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SOME CONSIDERATIONS ABOUT DESIGN EDUCATION

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1. Introduction

Design Science has a great importance in Engineering Education, from the formative and informative point of view.

The systematic way of proceeding, which is based on factorising the systems in functions and sub functions, which can be controlled, and eventually modified, until a well defined concept is reached (or a few alternatives) can be seen as a "funnel" (figure 1): in fact, after this stage, it is possible to move to the embodiment phase, and then to the production phase.

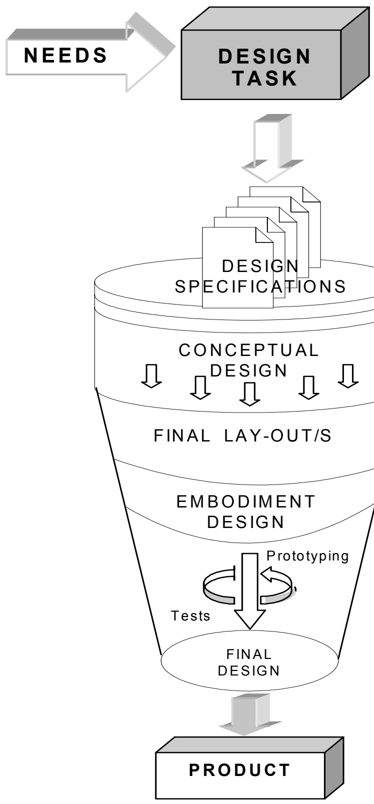


Figure 1. A scheme of the methodical design approach

Even though following such an approach might seem a time consuming activity, it actually represents a very powerful tool which makes the occurrence of mistakes or the pursuance of wrong solutions difficult, as well as being able to generate a great number of ideas, significant by increasing the occurrence of “good ideas”. On the other hand, the most widespread industrial approach to solving design problems, mainly because of lack of knowledge and market pressure, can be considered as a double funnel, in which the starting point is already constituted by one or a few product schemes.

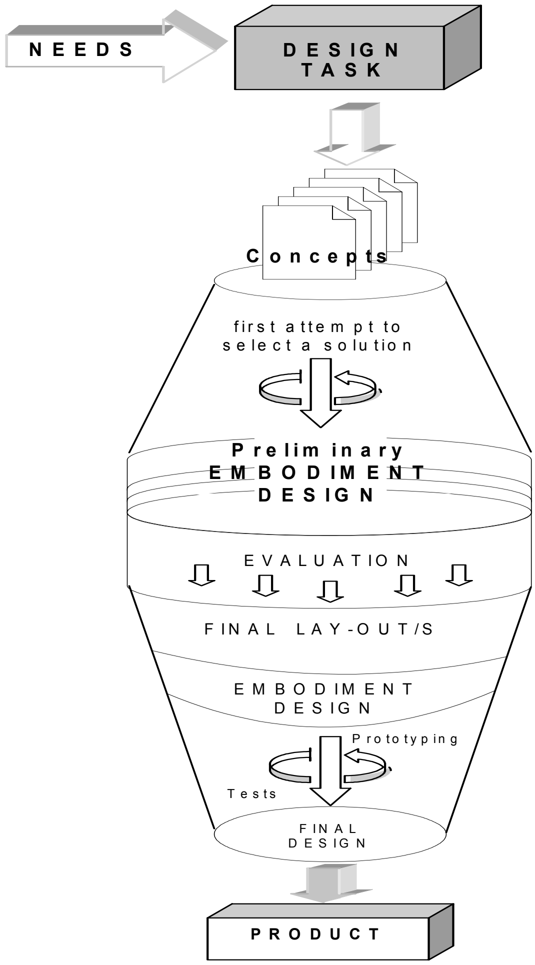


Figure 2. “Traditional” Design approach scheme

Such an approach greatly influences the way of thinking of industrial designers and engineers, making the distance from the academic approach very large.

Moreover, it is to underline that industrial simulation is difficult to run in academic settings because teachers may have economic difficulties (it is indeed true in the Italian case) as well as having little awareness of industrial reality.

The aim of the research work carried out is to build up a national interwoven group of design teachers in order to promote design education during the whole cycle of academic studies, from undergraduate courses to the courses dedicated to graduate engineers, i.e. spreading design experiences across all years of study, implementing specific courses not isolated from one other as well as providing a point of reference for those who are already involved in the industrial world, reducing the distance between the academic “way of thinking” and the industrial one.

2. Evolution of the Engineering Design Knowledge

As shown by many authors in the field (among all Hubka, Eder, Andreasen, Busby, Roozenburg Pighini, Ulrich, Eppinger), modern engineers have to acquire more and more widespread information and knowledge which concern not only the traditional topics (i.e. Mechanics, Physics, etc.) but also regard different fields, such as marketing, economics, psychology, law and so on.

Furthermore, the development of software and computer facilities brings people more and more to informatic studies; but, even though the knowledge of such tools allow us to reduce time and consumption of "resources" in many activities (i.e. calculation), on the other hand it also carries the risk of belittling designers "natural" skills, for instance:

- the tendency to follow "short cuts" in finding solutions and problems solving, instead of proceeding in a systematic and iterative way;
- the lack of knowledge about engineers language and rules, which makes the designers "weak" in facing problems in different contexts from the ones they are used to operating in.

It is clear that in such a context there is a need for a deeper education in the Design field, which makes students able to understand both prescriptive and descriptive rules of design language, in order to increase their creativity and skill in problem solving.

It can therefore be said that a continual improvement of the learning process, which provides an adequate training and understanding of what to do and why, is required.

3. Methodology

The first step in the design education is the determination of the objectives: in general, the objective of each education action is the behaviour of the user (students) after such action, i.e. the "terminal behaviour". The terminal behaviour can be analysed in "concepts": an "education unit" can transmit each concept. Such a unit shall be constituted by an informative, a critical and an applicative part.

In particular, the approach followed by the Authors, consisting in simulating the design for the development of industrial products following the principles of the Methodical Design approach: the aim is both to facilitate learning from problems which designers have to face in the real industrial world, and mainly to provide students (designers "in fieri") with several guidelines which can be applied in numerous different job situations, even though not properly as designers (as shown from the experience of many ex-students).

3.1 Terminal Behaviour

In particular, the terminal behaviour of the designer 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, 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. determining all the information (such as forms, dimensions, materials, tolerances) necessary to realize an industrial product;
4. developing and analysing in the optimal way the requirements of a good behaviour of the product in all phases of its life cycle, taking into account the "external properties" which characterize it (such as assembly, packaging, transportation, performances, maintenance, reliability, safety, environment).

Such terminal behaviour can be distributed in many study degrees, such as undergraduate, master and PhD degree.

3.2 Formation Methods

The following steps could constitute the formation process:

1. Terminal behaviour analysis, with the aim of enlightening all the concepts to be transmitted;
2. Teaching unit, i.e. the part of information devoted to the transmission of each concept. Such a teaching unit should be constituted by the following elements:
3. informative/critical part ("RUL"), such as traditional lectures, reading, specific seminars;
    - critical/practical part ("EG"), such as exercises, simulations, case methods, role playing, work experience.

4. The formation updating is very important, i.e. the Continuous Design Education (CDE). The aim of CDE is to maintain the required terminal behaviour in the professional life of the designer. The CDE can be of two fundamental types:
    - autodidactic, i.e. personal and autonomous activity of the designer, such as newspaper and books reading, conferences;
    - ethero-didactic, i.e. institutionalised courses.

4. Applications

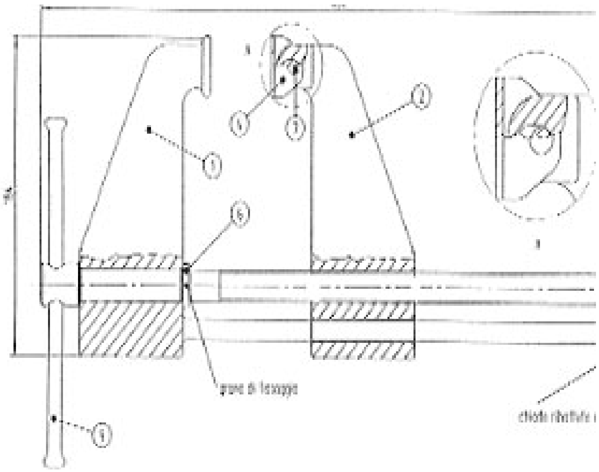
The design education has a great importance from the formative point of view also. It is important to teach the design not only to the designers, but also to all industrial engineers. A good didactic "design" of the design courses is necessary.

4.1 Design Education in Milan

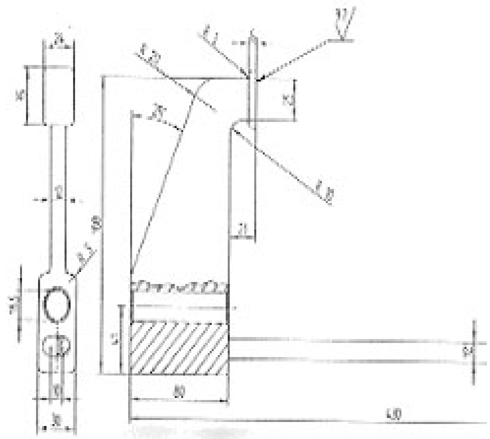
At the Polytechnic of Milan, some "design education" exercises were done through the following steps:

1. function (e.g. "press two wood sheets for gluing");
2. principles/constructive solutions;
3. assembly drawings, with all functional information;
4. constructive drawings, with all information necessary for manufacturing.

In figure 3 examples related to the steps 2.), 3.) and 4.) for the above mentioned function are shown.



2. constructive solution



3. assembly drawing

4. constructive drawing

Figure 3. Student applications at the Polytechnic of Milan

4.2 Design Education in Rome

Since 1995-1996 a specific course completely dedicated to the matter of Design Science has been held at the University of Rome "La Sapienza". The course topics are based on the methodical design theory [Hubka & Eder, 1988; Pighini, 1994] and provide the analysis of Strategic and Tactical Design Tools, as well as several seminars held by international and national experts and researchers.

In the ambit of the course students are required to carry out a project that consists of designing a mechanical system following the rules of Methodical Design and using the most common design tools, depending on the specific task assigned (in figure 4 and 5 some examples of students applications are shown). Recently, the Design Science principles have also been introduced in higher level education, in the ambit of courses for graduate and working people.

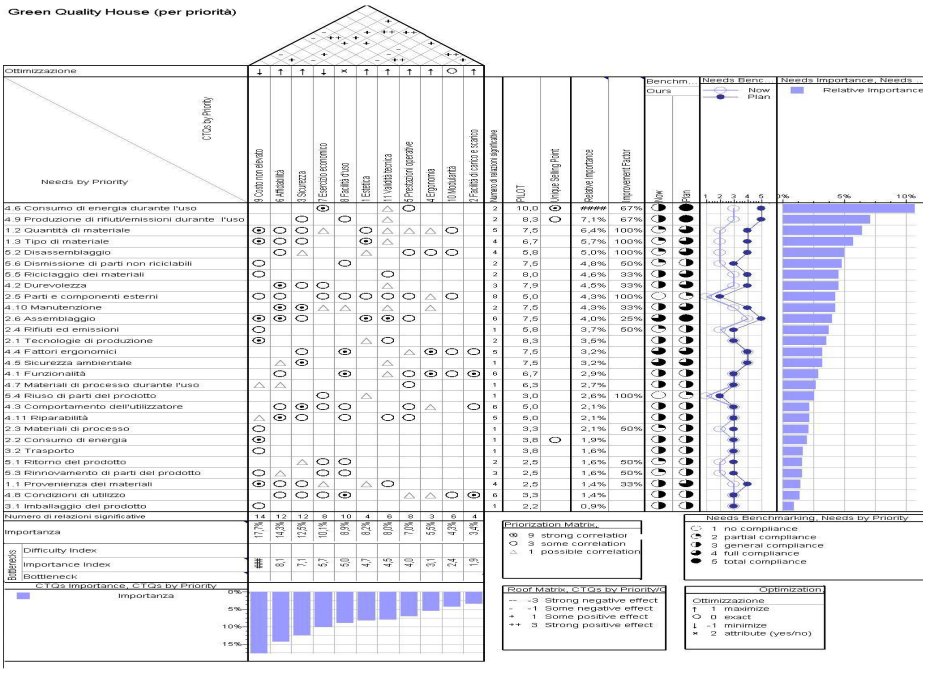


Figure 4. Student applications: Quality Function Deployment

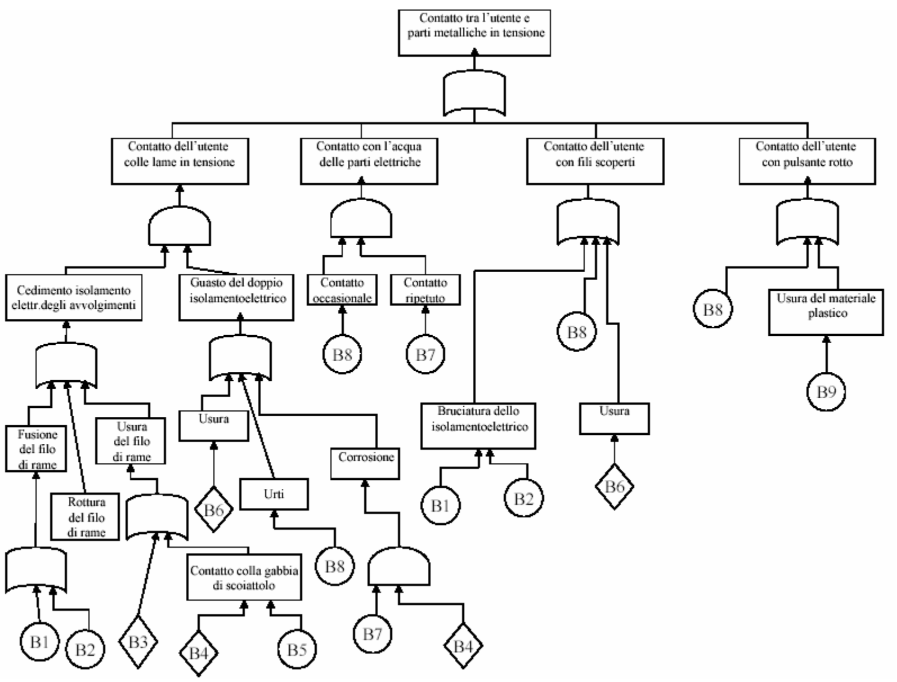


Figure 5. Student applications: Fault Tree Analysis

4.3 Results

Results obtained in the last years have demonstrated the following advantages:

- creativity improvement(the students have found a great number of innovative principles and constructive solutions: of course, not all are industrially feasible)
- expression synthesis of all functional and constructive information.

5. Conclusions

On the basis of the great attention paid by companies' research centres and public bodies' research departments to Design Science in recent years, it is becoming a fundamental topic both in university and in post graduated courses. In Table 1 the schedule of courses dedicated to Design at Polytechnic of Milan is listed. The research work carried out, based on the experiences made both at the University of Rome "La Sapienza" and at the Polytechnic of Milan, highlighted the following topics as further developments in the field of the Design Education:

- the idea of a possible "terminal behaviour" of the designer;
- the distribution of the contents corresponding to such terminal behaviour in two or more courses in the engineering curriculum;
- the importance of updating such terminal behaviour by the Continuing Design Education.

Table 1. Courses dedicated to Design at Polytechnic of Milan

Location	Course	Contents
2^{nd} or 4th semester	Machine Design	-fundamentals of design methodology -representation and modelling -machine elements
6^{th} semester	Methodical Design	-complements of design methodology -complements of modelling (RE, RP, RV) -application to complex mechanisms
CDE	Design Methodology for professional designers	-updating of product development and evaluation -updating of DfX theory -solution to given design problems

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