Software Tools and Simulators in the Education of Engineering of Telecommunications

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Abstract: - The use of software tools and simulators in the education field has a growing interest in most of universities and educational procedures. Nowadays, in university education new technologies are used to improve and complement the theoretical concepts explained in class. In this paper we are going to present the simulation tools most used in Telecommunication Engineering at the Polytechnic University of Valencia. These programmes are also used in other fields such as in the industry and researching. After presenting the main characteristics of each software tool, a questionary study is included to analyze the benefits and drawbacks of each tool from the point of view of the student, its complexity and advantages for educational purposes.

Key-Words: Education software tools, simulators, university teaching.

1 Introduction

Nowadays there are many subjects in the university education. There are also several types of activities (practices, proposed exercises, complementary activities, multimedia exercises, etc.) to improve and consolidate the concepts that are explained in the classroom [1].

These teaching methodologies are different to the theoretical classes. With these activities the students enhances other required skills in the world of work. For example: team work, the resolution of problems, the communication between students, the handling of instruments, etc.

There are lots of fields where these educational practical methods can be used to make the students to use tools and make tests about specific subjects. Nevertheless, in other fields, such as in computer networks, microwave devices, photonic devices, these practical exercises can be very sophisticated. For these reasons, it is necessary the handling of software tools to carry out certain tasks and able to study the latest developments in these areas.

Many of the tools used in the university teaching then are used in the work. In education, software tools and simulators are not so much extended, but the utilization grade increases in research and industrial environments.

We can see the importance of the introduction of software tools and simulators in the education at Universities. It is necessary to form best professionals and that they are able to use different tools to improve their productivity.

In this paper we are going to present the most used software tools in the Telecommunications Engineering degree of the Polytechnic University of Valencia. Then, we are doing a comprehensive study about the benefits that educational software. Finally, we will evaluate the exposed tools and if they bring improvements at the time of acquiring greater knowledge.

The paper is divided into 6 sections. Section 2 presents the state of the art of different studies about software and simulators in education. In Sections 3 the main characteristics of software tools are presented. A questionary study relative to educational technical software is presented in Section 4. In section 5, there are the results of our study. Finally the paper ends in section 6 with the conclusions.

2 Related Works

In this section, we present several works where we can see the use of software tools and simulators in education.

E.g., in [2] we can see a study of two networks simulators used to teach in Computer Networks subjects. This study examines the main features of these simulators and then discusses the advantages and disadvantages of each simulator from the point of view of the student and teacher.

On the other hand, you can also read in [3] about software tools applied to education: There, we presented a set of multimedia activities carried out with Flash [4]. These activities reinforce learned skills by pupils in each chapter. Finally, this paper

indicates the degree of satisfaction that has the pupils to perform these tasks.

In [5] Jason Taylor explains the use of a photonic simulation software tool for education. This paper examines the role that the software simulation tools plays in the education of students studying optical communication and related disciplines. The different techniques to employ photonic simulation software in classroom lectures, computer labs and graduate research are discussed.

In the case of mathematics, it is also required the use of software tools for improving the exposed concepts in the classroom. In [6], there are two software tools used in the logic education. A tool is focused for first year students and helps them to understand the basic concepts of logic in an interactive way using sematic tableaux. The other is oriented to a more advanced level, serves for understanding the link between the properties of the accessibility relation and the modal formulas.

Finally, there are also tools in medicine and in chemical engineering. E.g. in [7] we can observe the development of three software tools used for both, education and research, in chemical engineering. These tools have the functionality of a telelaboratory. A very important feature is its management through a web interface, which makes a simple GUI (Graphical User Interface).

3 Software Tools in Telecommunications Engineering

In this section we present the main software tools that are used in the Technical school of Telecommunications of the Polytechnic University of Valencia.

The subjects of the degree are divided into several areas. For this reason, we wanted to present the most important tool of each area. The relationship between the areas and the software applications that will be explained in the following subsections are the next ones:

1. Signal processing → Matlab & Simulink [8].
2. Signal transmission → Microwave Office [9].
3. Telematic → Opnet IT Guru [10].
4. Optical communications → VPI Photonics [11].
5. Electronics → Quartus II [12].

3.1 Matlab & Simulink

Matlab is a high performance language for technical calculation. The software integrates calculation, viewing and programming on a user-friendly environment where the problems and solutions are expressed in a formal mathematical notation.

Although Matlab has a user-friendly GUI interface, its operation is done through commands. Therefore, the user should know many commands and the syntax of the programming language for a proper operation.

The most typical uses of this application are: a) mathematical calculations, b) development of algorithms, c) modelling, simulation and prototypes, d) scientific and engineering graphs, etc.

Simulink is an interactive environment to shape a wide variety of dynamic systems. This software lets you make block diagrams with operations click-and-drag, change parameters of the model and display results during a simulation. It is also an open system, which allows the user to choose, adapt and create components or subsystems as it is needed.

The simulation can be performed from the menus or from the command line. The results can be seen during the simulation and recorded to a file or transferred to a workspace of Matlab for their analysis or processing.

Simulink is supported by Matlab. Matlab and its group of Toolboxes offer a set of tools of engineering and mathematics to define algorithms, analyse data and display results. Together, Simulink and Matlab, provide an integrated environment.

Finally, Matlab and Simulink operate on MS-Windows, Macintosh platforms, UNIX workstations, and platforms VMS. The programmes and models of Matlab and Simulink can be transferred from a platform to another retaining their features and functionality.

3.2 Microwave Office

One of the most popular microwave software environments, in both academia and industry, is AWR Microwave Office.

MWO is the linear and nonlinear solution for microwave hybrid, module and monolithic microwave integrated circuit (MMIC) design. It includes linear, harmonic-balance, timedomain, electromagnetic simulation, and physical layout. It includes linear and nonlinear noise analysis. MWO is, essentially, a frequency domain simulator.

Electromagnetic simulation is not based on the full-wave analysis (3D solver), but relies on a so called 2.5D solver that is suitable for layered structures, such as microstrip filters and antennas. It has predefined objects, such as rectangle, polygon, path, ellipse, drill hole, edge port, via, and so on. The 2.5D solver has only automatic meshing (subdividing the structure into smaller parts for better accuracy) in three levels.

MWO can generate a layout view from the schematic. The layout view represents the structure

that can be analyzed by the 2.5D EM solver. This is important for microwave structures when the circuit model does not take into account mutual couplings, parasitics, and discontinuities.

The layout view has many properties and options, so it might be over-sophisticated for introductory microwave courses. MWO cannot optimize physical structures, but it has a powerful optimizer for circuit model parameters.

Manual optimization, also called as tuning, is provided, so parameter values can be changed interactively while observing the resulting response. This feature is one of the most preferred features in research and industry.

MWO comes with a very useful transmission-line calculator TXLINE that can analyze or synthesize various lines, such as microstrip, stripline or coaxial.

3.3 Opnet IT Guru

OPNET IT Guru offers a virtual environment for networking. This software is able to shape the behaviour of many types of networks. Opnet IT Guru includes the elements that form the network such as routers, switches, hubs, protocols, etc., until the applications that run in the connected workstations.

This working environment is very useful for the responsible of the computer and I+D departments, network designers, operators and maintenance personnel of the network. This tool allows diagnosing problems efficiently, validate additions or changes in infrastructure before taking them out and predict the behaviour of the network.

The ACE (Application Characterization Environment) module of OPNET allows evaluating the benefits of the network. Moreover, this module resolves the potential problems efficiently and with low cost. A user can analyze hypothetical scenarios of network by means of several parameters (delays, productivity, etc.). He can make different configurations of the network scenario (number of stations, types of switches/routers, topology of interconnection, traffic generated, etc.) easily with GUI.

The OPNET simulator has a user-friendly GUI interface. For this reason, it is easier to learn through this kind of tools. In other simulators we must use commands or scripts and it is more difficult.

Finally OPNET has different software versions for the several operating systems (Windows, Unix, and Macintosh).

3.4 VPI photonics

VPIphotonics sets the standard for software and services supporting end-to-end photonic design automation. VPIphotonics is a division of VPIsystems, the leading provider of network resource planning software and services for the global telecommunications industry.

VPI includes several products and tools: VPI link Configurator, VPI transmission Maker, VPI component Maker and VPI player.

The most powerful tool is VPI transmission Maker that can fully verify link designs. This is used to identify further cost savings or investigate novel technologies. Links can be automatically imported from VPI link Configurator for detailed design and optimization. VPI transmission Maker is used to evaluate novel components and subsystems designs in a systems context, investigate and optimize systems technologies (e.g coding, modulation, monitoring, compensation and regeneration).

VPIplayer tool is also interesting from the point of view of educational targets. This player is a photonic simulation engine that runs a ready-made dynamic data sheet. It allows exchanging ideas with people who don't have access to professional design software. It is freeware, but it is limited only to run simulations predefined by the professors. The data sheet cannot be changed using the player. It's used in some universities.

VPI includes: interactive Simulation, design-Assistants, simulation scripting, data import with automatic file format conversion and MATLAB/DLL/Python co-simulation streamline and capture design processes. Technical marketing is supported, by providing a dynamic environment to design, evaluate, demonstrate and compare the technical and cost of solutions.

3.5 Quartus II

The Altera Quartus II design software is a comprehensive environment available for system-on-a-programmable-chip (SOPC) design. This design software delivers the highest productivity and performance for FPGAs, CPLDs, and structured ASICs and offers numerous design features to accelerate the design process:

- Incremental compilation to reduce the design cycle time.
- SOPC Builder for system-level design.
- MegaWizard Plug-In Manager to quickly and easily integrate a broad portfolio of intellectual property cores.
- Power analysis tools to meet stringent power requirements.
- Memory compiler function to easily use embedded memory.

The Quartus II software enables us to create and deliver FPGA, CPLD, and structured ASIC designs

with unmatched levels of performance and faster time-to-market.

The Quartus II software supports VHDL and Verilog HDL design entry, graphical-based design entry methods, and integrated system-level design tools. The Quartus II software integrates design, synthesis, place-and-route, and verification into a seamless environment, including interfaces to third-party EDA tools.

Moreover, Quartus II has the Quartus II University Interface Program (QUIP). This QUIP toolkit provides documentation, tutorials, data files, and sample code to enable access to the Quartus II CAD suite at different stages of the CAD flow. The toolkit enables researchers to write point CAD tools that perform one CAD optimization in a new or better way, and integrate their new CAD tool into a complete CAD flow so they can get realistic results on how this new idea improves circuit timing, routability, device utilization, compile time, or other metrics.

4 Questionary

In this section, the method used to evaluate the previous software tools is presented. This analysis will point out the benefits and drawbacks of each software tool from the educational point of view.

We have made a study with 50 students. Some of them are at final courses of the degree and others are already graduated in the Telecommunication Engineering degree of the Polytechnic University of Valencia.

The questions used to evaluate the quality of each software tool are shown in Table 1.

The responses have been patterned using questions with a kind of response closed in evaluation. The interviewee has a scale of increasing intensity, where the 1 indicates very badly and the very good is 5. In questions we get the adequacy degree of the software tools regarding the level of knowledge of the students, the subject contents, degree of utilization, the possibility to work without teacher assistance, etc.

5 Results

The results obtained from the previous study are analysed in this section. We will also present several graphs where the different software tools are compared.

In Fig. 1, we have analysed which software has free student license or an evaluation version. It can be observed that Opnet IT Guru and Quartus II (with its academic version) have obtained a goal of 4 points. On the contrary, the other tools obtained less than 2.5 points.

1	Is it easy to obtain a free-license or academic version of this software?
2	Can be this software used in several operating systems such as Windows, Linux or Mac?
3	How do you mark the graphical user interface?
4	Are there available examples, tutorials and documentation about this software?
5	Is another software needed to run the tool properly?
6	Does the tool allow developing new modules, protocols, etc.?
7	Is this software easy to use the first time?
8	Is this software used very much during the carreer?
9	Has this tool improved your knowledge in the specific field you used it?
10	Is this software used at the enterprise, the industry, research institutes, etc.?

Table 1. Software tools opinion poll.

Fig. 2. is focused on the compatibility of each tool with different operating systems. All of them have results above to 2.5 points. Matlab & Simulink and Opnet IT Guru have greater facilities. Moreover, these software tools have not problem with the exchange of files with different operating systems

In Fig. 3 we can see which simulators are easier to use or have more attractive GUI for the user. All tools had a good qualification. Matlab & Simulink offer the worst result. It is because the Matlab GUI is very basic. It only has a blank screen where the mathematical commands have to be introduced.

In the Fig. 4 we see which tools provide greater number of examples or documentation. In this aspect Matlab & Simulink and VPI Photonics are the software tools that have more tutorials and examples, according to the students. Microwave Office and Quartus II are the worst.

When we analyze if it is needed other software for the proper operation of the tool (see Fig. 5), we get that none of them needs it except the Opnet IT Guru. This tool needs a C compiler for its proper operation.

In Fig.6, the answers of the students about the capability of the software to develop new simulation modules, network protocols, etc. are summarized. In this case, Matlab & Simuling is the best rated tool, followed by VPI Photonics. Quantus II has been the worst one.

How much the simulation tool is easy to use or not, from the student point of view, is reflected in Fig. 7. It can be observed that all the analysed software have a result greater than 3 points. The first place is for Opnet IT Guru, the second one is for Matlab & Simulink.
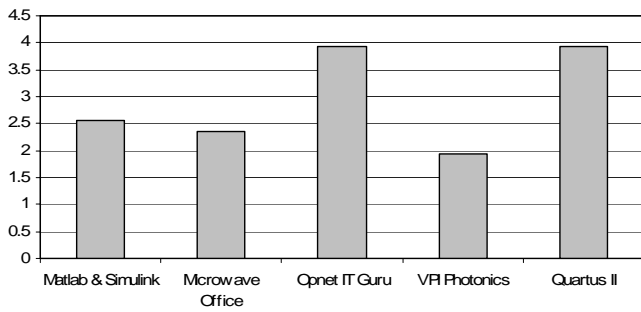
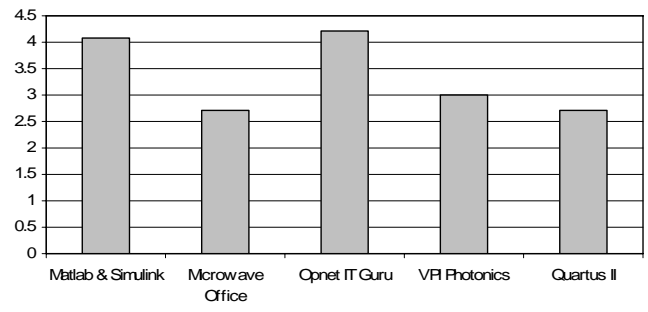Fig. 1. Results for the first question.

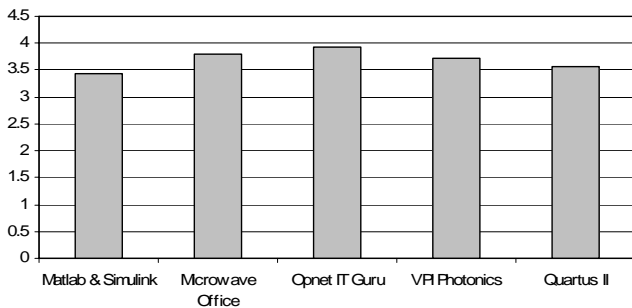Fig. 2. Results for the second question.

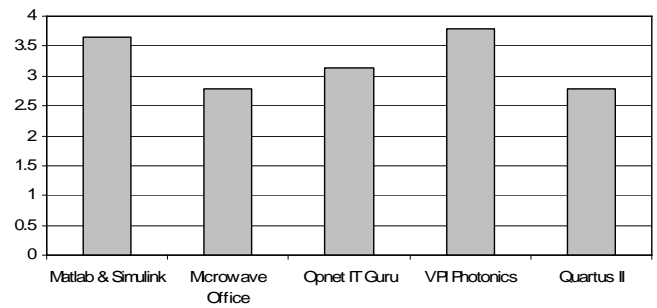Fig. 3. Results for the third question.

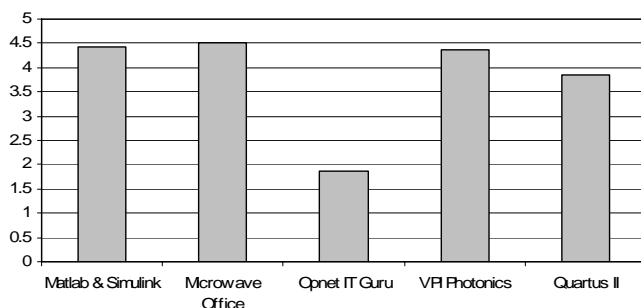Fig. 4. Results for the fourth question.
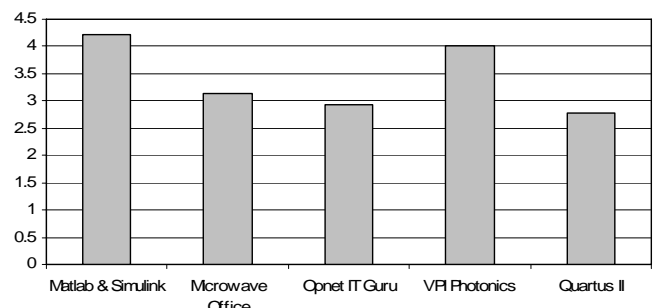

Fig. 5. Results for the fifth question.

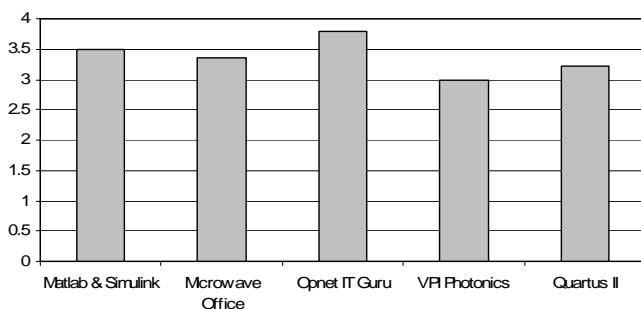Fig. 6. Results for the sixth question.

Fig. 7. Results for the seventh question.

On the other hand, VPI Photonics is the most difficult tool for the student.

In Fig. 8, it is shown how much is used each simulation tool in the analysed technical engineering career. This results point out that Matlab & Simulink is the most used software. This is due to it is a very useful software that can cover several educational fields not only maths, but physics, signal processing, microwaves, antennas, and so on. For this reason, this simulating tool is used in several subjects during the telecommunication career. The ones with less use are

Opnet IT Guru and VPI Photonics. They are only employed in 2 o 3 practical subjects.

The educational benefits contributed by each of these tools to the student is shown in Fig. 9. Matlab & Simulink is the one with higher mark. It could be due to this software is used very often along the career and it helps the student in several fields. VPI Photonics has the worst result as is rarely used.

Finally, in Fig. 10, the use of each simulation software in the industry and research institutes is analyzed. It can be observed that all the tools obtained have more than 3 points. All the presented tools are used at enterprises but the most used is Matlab because it is a generic software that can be applied to several areas such as processing data, obtaining graphs or solving equations.

6 Conclusions

In this paper we have studied and compared several software tools and simulators that are used in several subjects inside Telecommunication engineering carreer. This study and comparative has a global and not technical character.
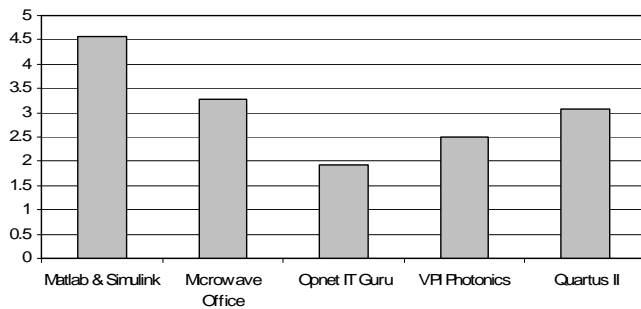
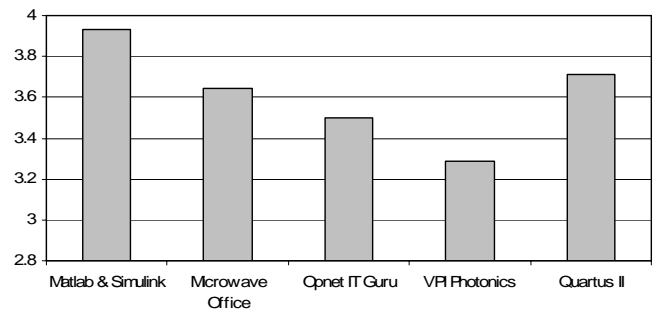Fig. 8. Results for the fourth question.

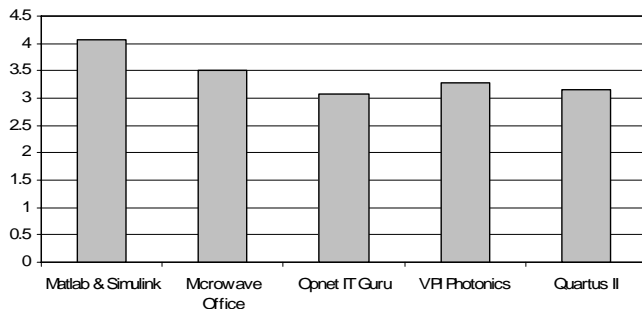Fig. 9. Results for the ninth question.

Fig. 10. Results for the tenth question.

In this study, we have presented the benefits and drawbacks of each software tool from the point of view of the student.

Once these characteristics are shown, lecturers have to choose the most adequate simulation tool for our purposes. The election should involve the most interesting points of this paper.

Finally, the resources offered by new technologies such as simulating tools, involve very positive experiences for students and teachers and contribute to improving the teaching-learning process.

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