AEDS 2004 WORKSHOP
11-12 november 2004- Pilsen-Czech republic

ASPECTS IN DESIGN EDUCATION OF ENGINEERS AND INDUSTRIAL DESIGNERS AT "POLITECNICO DI MILANO"

Giorgio COLOMBO, Edoardo ROVIDA

Keywords: Design Education, Engineering Design, Industrial Design

Abstract

This paper refers about activities of the authors in design education at "Politecnico di Milano". They are involved in training of engineers and industrial designers teaching courses related to design methods, technical drawing, virtual prototyping and computer graphics. Differences in skills and in training methodologies in mentioned domain are highlighted; examples in using methods and tools are also presented and discussed.

1. Introduction

The authors are actively involved in educational activities concerning design field at Politecnico di Milano, an Italian technical academic institution with height thematic faculties devoted to the training of engineers and architects. One faculty is oriented to mechanical and aerospace engineering (Faculty of Industrial Engineering), whereas an architectural faculty is dedicated to industrial design (Faculty of Industrial Design).
Training of engineers and designers was recently modified in Italy, introducing a new structure of studies called "3 + 2"; a first course articulated in three years permits to reach the first degree, whereas the second level provides two years to reach the master.
Such new structure implies new teaching methods and organization: short teaching times, more attention to practical aspects, courses and laboratories oriented to the immediate acquisition of technical competences. At the same time, it is necessary to develop traditional skills of engineers and designer and develop competences in new methodologies and tools.
The authors teach some courses, at first and second level, such as "Technical drawing", "CAD Laboratory", "Computer Graphics", and "Design Laboratory". In this paper, we discuss about contents and skills and we present some considerations derived from our experiences in design education.

2. Skills for engineers and designer

The "forma mentis" of an engineer and of an industrial designer are very different and, particularly, the design activity in the related professional fields has a different meaning. This fact has relevant effects on their education.
In engineering field, design basically means:

- function definition;
- parts dimensioning;
- kinematic dynamic and structural verifications;
- prototype testing;
- manufacturing definition and planning.

In all these activities, focus is on technical point of view. In this context, a very important aspect is related to the ability to develop quantitative models of phenomena, machines and systems with the aim to analyse and optimize them. In training, to develop this skill fundamentals of calculus, physics, mechanics, thermodynamics, electromechanics, science of materials are presented; moreover, the basics of technology for what concerns product archetypes, machines and production plants must be also treated. We can summarise our considerations saying that the emphasis of engineering training is focused on the development of analysis skills; minor attention is on the synthesis aspects.
In the industrial design field, however, other aspects are highlighted, e.g.:
- functional-technological that means:
    - physical phenomenon, historical heritage, forms, motions, fits;
    - morphology, materials, processes;
- ergonomic-environmental:
    - access, usability, driving, safety;
    - behaviour in regards to external agents, reuse, liquidation;
- aesthetic-symbolic:
    - fashion, style, colours;
    - product appeal, status symbol;
- economical-financial:
    - design for costs, product easy saleable;
    - cost/benefits relation, marketing, advertising.

In the design field, the objective is the synthesis of the product, with little regard to analyses using quantitative model. In education, major attention is then dedicated to definition of market needs, communication methods and tools, analysis of products (furniture, clothing, shoes,), ergonomics, styling and so on. Practical knowledge is privileged than basic theories and methods; in this sense, a lot of laboratory courses are scheduled, starting from the first year. In laboratory courses students can also learn to work in group, a typical skill today necessary to develop a real project.

3. Considerations about training in design and virtual prototyping

In the previous section we have put in evidence the different skills that must be developed in education of engineers and designer; now we present our experience about how these differences can be reached during academic education.
Our activities are related to project documentation and virtual prototyping; the courses are distributed at the first level of Industrial Engineering Faculty (“Technical Drawing”, at first year and “CAD Laboratory”, at the last year) and at second level (“Reverse Engineering” and “Design Methods”); while in Industrial Design Faculty, our courses are placed at first level (“Computer Graphics Laboratory” and “Design Laboratory”) and at second level (“Technical Drawing”).
In engineering courses of first level we work to develop some fundamental skills related to technical documentation and geometric modelling of machines. In particular, the treated topics can be summarised as follows:
a) functional analysis of a machine or device and identification of construction solutions: the machine is presented to the students and the functions are explicated (see example on figure 1);
b) representation of the machine/device parts by freehand sketches realized in conformity with method of orthographic projections and ISO drawing standards;
c) development of the ability to read technical information stored in 2D drawing, as in figure 2;
d) 3D modelling of mechanical parts: students are involved in modelling parts, by using different commercial packages such as Solid Edge (UGS PLM Solutions), Inventor (Autodesk), Catia (Dassault Systemes), UG (UGS PLM Solutions);
e) assembling of the parts to realize virtual prototype (figure 3 depicts parts and assembly realised by students);
f) drawing in orthographic projections of the assembly and parts by using the same commercial package;
g) self correction, by comparison between b) and f);
h) technical characterization of the virtual prototype individuating all other necessary information, such as materials, tolerances, roughness, standard parts, and so on;

i) parametric modelling of parts and assemblies;
l) management of part libraries.

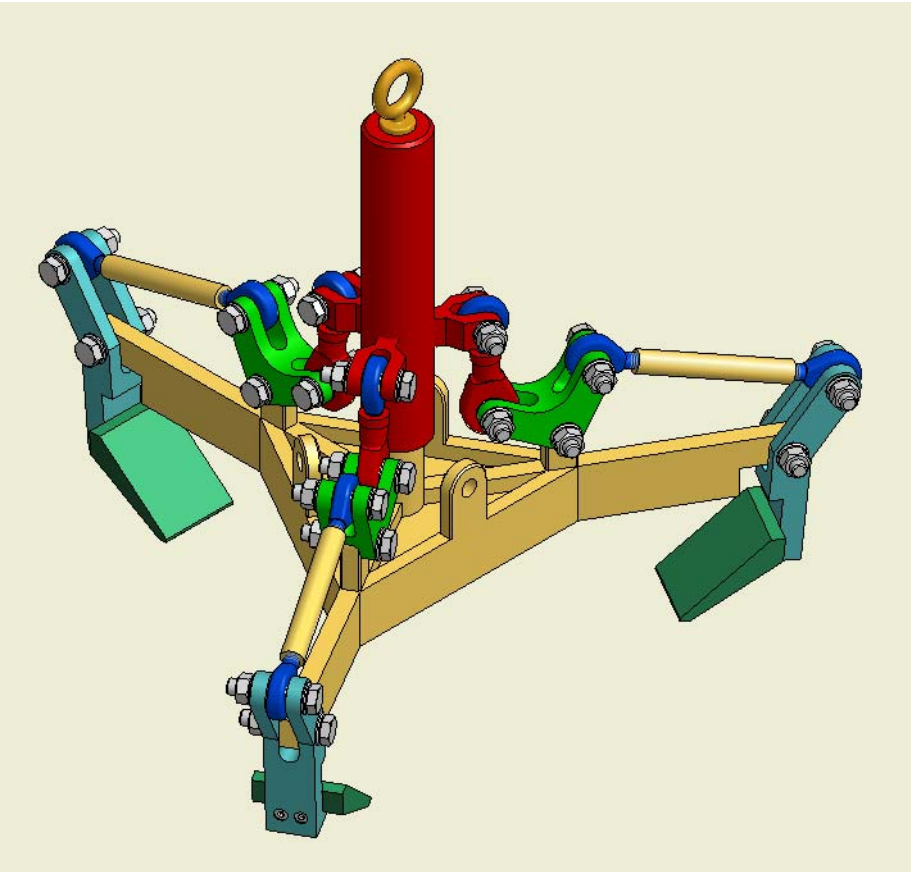

Fig. 1. An example of machine used in functional analysis.

Other examples of skills required at the first engineering degree is illustrated in figure 4 and figure 5, where a 3D model of a SCARA robot and valve gear of an engine are reported. At this level fundamentals in multibody kinematics and structural finite element analysis are also provided; students acquire how to analyse stresses and strains in mechanical parts and motion of machines and mechanisms.
Master students improve their training in analysis methods and acquire competences in specific complementary topics such as design automation with Knowledge Based techniques, reverse engineering and rapid prototyping.

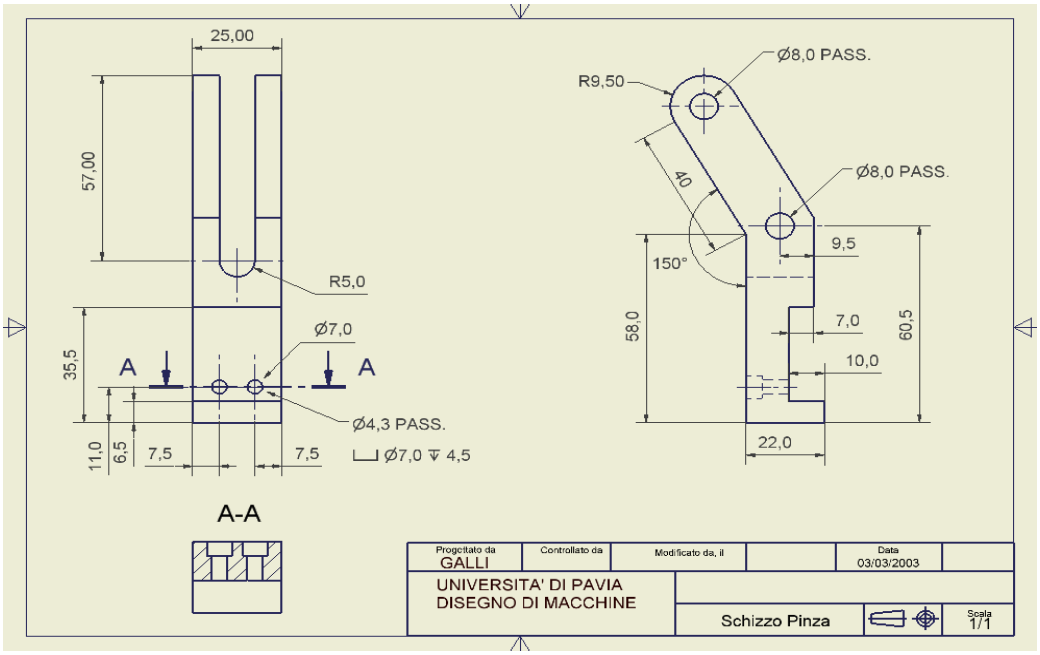

Fig. 2. Drawing of a part of machine shown in fig.1 and used to verify reading ability.

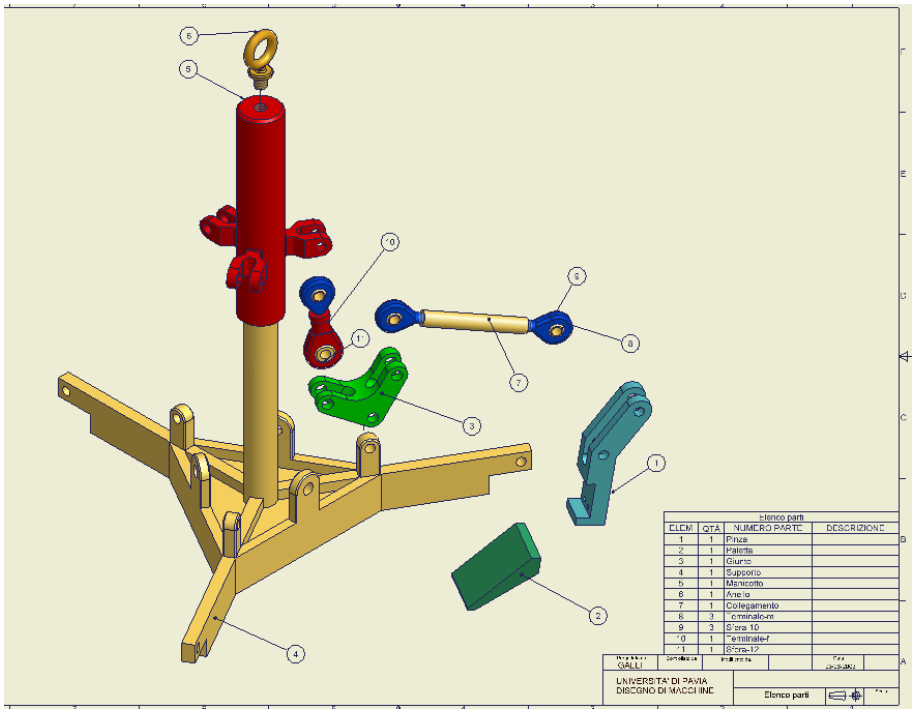

Fig. 3. Parts and assembly realised by students.

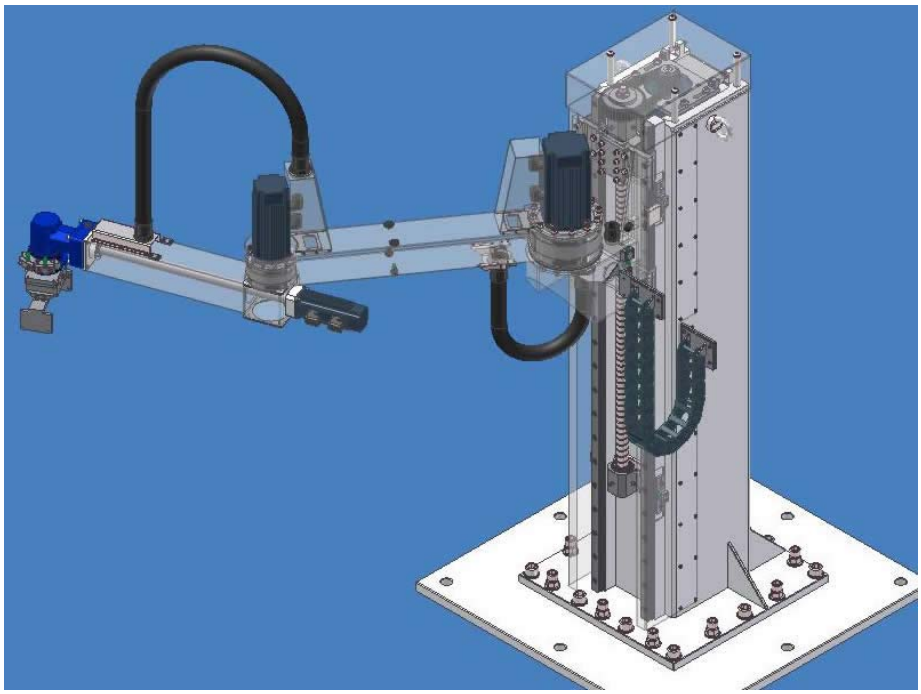

Fig. 4. Virtual prototype of a SCARA robot realised by Engineering students.

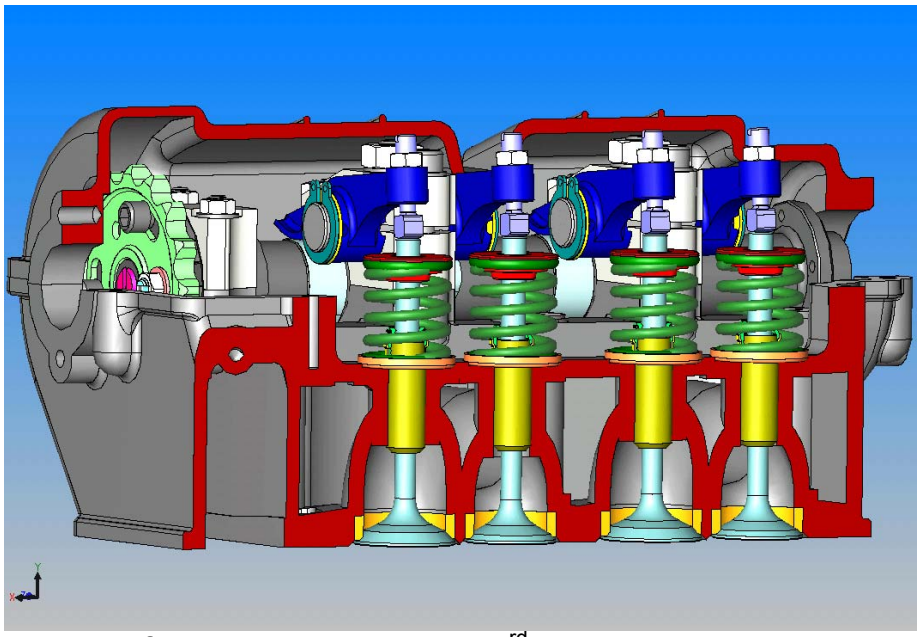

Fig. 5. Valve gear of an engine modelled by 3rd year Industrial Engineering students.

On the other hand, first level students of industrial design must acquire know-how in product documentation with digital techniques; a course such as “Computer Graphics Laboratory” where basics of virtual product modelling, digital images and movies are presented provides these competences. The proposed approach is based on geometric model used to realise realistic digital images and animations to present products. In this case emphasis is the on application of surface modelling, illumination, shading and texture techniques; they are proposed in a simple manner without a detailed technical description. Examples of models and images realised by students are illustrated in figures 6, 7 and 8. Figure 6 portrays a complex scene with Star War machines realised by a second year student group. Figures 7 and 8 illustrate digital images of a lawn mover and a digital camera.

The examples show the relevant differences about the same tools, 3D CAD modellers, in engineering and design courses; these differences are strictly related to the type of required training.

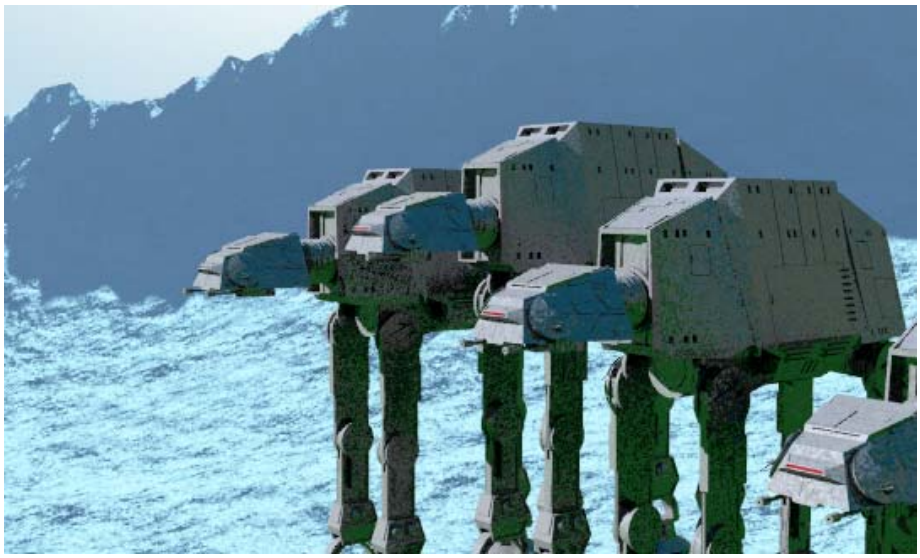

Fig. 5. Star Wars machines realised by Industrial Design students.

Fig. 6. A lawn mover modelled by 2nd years Industrial Design students.

Fig. 7. Digital image realised by 2nd year Industrial Design students.

4. Conclusions

In the paper we discuss skills and methods for different professional people: mechanical (industrial) engineers and industrial designers. In our training process great importance is put on methods and tools necessary to develop product, in particular to document design activities. The experiences of the authors in teaching disciplines such as “Technical drawing”, “CAD laboratory” “Design Laboratory” and so on, permits to highlight differences between the two design approaches; engineers privileges analytical approach whereas designers have good skills in synthesis. The use of tools such as 3D CAD systems also reveals the different attitudes; engineers often prefers virtual prototyping as a starting point for analysis activities while designers use virtual prototype to generate digital images and movies.

References

Biggioggero G.F., Rovida E. “Methodic design as way to improbe students creatività” Int. Des. Conf. Design 98 Dubrovnik , May 19-22, 1998

Biggioggero GF., Gorla C., Rovida E. “A general method for the determination of the objectives of an engineering course” IGIP Conference Klagenfurt 2001

Biggioggero G.F., Galli G. Rovida E.”L’esperienza di insegnamento del Disegno di Macchine all’Università di Pavia” XIV Convegno Nazionale ADM-XXXIII AIAS Bari 31 agosto-2 settembre 2004

Prof. Ing. Edoardo Rovida
Politecnico di Milano Mechanical Departement
Via La Masa 34 20158 Milano
Tel (+39)02-23998205 Fax (+39) 02-23008202
Email
edoardo.rovida@polimi.it

Prof. Ing. Giorgio Colombo
Politecnico di Milano Mechanical Departement
Via La Masa 34 20158 Milano
Tel (+39)02-23998259 Fax (+39) 02-23008202
Email
giorgio.colombo@polimi.it