Advance of 140 mm/min: F140
• Constant turning speed: G97
• Turning speed of 1000 rpm: S1000
• Number 1 tool: T01 D01
Therefore the program line N010 results are:
N010 G90 G94 G97 F140 S1000 T01 D01

Fig. 5. Lesson 2, example number 3.

Lesson 2: Introduction to NC turning lathe programming

Objectives
Notes
Examples
Exercises
Evaluation

Bibliography
Links
Syllabus

Exit

Exercise 2:

Indicate whether the following statements are true or false:	True	False
•The M30 function is not necessary to be the last function written in a program	○	○
• The comments that appear in the program lines will be preceded with the sign ';'	○	○
• The G94 and G95 functions can be programmed on the same line	○	○
• When the G97 function is implemented it is not necessary to indicate any value of S	○	○
• It is not possible to fix the co-ordinates in absolute value and then change the incremental co-ordinates within the same program. The inverse is possible	○	○
•The co-ordinates in the X and Z axis must always be positive	○	○
• The sense of the chuck turning must remain constant throughout the whole program	○	○
		Accept

Fig. 6. Lesson 2, self-evaluation exercise number 2.

Table 3. Lesson 3 evaluation exercise definition

| Case study		Information/ Data
Title	◇	Programming and machining of a revolution piece using G68 and G88 cycles.
Technical requirements	⊙	The conditions of cutting must be calculated by testing the material (breaking load, strength, composition . . .)
	⊙	At least two circular interpolations must be programmed: one clockwise and the other anti-clockwise.
	⊙	These must include at least three tolerances: one of surface finish, other of form, other dimensional.
Scope	*	Graphical representation of the piece in CAD.
	*	Programming in NC *Fagor 8055*®.
	*	Simulation in *WinUnisoft*® environment.
	*	NC turning lathe machining.
	*	Dimensional control on surface-finish testing instrument, three coordinates measuring machine and profile projector.
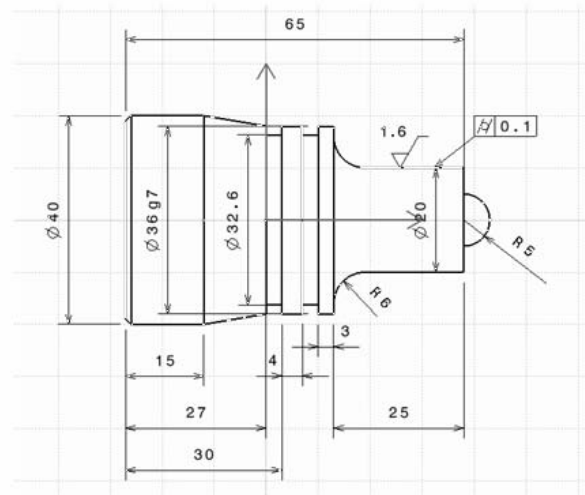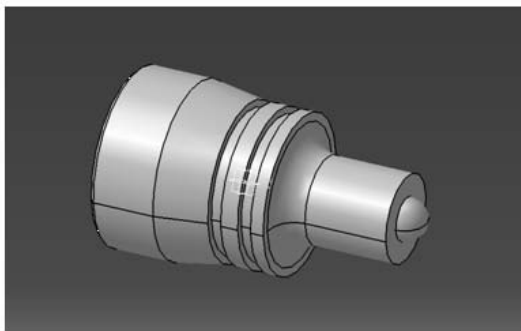
Fig. 7. (a) 3D graphical representation, (b) scale drawing.

shown in the application window. The 'Exercises' option is used as a self-evaluation tool through which the students are able to individually and autonomously compare the level of knowledge that they have acquired at each point. Its structure and content specifically adjusts to correspond with each lesson. In generic terms, a division into two large sections has been established: (a) exercises where the data stay the same (and the results are therefore always identical and the same for all); and (b) exercises that generate data randomly (and therefore have different results each time these are accessed). The requested answer in one or the other case could be: numerical, alphanumerical, true–false, graphical, printed, oral, instantaneous, recorded etc. Figure 6 shows a self-evaluation exercise belonging to lesson 2.

The 'Bibliography' option shows the most relevant bibliographical references of each lesson and indicates the topics or page references for each text. These references can be: books, manuals, rules and technical catalogues that are always accessible and available to the students in the laboratory. The 'Links' option permits access through the laboratory's wireless system to different predefined Webpages where there is electronic information to complement each lesson's content. Once the corresponding training contents have been studied and simulated, after the student has passed the self-evaluation exercises, the professor starts the verification process to confirm the level of knowledge achieved. The tool used is the 'Evaluation' exercise. In general, each lesson's evaluation exercise integrates knowledge acquired in previous lessons and requires the use of other knowledge and skills learned in other subjects such as Mechanical Technology, Metrology and Materials Science. The evaluation exercise of lesson 3 'NC fixed cycle turning lathe programming' (Table 3) is shown as an example, along with a possible solution and how this was arrived at (Figs 7– 9).

EVALUATION

With the aim of obtaining objective information about the designed software, the teaching environment and the employed methodology, a preliminary evaluation measuring student satisfaction levels was carried out. An evaluation of their academic results was also taken into consideration.
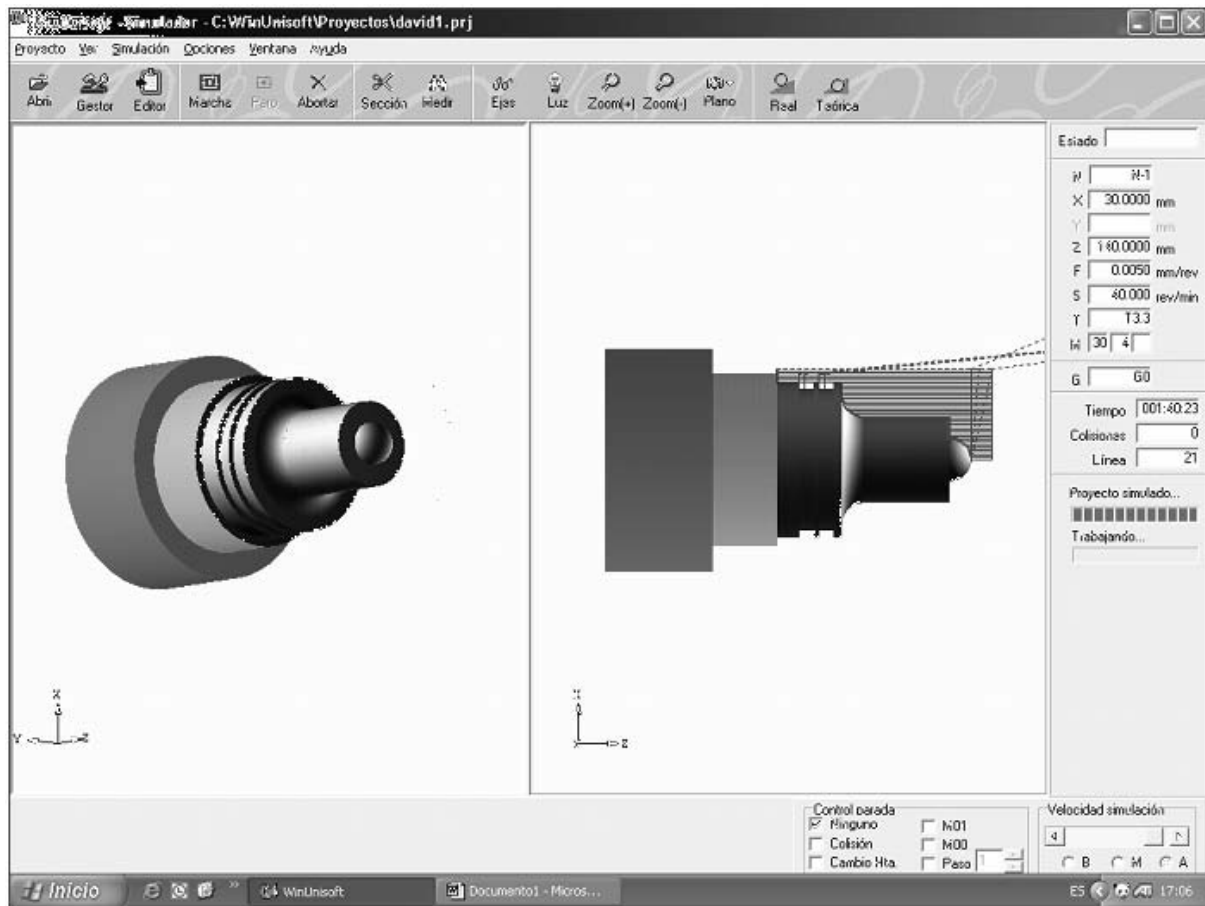
Fig. 8. 3D simulation of the machining piece.

Evaluation of software, environment and teaching methodology

This evaluation was carried out via an anonymous questionnaire where the undergraduates must answer 15 questions. The survey was carried out at the end of the course and before the qualifications were received. In each case the level of satisfaction is indicated between 1 (very negative) and 10 (excellent). Tables 4, 5 and 6 show the results.

The data show a very good perception of the developed software and the teaching environment. In terms of methodology used, the students indicated that they are satisfied and gave a score of more than 7.5 points to all the evaluated aspects.

Fig. 9. (a) Machining piece, (b) shape and size control (CMM).

Nevertheless a slight reduction in points was observed and an increase in the variability of answers 1 and 2 (Table 6). When these aspects were analysed in more detail, it was found that the students had demonstrated that the level of autonomy was higher than they were used to in other subjects, forcing them to do extra work that, in their opinion, would be more tolerable if the professor had dedicated more time to explanations. These two questions were answered only by 15 and 17 students, with a high level of abstention, which shows their doubts regarding the advantages and disadvantages of an initial extra effort in the learning process.
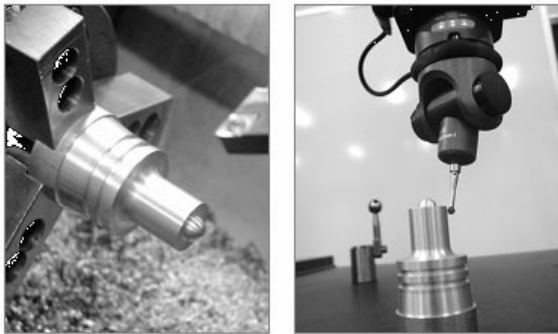
Evaluation of academic performance

Academic performance was determined through the rating of the individual evaluation exercises that all the students completed. Each exercise was graded between 0 and 10 points. The maximum, minimum and average grades of the students were taken for each of the 12 lessons and are represented in the chart in Fig. 10. The lowest rating was 6 points, the highest was 10 points and in all cases the average rating was above seven points. These results reveal a successful academic performance by the students who studied Manufacturing Engineering Technology during the 2006/07 academic year.

Table 4. Evaluation of developed software

Item	Question	Number of answers	Mean	Std. deviation
1	Ease of navigation	21	8.5	0.93
2	Clarity of contents	21	8.2	1.04
3	Structure of contents	21	8.5	0.93
4	Training capability	21	7.8	1.32
5	Flexibility	21	9.2	0.55

Table 5. Evaluation of training environment

Item	Question	Number of answers	Mean	Std. deviation
1	Space and equipment distribution	21	9.2	0.22
2	I.T. equipment	21	8.5	0.34
3	Manufacturing laboratory equipment	21	9.0	0.50
4	Metrological laboratory equipment	21	9.0	0.50
5	Library resources and web access	21	8.7	0.56

Table 6. Evaluation of methodology

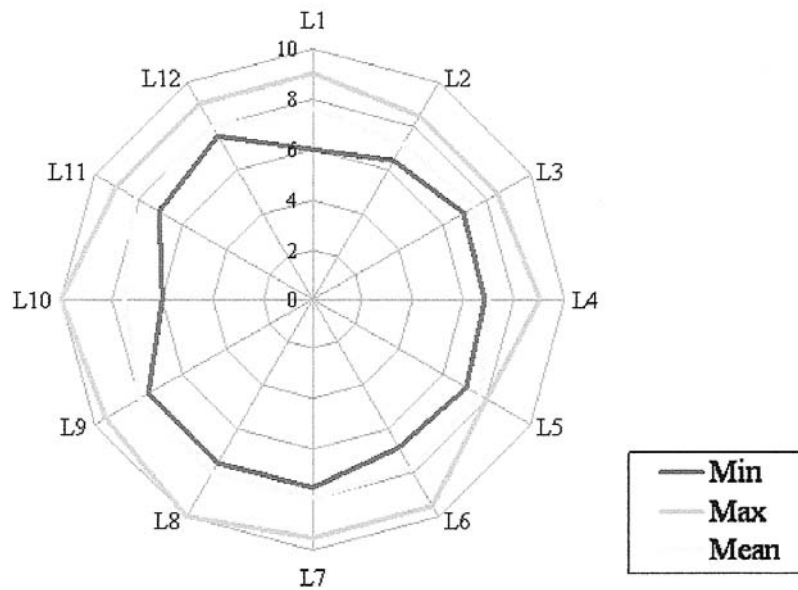| Item	Question	Number of answers	Mean	Std. deviation
1	Level of autonomy in the study	15	7.6	1.78
2	Time of professor explanations	17	7.5	1.23
3	Interaction with other students	21	8.9	0.58
4	Clarity of practical examples	21	9.1	0.33
5	Self-evaluation exercises	21	9.0	0.66

Fig. 10. Maximum, minimum and average ratings.

CONCLUSIONS

According to our experience, the most appropriate teaching methodology for imparting the subject of Manufacturing Engineering Technology, together with other subjects that have similar characteristics, is within the framework of the model that we have named DE-learning (driven electronic learning).

DE-learning is an autonomous teaching model, provided with interactivity that integrates the advantages of face-to-face teaching with those of electronic teaching. This combines the classic resources and the e-learning resources in the same environment, in such a way that the merging of the two assumes a new methodology that is more efficient and attractive to the students. This has self-developed software that integrates the

theoretical contents of the subject, exercises, links, self-assessment tests, simulation etc., all of which are ordered by lessons. Furthermore, the equipment necessary to carry out practical classes in manufacturing and dimensional verification is available to the students in the same environment. The role of the professor is limited in this model to providing advice, directing and guiding, with the professor being an extra teaching resource available to the students.

The DE-learning methodology provides, in our opinion, an excellent framework for training focused on the student and learning, in accordance with that outlined in the new European Higher Education Area.

The teaching experience carried out with the DE-learning methodology during the 2006/07 academic year has demonstrated good academic performance amongst students and has achieved the following objectives:

- Excellent student integration in a new multi-disciplinary environment
- A high level of collaboration
- Motivation, interest and creativity
- Skills development and technological abilities
- Improvement in team working abilities and consensus decision making
- Critical analysis and a significant improvement in understanding of the technical/economic

aspects associated with manufacturing engineering activities.

FUTURE WORK

Work is currently being carried out on refining the developed software, incorporating new solved examples and modifying the notes files, whereby all the PDF files are being substituted by HTML formatted files, which are preferred by the students as they can be easily managed and are versatile.

From the experience of the 2006/07 academic year it has been proven that, on occasions, the fixed data entry exercises were not effective in adequately clarifying the theoretical concepts of certain parts of the subject, and the students required additional help. Consequently, work is currently underway to incorporate new practical exercises that include stochastic data entry to the application. This will allow the students to repeat the same problem as many times as they wish using different initial data.

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