

EXPERIENCES OF ENGINEERING DESIGN EDUCATION AT PAVIA UNIVERSITY

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## Abstract

The described experience is constituted by some operations (disassembling, measuring and sketching) on the real machine and by virtual prototype and FEM approach.

*Keywords: Design Education, Engineering Design, Mechanical Design Education*

## 1 Introduction

At Pavia University, the courses of Mechanical Engineering are strictly related with Politecnico di Milano. The course “Laboratory of Aided Design” is held at 6<sup>th</sup> semester.

The objective of the course is to introducing the students to the fundamental methods of mechanical design, by using the most important instruments.

The course has few students (about 30) in relation to the number of students in corresponding courses of Milan.



Fig. 1 Authors,  
go kart

students and

## 2. Objective of the course

The objective of each technical communication (and a university course is an example of technical communication) could be formalized in terms of “terminal behaviour”, i.e. the amount of knowledges to be reached by the students, which are starting from some prerequisites, that could be called “initial behaviour” .

Such initial behaviour can be assumed, in first approximation, as the terminal behaviour of the first course(Machine Design): ability to express the function performed by a simple machine with an assembly drawing; then, the ability to express all the constructive information (forms, dimensions, materials, tolerances) of all parts of the machine with constructive drawings. The above described abilities must be expressed with freehand sketches and with 3D Modeller Autodesk Inventor.

The “terminal behaviour” could be assumed as follows.

The designer:

1. starting from the assigned function and requirements(if necessary, correctly formalized) of the product;
2. using methods(such as Theory of Technical Systems, TRIZ, Design for X, evaluation criteria, representation and calculation methods, updating ability) and means(such as computer(HW/SW), materials, technological processes, components, standards, cooperation among colleagues, technical documentation);
3. determines all the information(such as forms, dimensions, materials, tolerances)necessary to realize an industrial product;
4. develop and analyse in the optimal way the requirements of a good behaviour of the product in all phases of its life cycle, take into account the “external properties” which characterize it( such as assembly, packaging, transportation, performances, maintenance, reliability, safety, environment).

The authors aim is the simulation of a technical office, with the constitution of some “working groups” independent, but in cooperation, each of them is working about a mechanical group of the general machine.

Other aims are the application of methodic design theories and the use of traditional, but very important, instruments, as, e.g., freehand sketches and measuring instruments, as micrometer.

## 3. Communication methods and means

The considered machine was a go-kart: the real machine(courtesy of HAASE) was in the room during the months corresponding to the course.

The steps of the work is in the table 1

Table 1

<b>Object</b>	<b>Instruments</b>	<b>Operations</b>
Real go-kart	Methodic design theories	General function
Disassembling of the machine in mechanical groups	Methodic design theories Disassembling devices	General function analysis and component functions individuation
Measuring, machinery survey	Measuring devices(as micrometer) Freehand sketches devices	Freehand sketches and dimensions of all parts of the mechanical group
Modelling	3D-Modeller(Autodesk Inventor)	3D-Models of all parts of the mechanical group
Virtual assembling of the mechanical groups	3D-Modeller(Autodesk Inventor)	Congruence verifying
Simulation	FEM Software	FEM-Analysis of some parts and proposal of variations
Virtual assembling of the go-kart	3D-Modeller (Autodesk Inventor)	Virtual prototype
Real assembling of the go-kart	Assembling devices	Real machine Verifying of correct assembling

#### 4. Steps of the course

a) real go kart (fig. 2)

The real go-kart was carefully considered and studied. Some theoretic lessons about automotive engineering (strictly correlated to the go-kart) were held. By using the methodic design theories, the general function of the go-kart was individuated.



Fig. 2 Real go

kart

b) disassembling of the machine in mechanical groups (fig. 3)

The mechanical groups of the machine (recognized in the step 4.1) was disassembled, by using disassembling devices. The general function was analyzed in component functions and each of them was linked to the corresponding mechanical group.

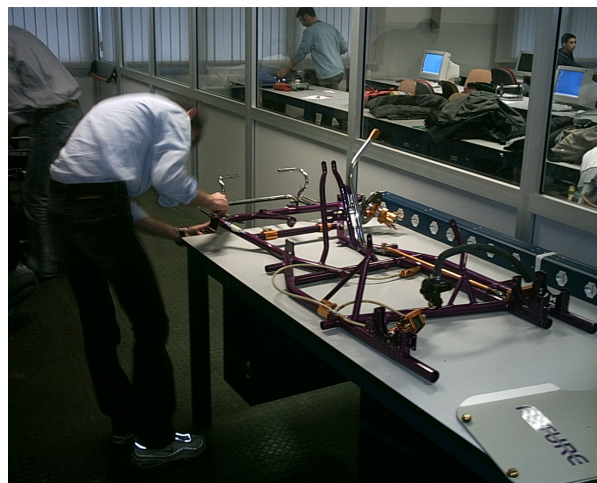


Fig. 3 Disassembling of the go kart

c) measuring and machinery survey

Each students group has studied a specific mechanical group of the go-kart.

The first step of the study is the freehand sketches of all parts of the group, included the fundamental dimensions, deducted by direct measurement with micrometer (fig. 4).

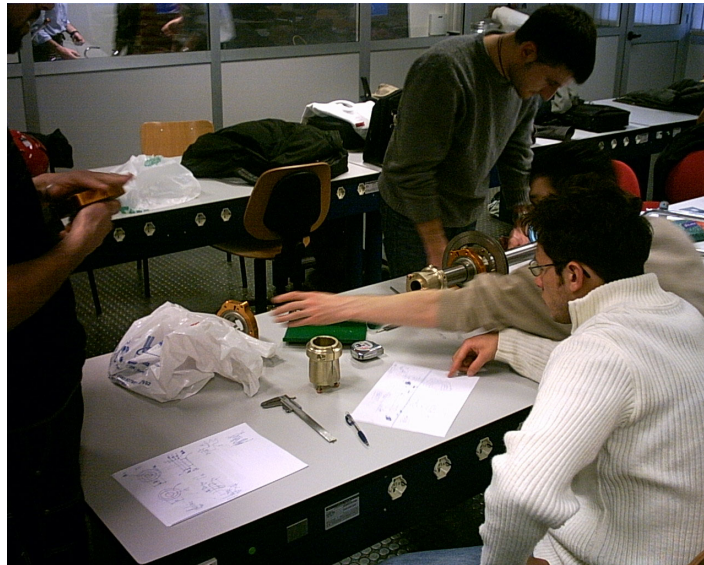


Fig. 4 Sketching and measuring

d) modelling

Each group of students, starting from freehand sketches, has realized the modelling of all parts of the mechanical group. Such operations was realized by using the 3D-Modeller **Autodesk Inventor** (fig. 5, 6).

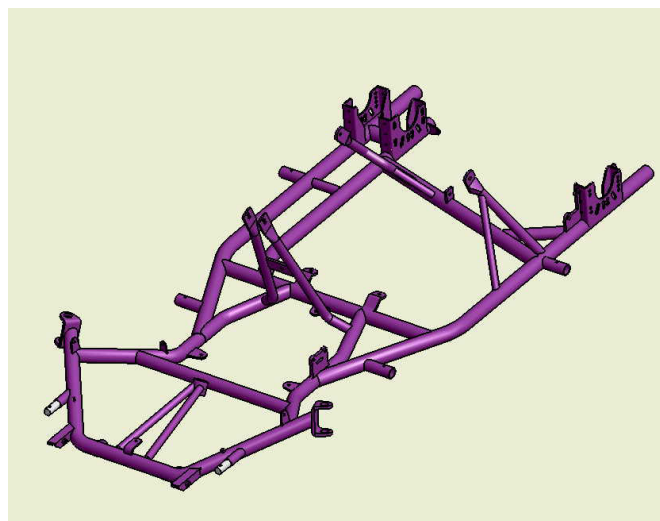


Fig. 5 3D Model

e) virtual prototyping

In this step, the models of all parts of the mechanical group are assembled, with the aim to reach a virtual prototype of the specific mechanical group.

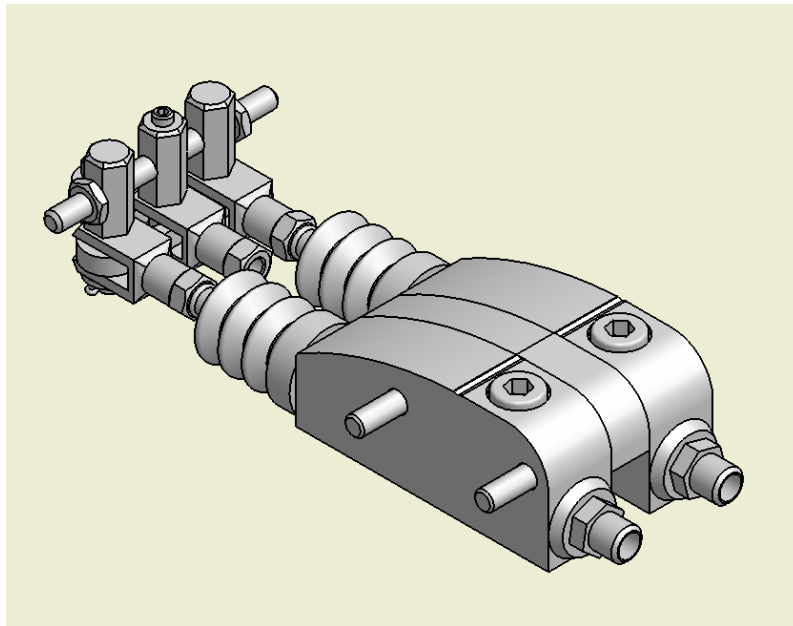


Fig. 6 Virtual mechanical group

prototype of

f) simulation

In this step, starting from the virtual prototype of the mechanical group, a CAE approach was made, by using the FEM Module included in the Autodesk Inventor, with the aim to reach a stress and strain analysis of some significant parts of the assembly.

After critical considerations of stress and strain levels, some proposal of variations was made.

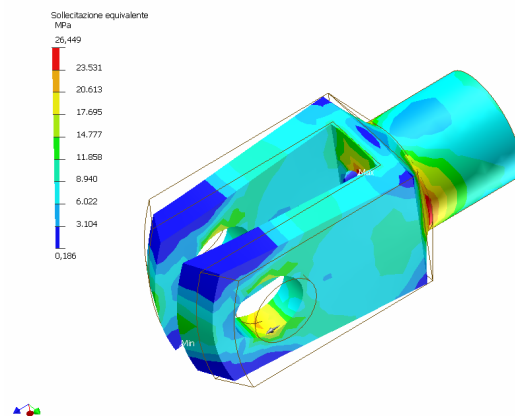


Fig. 7 FEM approach



g) virtual assembling of the go kart

By using the same 3D Modeller Autodesk Inventor, the students realizes the virtual assembly of all mechanical groups , i.e. the virtual prototype of the complete go-kart. Of course, in this steps, all necessary modifications was made, to reach the congruence of all parts and dimensions.

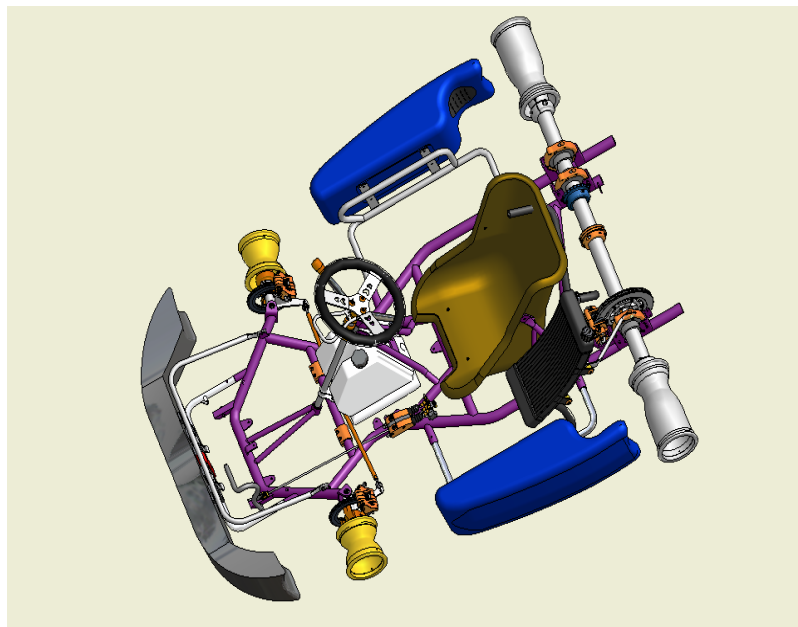


Fig. 8 Virtual prototype of the complete machine

h) real assembling of the go kart

In this least step of the course, the students, by using mechanical assembling devices, realizes the real assembling of the o-kart.

The output of this step is the real machine, in the same initial conditions.

The correct functioning of the go-kart was verified.

## 5. Conclusions

The experiment could be considered very successful. The student have worked with enthusiasmus and good results.

In the figure, the virtual prototype of the go-kart.

Very important is the “real” exercise too: the students have really worked about the machine, with mechanical devices and have learnt many mechanical operations, that can be considered important for an engineer too.

The amount of knowledges reached by the students regards, in this way, many field very important for a mechanical engineer, such as functional analysis, study of real machine and mechanical operations about such machine, freehand sketching, mechanical measurement of dimensions of parts, use of 3D-Modeler.

The assumed terminal behaviour can, in this way, be considered in very good measure reached.

The authors, starting from this experience, has in program to continuing this way of teaching, by applying some corrections and with other types of machines.

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