USING NET-SOFTWARE IN DESIGN EDUCATION

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ABSTRACT

In the early stages of the design process three major activities are involved: designing the concept, resolving the observed critical aspects and modifying the concept as a result of the previous step. This is a circular and iterative process until the final concept is ready for the detailed design phase. It is the purpose of every design method to minimize the total design time and produce well elaborated design concepts. The use of specialized software is of invaluable help in this attempt to reduce design time.

A lot of different software is available on the Internet as downloadable freeware, shareware or demo versions. Most of this software has reduced capabilities; however, many software is excellent for educational purposes. We will call this software "Internet Software" or "net-software". In this presentation two topics with respect to net-software will be discussed:

1. criteria for choosing net-software for educational purposes, and
2. the implementation of net-software in the new bachelor-master curriculum at the Higher Institute of Integrated Product Development (HIIPO) in Antwerp.

A major activity in designing products is the early verification of the product concept with respect to structural, thermal and geometrical integrity. This typical verification net-software can be found in different flavours: for different applications, in different levels and with different user interfaces. Finding easy-to-use and efficient net-software is a rather straightforward task, integrating the software in the curriculum is a more difficult task. The implementation of verification net-software will be explained "in extenso" during the presentation. Two different levels of integration are discussed: basic verification for the bachelor degree and advanced verification for the master degree. It will be shown that the former approach can almost completely be reversed by using net-software from the early beginning of the course. This new way of teaching is completely different from the traditional way where first an extensive theoretical background is taught, supported by exercise sessions after an initial period of several weeks. In the new approach students are confronted with typical problems from the beginning of the course. They like the efficient way of treating real-life problems and the visual way of looking at the solutions. Theoretical background is now given along the course sessions as an answer to the questions evolving from the practical problems.

Keywords: design education, verification techniques, FEM, electronic design

1   INTRODUCTION

Courses at Design Institutes in all European countries are always related to the following fields: applied sciences, economical sciences, human sciences, visual communication techniques and design sciences (e.g. design methodology). It is clear

that in many institutes the courses in applied sciences are the most difficult to assimilate for the students. Many students have followed their secondary education at art schools.

Thermal and structural verification are examples of courses that are perceived as abstract and difficult. Their importance in the design of many products is crucial however. In engineering studies these courses are treated on a theoretical level. Many analytical formulas are produced and empirical data are discussed. The practical use of these formulas is very restricted however. If the structure or the product has too many constraints with respect to the number of degrees of freedom, the problem becomes even more complicated. Only a very limited number of practical cases can be solved. Teaching the same course for designers is useless. Designers are not interested in solving difficult theoretical problems. They do want practical guidelines for their design. Technical designers feel a constant pressure to release new products earlier and earlier. The usual design specifications, stronger, quicker, lighter and cheaper have become routine specifications. Also the need to reduce the number of prototypes has become standard procedure. For that reason early verification techniques are necessary. The questions that have to be solved as soon as possible during the design process are:

- will the design work as expected
- will the structural integrity be preserved during the life cycle of the product
- is there a way to improve product ideas
- how can we minimize material cost and tooling expenses by investigating the structural properties.

One could ask structural engineers to make the necessary calculations. Although this is mandatory for a number of products, we believe that designers can solve many of the problems and should also be taught how to do so. They should be able to solve critical aspects of the product design in the early stages of the design process.

Another difficult topic at design institutes are the courses in electronics and software. Now that products are becoming more and more smart, intelligent and based on microcontrollers, the electronic and software aspects of products become very dominant. Electronics and software courses can be very diverse: fundamentals of electric and magnetic fields, analogue and digital electronics, sensors, actuators (electrical motors and solenoids), microcontrollers, wireless communication, real time systems, software design, user requirement documents, graphical user interface, programming languages, ... The big question is: how deep should the responsible lecturer enter into the different courses so that students can be a member of a design team for smart products.

2   INTEGRATED APPROACH FOR STRUCTURAL VERIFICATION

At the Higher Institute of Integrated Product Development in Antwerp an integrated approach has been taken to educate designers in applied sciences. It is clear that a theoretical background is necessary in order to understand the use of the FEM-method for structural, thermal and geometrical verification. It is also clear that the fundamentals of physics are needed in order to understand electric phenomena. We have chosen to teach an extended course in the fundamentals of physics in the first two bachelor years. In this course only those parts relevant for other applied sciences courses have been retained. Much attention is given to the chapters about "statics and dynamics of rigid bodies" and this by using vector algebra. A thorough knowledge of vector algebra is important for other courses too (e.g. geometrical principles of CAD-software).

Also the principles of energy are thoroughly studied because these principles are crucial for the understanding of structural FEM-methods. The scheme used for the bachelor

years is shown on the first figure. One can see that the notion of energy is important in all of the third year courses.
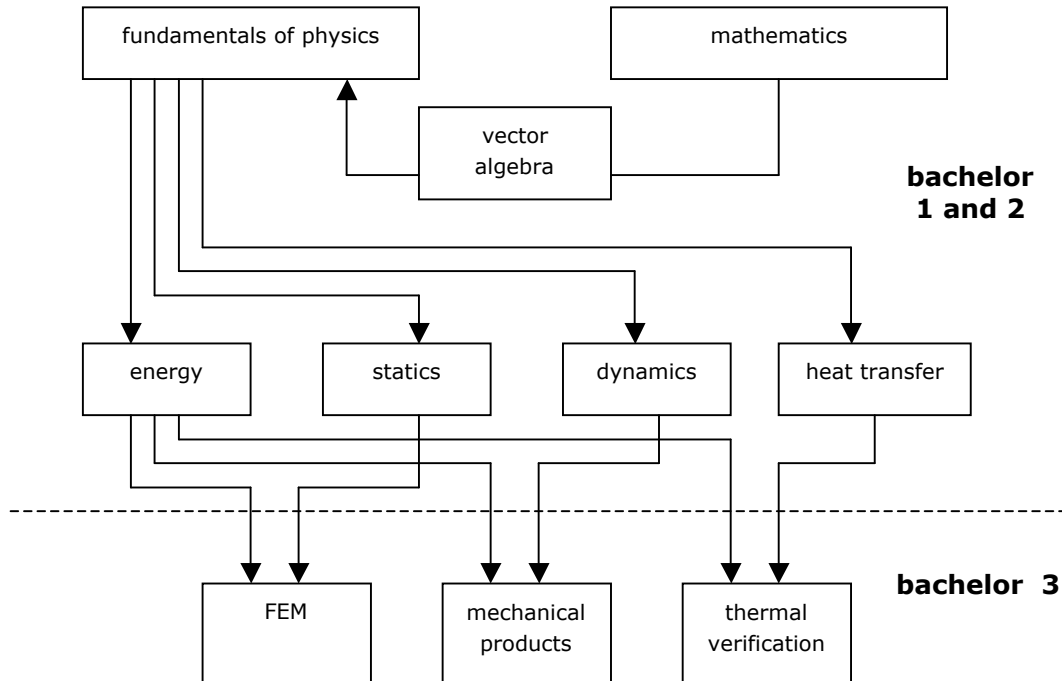

Figure 1. Verification techniques

3   EXAMPLE OF STRUCTURAL VERIFICATION NET-SOFTWARE

Different net-software can be compared using a trade-off procedure. A number of criteria are chosen and are given a weight factor. The individual net-software is then evaluated using the 3- 6-9 principle. Following criteria have been evaluated:

- implementation of the FEM flow in the software
- consistent and stable software
- consistent user interface
- separated functional parts
- number of used elements
- visualisation of obtained results
- input/output possibilities
- possibility for different analyses (especially for the verification of frames and trusses)
- available information about the hardware and the operating system

We have chosen "AxisVM" as the reference software for the bachelor degree. This software is available on the Internet as a demo version. The demo version is as powerful as the commercial version but the number of elements is restricted. It is the ideal software for designers as the software is very strong in calculating frames and trusses. The theoretical background of structural analysis (axial deformation, bending, moments of inertia, buckling ...) can be easily explained by using the software in the class room.

If the software is trained by designing typical frame structures (bicycle frame, metal lamp holder ...) students can benefit immediately from the software and use the software in the design projects.

The lessons are based on the following scheme:

- PowerPoint presentation showing the results of FEM calculations of different products and vehicles (the hull of ships, airplane bodies and car parts are very successful examples)
- presenting a demo of the software and an overview of the possibilities (explaining the different definitions)
- the material database is shown and explained (referring to the stress – strain diagram)
- in the following lessons, the different topics of the theoretical course "strength of materials" are explained (tension and compression, pure bending, torsion, etc…). These topics are illustrated by using the software and the theoretical background is given after the software demonstration.
- in each lesson the GUI of the software is explained and new tips are presented
- the main purpose of using the FEM is illustrated in each lesson: verification of the product performance by using a model. How to make an adequate model is the most important step in using a FEM.
- at the end of the course more difficult problems are solved.
- the students are now invited to solve a problem on their own (examples of the past are: a bicycle frame, the frame of a small lorry, …)

The major conclusion of this way of teaching is that full emphasis is put on the making of an adequate model. Using FEM software is only the last step in the verification process. Drawing conclusions out of the results and refining the model is the following step. The quoted steps are normally not sufficiently taught in a "strength of material" course. Using net-software is a possible solution to this pedagogic problem.

We have installed the full version of the software on a number of computers that the students can use if they need the full version. These computers are also used for the full versions of other net-software that we use at the Institute.

For the master degree the Cosmos software is used. This software is an integral part of SolidWorks. If complex three-dimensional structures are drawn in the CAD-software a structural verification can immediately be started. As such Cosmos is the ideal follow-up for AxisVM. If AxisVM is well suited for three-dimensional frames, Cosmos is ideal for three-dimensional solids.

4   INTEGRATED APPROACH FOR ELECTRONIC COURSES

The book "Fundamentals of Physics" (Resnick and Halliday) together with the necessary mathematical background is taken as a basic course for the electronic courses. The focus is on the physical aspects and effects of the electric and magnetic fields. This means that the emphasis is on the use of the electric and magnetic fields in products. The course on sensor technology is a further explanation of the properties of materials and the use of electric and magnetic fields to measure physical properties (resistance, inductance, capacitance ...). Instead of explaining how capacitors and coils are used in electric circuits the potential of a capacitor and a coil as a sensing device is explained.

For a thorough training in circuit theory, another net-software package is used. Many electronic software is available on the Internet. After a trade-off procedure the following net-software packages have been chosen as educational and verification software: CircuitMaker and Proteus.
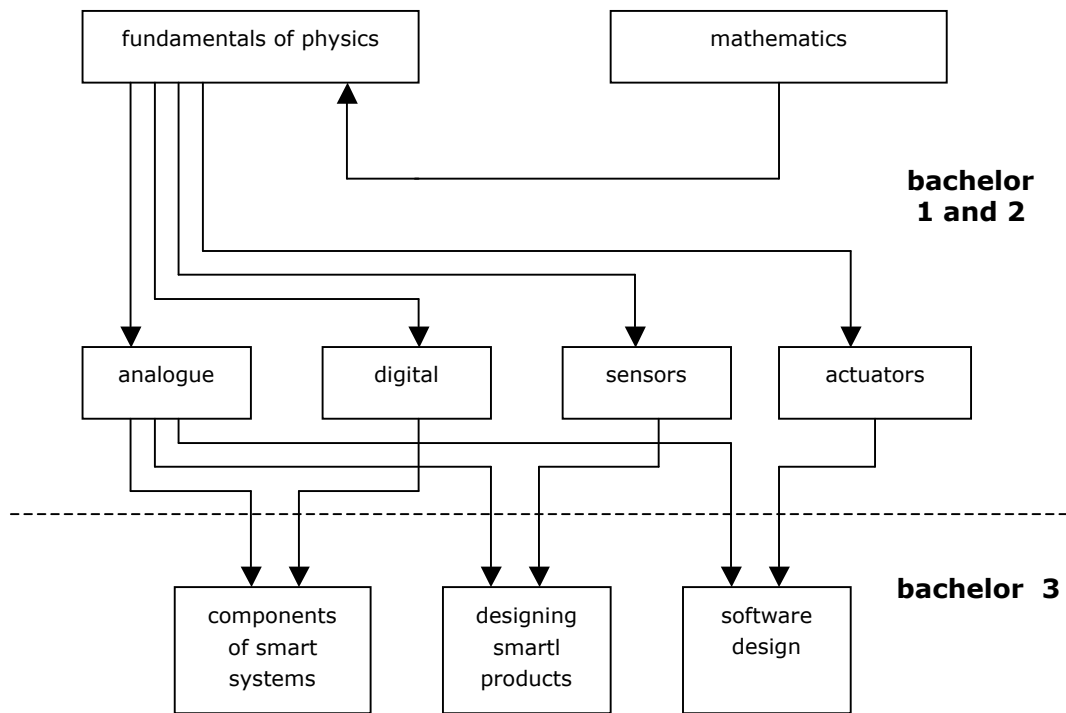
Figure 2. Electronics courses

Circuitmaker is used at many American universities and is very easy to learn. It has many simulation capabilities and is very efficient in the design of both analogue and digital electronics circuits. Voltages and currents are calculated on line and are shown to the user (AC and DC). Students are able to analyse difficult circuits (AC and DC). Many parts of the electronics course can be studied by using the net-software. The demo-software has a few restrictions but these are not relevant to the use as educational software. As a general electronics software Circuitmaker is perfect for the electronics courses in the bachelor years.

Proteus is a very powerful software for two reasons:

- complete circuits can be simulated by using virtual instruments, virtual actuators and output devices
- the ability to program microcontrollers in the circuit (this option is not available in the net-software version).

Because Proteus is more difficult to learn than Circuitmaker we use it only in the master years. Furthermore Proteus is complete software: schematics, simulation and PCB-design (including an efficient auto-router).

5   INTEGRATED APPROACH FOR DESIGN COURSES

In the master years, a new approach has been developed during the last years. In order to provide the students with enough information about components of smart products, all available information has been systematically catalogued in a web based database ("I-ware"-database). The idea of providing information through the Internet has been taken from the approach applied in the research projects. All research projects have their

own website (www.d-sciencelab.com). The software developed to bundle the information on a website has also been used in the electronic components database.

The "I-ware"-database is very essential during the design projects. Students help in completing and renewing the database. They find all necessary background information on the website for their project and the work they do in keeping the website up-to-date is a part of the design project.

6 CONCLUSION

The Internet has thoroughly changed the way design education is organised at the Higher Institute of Integrated Product Development in Antwerp. Not only the chosen software has changed the way designs are verified but also the Internet as a medium has been fully integrated in the design projects. Also the way theoretical courses are organised and the content itself of the courses are examples of the way the Internet is changing educational schemes and the way of teaching.

REFERENCES

[1] AxisVM – www.axisvm.com Professional finite element software for structural analysis.

[2] Cicuitmaker – www.microcode.com Professional Virtual Electronics Lab software, allowing to design, simulate and output printed circuit board designs.

[3] Proteus – www.labcenter.co.uk Professional schematic capture and PCB design software with automatic component placement, track routing and design validation.

[4] SolidWorks – www.solidworks.com 3D mechanical design software, and a full selection of design communication, productivity enhancement, and analysis tools.

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