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# INNOVATIVE TEACHING AND LEARNING AT ENGINEERING IN SALERNO (ITALY): THE MASTER DEGREE MODULE IN VIRTUAL DESIGN LAB

*Abstract: How can academics and teachers improve the learning capabilities of Master Degree (MD) students of Engineering courses through the use of new methodologies, new instruments and new teaching approaches? This paper wants to give a possible answer to this question by sharing the experience of Virtual Design Lab module at the faculty of Engineering at University of Salerno (Italy). Teaching and learning methodologies are explained and the experience of students is evaluated through a standard questionnaire. Results seem to be promising for the organization of new modules.*

*Key words: Virtual Design, Learning skills, Teaching methods, Engineering modules, Ergonomics.*

## 1. INTRODUCTION

The Master Degree (MD) courses in Mechanical Engineering and in Management Engineering of the Department of Industrial Engineering of University of Salerno (Italy) are organized into 120 ECTS (European Credit Transfer System) to be accumulated in two years by students. Some of them are dedicated to Thesis (Final project) and to an intra-curriculum traineeship to be held in cooperation with Universities labs or Companies labs.

The curricula-studiorum of both courses are organized in order to give to the MD student, theoretical skills, soft skills and hard skills in order to prepare them to face the world of company-job; inside each curriculum, several mandatory modules have to be followed by students in order to acquire the basic knowledge and skills to work as mechanical or management engineers.

84 ECTS have to be accumulated through the acquisition of knowledge and skills inside the modules in a blocked study plan; 12 ECTS are mandatory but students can make a choice inside a wide range of modules offered not only by Engineering faculty but also by other scientific faculties of the University of Salerno like Mathematics, Physics, Pharmacy, Natural science, Biotechnology, Informatics and so on.

The curricula studiorum have to be approved by the Didactic Committee thus the student can acquire all needed ECTS to have access to the final exam and to be awarded the Master Degree in Engineering.

The Virtual Design Lab (VDL) module is one to be chosen among not mandatory modules; it counts six ECTS that can be acquired after a 60 hours course.

The module program has been re-arranged in the last three years in order to improve learning capabilities of students.

This paper wants to explain what were the reasons, the didactic methods and the results of the new arrangement of this module and what were the methods of teaching/learning and the learning/teaching instruments used to perform good results in student's knowledge and skills improvement.

## 2. STATE OF THE ART

As everybody knows, after the Bologna Process [1] the contents of the Third level education courses (University degrees, Masters and PhD), have been reorganized and can be measured in ECTS.

Each course's content can be described through the Dublin descriptors [2]:
• Knowledge and understanding;
• Applying knowledge and understanding;
• Making judgements;
• Communication skills;
• Learning skills.

In our university, each module has to be described trough these descriptors and the content of the course of VDL is described as follows:

**Learning skills:** Theory about modelling, Virtual and Rapid Prototyping, The product development plan for industrial products, Computer Aided Design (CAD), Digital Human Modelling (DHM), Human-Machine Interface modelling (KMI), Human Centered Design (HCD), Human factors and Ergonomics.

**Knowledge and understanding**: 2D and 3D languages and terms for Virtual Prototyping and Virtual design. Product Lifecycle Management (PLM).

**Applying knowledge and understanding**: Skills in CAD 2D and 3D modelling and in DHM simulation. Ergonomics of HMI; skills about the way of interacting between humans and artifacts. Skills about the mathematics underlying the 3D CAD modelers.

**Making judgements**: Methods of designing, improving and evaluating an industrial Product/Process. How to choose the right Commercial software for improving efficiency and effectiveness of Virtual Design activities.

**Communication skills**: Work in-group, the right language for presentations and explanations of topics related to Virtual. Prototyping, skills about the right nouns in Italian and English language for communicating ideas and data related to the virtual product design process.

**Lifelong learning skills**: capabilities of using the acquired knowledge for different purposes in the technical field and in other fields of study, research and application.

In order to implement those contents inside the module, the Blooms' Taxonomy [3] about teaching/learning has been used.

In 1956, Benjamin Bloom et al. [3] published a framework for categorizing educational goals: Taxonomy of Educational Objectives: The Bloom's Taxonomy.

Six major categories can be recognized in the framework elaborated by Bloom and his collaborators: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Knowledge was the necessary precondition while the others were presented as "skills and abilities" (see fig.1).
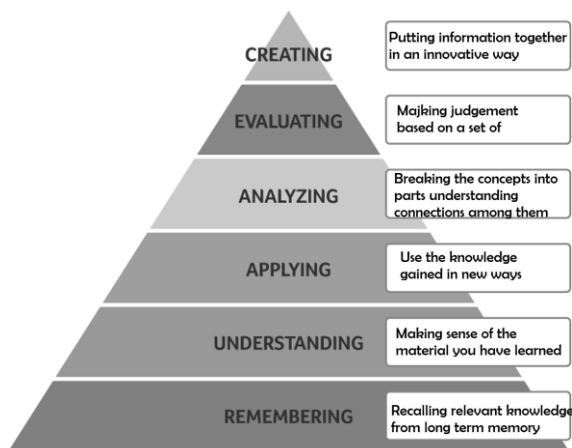


**Fig.1:** The Bloom's Taxonomy

Each category contained subcategories and all of them are organized from simple to complex and concrete to abstract.

In 2001, [4] Bloom's Taxonomy was revised and renamed as "A Taxonomy for Teaching, Learning, and Assessment". In the revision, authors underscore the dynamism, using verbs and gerunds to label their categories and subcategories.

Up to the authors, when designers (thinkers) encounter and work with knowledge, their cognitive process can be described through these "action words": Remember (Recognizing, Recalling), Understand (Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, Explaining), Apply: (Executing, Implementing), Analyze (Differentiating, Organizing, Attributing), Evaluate (Checking, Critiquing), Create (Generating, Planning, Producing).

Such as in the original taxonomy, in the revised one [4], knowledge is at the basis of the six cognitive processes in Fig. 2; its authors created the following new taxonomy:

- Factual Knowledge
  - Knowledge of terminology
  - Knowledge of specific details and elements
- Conceptual Knowledge
  - Knowledge of classifications and categories
  - Knowledge of principles and generalizations
  - Knowledge of theories, models, and structures
- Procedural Knowledge
  - Knowledge of subject-specific skills and algorithms
  - Knowledge of subject-specific techniques and methods
  - Knowledge of criteria for determining when to use appropriate procedures
- Metacognitive Knowledge
  - Strategic Knowledge
  - Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge
  - Self-knowledge
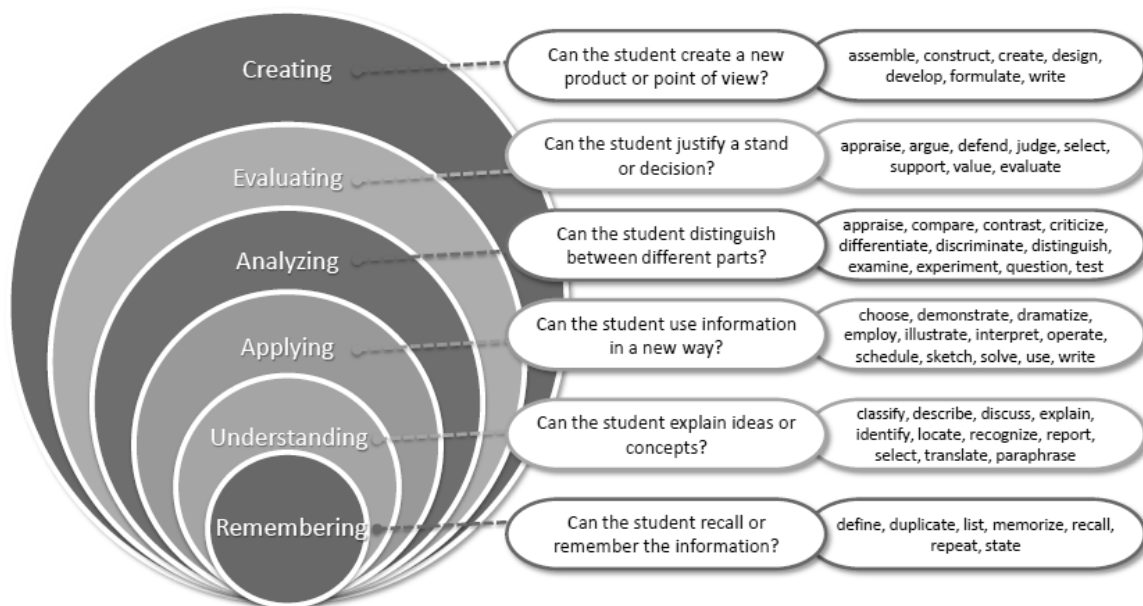


**Fig.2:** Revised Bloom's Taxonomy

Mary Forehand [5] provided the guide to the revised version; her work gives a brief summary of the revised taxonomy and a helpful table for navigating into four types of knowledge and six cognitive processes.

## 3. VDL MODULE

### 3.1 Module content

In order to better understand the following sections, a brief description of the module contents, as reported in the student guide, is needed. The module is divided in the following nine sections:

1) 2 hours of Theory about Innovation and Prototyping (Product development plan, nouns, terms and history and evolution);
2) 4 hours of Theory about CAD technologies (Computer Aided Drafting and Design) in Product Development plan for time-to-market improvement;
3) 4 hours of Theory and 10 hours of Exercises and Laboratory about CAD-CAxx Techniques (CAD modelling, Computer Aided Manufacturing (CAM), Engineering (CAE), Production Planning (CAPP), DHM;
4) 2 hours of Theory about PLM (product lifecycle and its management, Product Data Management (PDM), Customer Relationship Management (CRM), Enterprise Resource Planning (ERP);
5) 2 hours of Theory about Modelling domains and Representation domains for CAD;
6) 4 hours of Theory and 8 hours of Exercises and Laboratory about Modelling techniques and representation schemes for Virtual prototyping;
7) 4 hours of Theory and 8 hours of Exercises about Mathematics for Computer: Parametric curves and surfaces, Functions for approximating curves and surfaces;
8) 4 hours of Theory about Reverse Engineering and Rapid Prototyping (TTM Compression Techniques);
9) 4 hours of Theory and 8 hours of Exercises and Laboratory about Human Factors and Ergonomics: Ergonomics principles, evaluation scales and methods, workplaces analysis.

### 3.2 Teaching methods

In order to apply these principles, the teacher of the module (the author) adopted a strategy of using different teaching methods based on:

- In-classroom direct teaching both using classical instruments like blackboard and chalks, whiteboard with markers, Whitepaper with pencil, electronic instruments like laptop and projectors with PowerPoints, electronic whiteboard, etc…
- E-learning platform, both for store and spread the lessons' contents, for organizing didactic material and for giving students exercises or other instruments for improve their knowledge/skills. The e-learning platform was also used for communication both live and catch-up.
- In lab exercising in which students have been involved activities like Group meeting, Competitive homework, Competitive projects.

- Mentoring and advising during the development of an assigned project in-group, with brainstorming techniques and like-company structured team working.

### 3.3 Learning strategies

Student are invited, along the entire module, to develop their own learning strategies in order to find the better way to acquire knowledge and skills. The most common strategies are:

- Learning by hearing: students follow the explanations of the arguments by the teacher and, during the interactive frontal lesson, answer to the direct question of the teacher.
- Learning by reading: Every lesson is accompanied by PowerPoint® (By Microsoft) slides and by a chapter of one or more books (that deal with the same topic); students are asked to study and deepen the lesson contents.
- Learning by doing: Usually, each lesson is offered both through theoretical arguments and by exercises. Exercises are both theoretical and practical. In particular, the practical exercises are about the use of virtual prototyping instruments, the realization of experimental setup, both in virtual and in physical, and the construction of prototypes for developing, practically, students' ideas, both in a reduced scale and in real scale (1:1) – see fig. 3. Finally, when possible, also the use and the interaction with prototypes are experienced by students – see fig. 4.
- Self-evaluation: usually, within each group, a group leader is requested in order to evaluate the work of the team. Each student has to be the leader of the group for two weeks in order to give to all of them the possibility to experience the role of leader and evaluator.

### 3.4 Detailed description of module organization

The module is offered in the second semester of the second year of the Master Degree courses for Mechanical and Management Engineering, The course is divided in two sections of 30 hours: the first section is a theoretical section in which the theoretical bases of the topics are explained and deployed; the second section is the laboratory&application section in which both Virtual Prototyping and Lab prototyping of an experiment is designed and performed.

In addition to the University activities, two weeks of not mandatory activities outside the lab, in a company that is linked to Departments with an agreement, are offered to the students.

Usually, in a week, 2.5 hours of theoretical activity and 2.5 hours of exercise/lab activity are developed.

In the academic years 2015-2018, three classes of students followed the modules:

2015-16 – 22 Students
2016-17 – 30 Students
2017-2018 – 18 Students

The variability of the students' number depends on several factors depending on the number of MD applications per year and on the performance of students.

The module is not mandatory in the students' yearly plan. The module is developed in 14 weeks; after 6

weeks, students are asked to divide themselves in groups for developing a project. In the meanwhile, the program development allows them to be able to work on a virtual prototype of their project ideas.

In the second half of the courses, after three weeks, students spend one week inside a company to acquire the right knowledge for design and build a physical mock-up of their project.

In the following three weeks, the students attend the module lessons and discuss with professors and research assistants about their projects, in particular for planning their experiments to check and verify the designed performances of their projects.

Finally, in the last week, experiments are performed and acquired data are processed for results synthesis.

## 4. THE 2018 EXPERIENCE AND THE FINAL WORK.

In academic Year 2017-18 the courses have been offered in the period March-May 2018.
Students faced the theoretical part as usual and they began to acquire knowledge and skills about modelling software (CATIA® by Dassault Systemes) in the first 3 weeks. Between the fourth and the sixth week, they acquired knowledge and skills about anthropometry, human factors and ergonomics, comfort and experimental design topics, while they acquired the right skills to use a DHM modelling system (DELMIA® by Dassault Systemes).

In the seventh week, they presented their project ideas and went to work inside the company (MGR Srl.) to understand the feasibility of their ideas and the manufacturability.

In 2018, the work was done by 14 students (the other four of the group went to develop their work abroad) divided in two groups of seven people. In the class, four foreign students coming from Portugal, Turkey and Spain, were present so, all practical activities were performed in English language.

The project assigned to students was about the development of a special seat pillow that was suitable to improve the comfort experience while driving a car.
Students' work was organized like the work of two company teams, further divided in two sub-teams: the first one was involved in research (3 people) and product design (4 people); the second one was involved in product development (4 people) and experimental design (3 people). Finally, all people were involved in in-car experiments (like in [6]), data acquisition (like in [7]), data analysis (like in [8]) and results synthesis (like in [9]). All the activities were developed together and inside the company MGR S.r.l. that is an Italian leader company in design and production of personalized interiors for vehicles and boats.

Results were synthetized in terms of:
1) Virtual prototypes of two new products;
2) Virtual prototype of the user experience through CAD and DHM simulation;
3) Physical prototypes of the pillow (in three different updates);
4) Physical prototype of a new seat with integrated pillow;
5) Results of experiments on seating buck [10];
6) Results of experiments inside a real car;
7) Design guidelines for a comfortably seat.



**Fig.3:** Pictures of physical prototype manufacturing

All these aspects were analysed during the final exam in which students had to discuss the project using both PowerPoint® presentation and virtual/physical prototypes.

During the exam discussion, the students were asked to answer to theoretical questions about the course contents.

## 5. DISCUSSION AND CONCLUSIONS

The module experience allows students to develop all the aspects of Blooms' Taxonomy, both in the old version and in the new version. In the following, all the developed aspects have been reported and detailed using the same structure of Blooms' Taxonomy itself, both in the original one and in the revised one.



**Fig.4:** Picture from experiments

In the original taxonomy:

### Remember

*Recognizing and Recalling*: students were able, during the exams, to recognize and recall all theoretical skills and knowledge learned during the course.

### Understand

*Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing and Explaining*: the PowerPoint presentation, discussed both singularly and in group during the exams, was able to show to the teacher how those skills have been developed by the students.

### Apply

*Executing and Implementing*: the development and construction of physical prototypes and the experimental experience gave to students the capability of applying, executing and implementing their acquired knowledge.

### Analyse

*Differentiating, Organizing, Attributing*: the design of experiments experience and the data acquisition and analysis gave to students those skills.

Evaluate

*Checking and Critiquing*: the synthesis of results, their representation and the transformation of results in design guidelines is the proof of understanding these aspects.

### Create

*Generating, Planning and Producing*: the physical prototype is the practical proof and realization of these learned skills.

In the revised taxonomy:

### Factual Knowledge

*Knowledge of terminology, Knowledge of specific details and elements*: they are acquired during theoretical, practical and in-lab activities and clearly proved by the students in the final presentation and discussion.

### Conceptual Knowledge

*Knowledge of classifications and categories, Knowledge of principles and generalizations, Knowledge of theories, models, and structures*: they are acquired during theoretical activities and clearly proved by the students during the exam on the theoretical part; also, the use of this knowledge in the prototypes development and in experimental design is proved through their experience.

### Procedural Knowledge

*Knowledge of subject-specific skills and algorithms, Knowledge of subject-specific techniques and methods, Knowledge of criteria for determining when to use appropriate procedures*: they have been acquired during theoretical, practical and in-lab activities and clearly proved by the students in the final presentation and discussion, during the activities of realization of both virtual and physical prototypes, and also during the exam on the theoretical part.

### Metacognitive Knowledge

*Strategic Knowledge, Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge, Self-knowledge*: they have been acquired during theoretical, practical and in-lab activities and, in particular, during the research about patents, state of the art and similar products; their acquisition is clearly proved by the students during the group activities, in the final presentation and in theoretical discussion.

At the end of the module, University of Salerno (Italy) obliges their students to perform an evaluation of the teacher, of the module organization and of classroom and labs facilities. The evaluation is made through several questionnaires that measure the performance of each course.

The final check about the teacher experience is a final report about teacher with a vote 0-4.

For the 2018 VDL module, the votes were always more than 3.5/4, resulting one of the most appreciated modules of the MD.

As final comment, the work of students has been synthesized in two papers that will be presented at the Second International Comfort Congress on August 2019.

This paper deal with the author experience in re-organizing a MD module in order to implement and fulfil the Bologna Process requirements and the Bloom's Taxonomy characteristics. After three years, the experimental approach was assessed and will be used in the future.

## ACKNOWLEDGEMENT

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