New teaching methods for marine engineer university studies

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Abstract: - Nowadays, in conformity with European university studies, the syllabus for marine engineers’ studies in Spain needs realistic software tools for design, maintenance, and operation of equipment. These software tools must consider the limited resources available in a ship. On the other hand, it was found there was need for reducing the time allocated for teaching subjects like applied thermodynamics in accordance with the Bologna declaration. Consequently, the Department of Energy and Marine Propulsion of the University of A Coruña set up a research task to solve this problem. Results showed that new software resources like EES (Engineering Equation Solver) and programming languages like VBA (Visual Basic for Applications) provided the best solution.

Key-Words: - Teaching, method, thermodynamics, numerical methods, marine, university.

1 Introduction
Nowadays, in conformity with European university studies, the syllabus of the marine engineers’ studies in Spain presents the need for use of realistic software tools for design, maintenance, and operation of equipment on board the ship. On the other hand, it was found that, in accordance with the Bologna declaration, there was need for reducing the time allocated to teach subjects like applied thermodynamics.

When our objective was to solve a current issue there was scope to employ some software resources. For example, if we want to work on maintenance and design we could employ commercial software resources [1] like fleetwisevb [2] and Ship Constructor [3] that were designed for use by marine engineers in their typical daily activities.

Despite this, when we attempted to adapt the software with a particular condition of a ship we found obvious incompatibility between this software and the real situation; therefore, most marine engineers tended to employ visual resources like Microsoft Excel. These resources let the users develop their own methodologies like their own statistical studies and maintenance alarms comfortably. Furthermore, most of the time the marine engineer needs to work on problems of equipment selection versus cost analysis that present need to automate a lot of calculations in rows and columns and perform statistical analyses. Once again, that Microsoft Excel solves these problems with ease clearly illustrates the type of light resource that produces straightforward solutions to most typical problems.

Despite the fact that Microsoft Excel appears a good solution for most applications, it was observed that marine engineer’s needed resources to utilize its calculation programming features for some operations. Consequently, the principal programming methodologies employed in engineering education were analysed. In this context, Visual Basic for Applications (VBA) presented such a better solution for marine applications because its language is very similar to Basic and, when one is conversant with programming a task this calculation can be done and recorded and converted to VBA using the Macro recorder option. Therefore, this methodology was considered easier to learn.

Once the software to be employed in maintenance operations was selected, another problematic situation was encountered in marine engineers’ education in the context of the Bologna declaration. The problems posed by the use of the European Community Course-Credit Transfer System (ECTS) had surfaced in the last few years. This system is a European standard to measure the average amount of work a student has to devote to a programme and its components; this caused some problems in a few technical University courses such as Marine Engineering. Nowadays, in Spain a student must attend considerable number of hours of applied thermodynamics in subjects such as engines,
frigorific systems, and air conditioning, systems among others, [4-9] in order to complete the syllabus of the Marine Engineers studies. In order to study most parameters of the Thermodynamic cycle, professors and students use several equations and formulae that require at least about an hour to solve each simple case of a cycle; moreover, the students’ attendance is essential. Due to this problem, students are neither able to study a sufficient number of cases nor get the time to master thermodynamics. Arising from this situation, this paper suggests EES software as a better alternative to reduce the time need to learn most of subjects in the marine engineers course.

2 Materials and Methods

2.1. Microsoft Excel
To achieve predefined objectives, software resources like Matlab [10], Mathematica [11] and Microsoft Excel [12] were utilized. However, software like Mathematica and Matlab present clear disadvantages in programming time and graphical interpretation when compared with MS Excel.

2.2. Visual Basic for Applications
As already explained before, Microsoft owns the VBA, whose code is compiled [13] in an intermediate language called P-code [14]; the latter code is stored by the hosting applications (Access, Excel, Word) as a separate stream in structured storage files (eg., .doc or .xls), independent from the document streams. An intermediate code is then executed [13] by a virtual machine (hosted by the hosting application).

2.3. Engineering Equation Solver
To analyse the feasibility of EES as the method of teaching thermodynamics for reduction of time, Marine Engineering students from two different years were compared.

In order to guarantee that the students could do the course, especially those enrolled in the course, it was necessary to write sufficient material such as books and manuals. Therefore, the University of A Coruña sponsored nautical studies to prepare the students’ didactic material for reducing its teaching hours for thermodynamics. Its Department of Energy wrote books on thermodynamics employing EES (Engineering Equation Solver).

2.4. MS Excel and VBA
To analyse the feasibility of MS Excel and VBA as principal resources, professors of the Department of Energy and Marine Propulsion collaborated with professional marine engineers to recompile the most important numerical methods of applications utilized by marine engineers in their daily work. Following the recompilation process, these professors, along with the professors of the Department of Mathematics of the University of A Coruña, began a resolution process for each typical problem with MS Excel and compiled these resolutions into a guidebook for marine engineering students. Thereafter, to evaluate the time requirement of VBA in MS Excel, the marine engineering students were challenged to develop software to design an entire scheme of air-conditioning systems in a ship.

3 Results and Discussion

3.1. Numerical Methods
3.1.1. Iteration process in MS Excel
To emulate the close loop system needed in each iteration process the iterative option of MS Excel was used. As seen in Fig. 2, if this option is not selected MS Excel displays an error message.

To use this option one must select it in the iteration box of the options menu, as seen in Fig. 3. In the same figure the maximum number of iterations and the maximum change are also shown.

Fig. 1. EES Software.

Fig. 2. Iteration problems.

Fig. 3. Iteration option.
3.1.2. Typical MS Excel problems
After defining the iteration process, each of the principal problems was solved employing MS Excel. Nearly all the numerical problems employed in other subjects can be solved with Microsoft Excel. For example, ordinary differential equations are employed in subjects like Control Methods where the selection of one or another method depends on the knowledge obtained in previous numerical methods subjects.

3.2. VBA
The students learnt the VBA in about fifteen hours, commencing from the knowledge of MS Word, Excel and Access obtained in an earlier computer-skills class. Fig. 4 and 5 show the software resources obtained.

Results showed that most of basic methods could be employed with Microsoft Excel. Furthermore, this methodology enables students to acquire a visual understanding of the number of iterations with the number of files employed. After deciding that MS Excel was a good tool for numerical methods, and because of the need for its implementation with a programming language, it was proposed to utilize MS Excel with VBA. The fixed objective was to develop a software resource for HVAC by marine engineers’ students. Results showed that the students reached each of the objectives quicker than expected. In Fig. 4, a psychometric calculator is shown; it introduces two moist-air variables and the pressure of each state in a programming time of twenty-two hours. This relatively longer time spent on programming was due to the need for a clear quantitative resolution for each psychometric algorithm. Fig. 5 shows the fan-selection modules; this step consumed eight hours because only a simple automation of calculation was carried out.

Less time was needed than expected when graphical modules were designed, particularly after the multipressure psychometric chart was designed with the same equations as in the previous module. Finally, about ten hours were needed to interconnect the modules and to execute a graphical representation of the solving method for the HVAC system. In summary, it was observed that the principal advantages of VBA methods are:

1. Less time is needed to automate its calculations. This time-reduction is based on the fact that most of the operations were previously automated in MS Excel and implemented with a few algorithms from the VBA.

2. There is nothing to buy or install, as all features are already available in Excel.

3. The graphical output, which was in reality easy due to the chart designed earlier in MS Excel.

4. A professor must take into account the basic differences in the programs when choosing between these different programming languages. VBA offers the same powerful tools as the Visual Basic in an
existing application context, and it is the best choice for customising the software that already meets most of the required standards.

5. Finally, it can be confirmed that VBA will endure for years to come in applications such as Microsoft Office 2008 for Mac.

On the other hand, it was observed that the VBA has some disadvantages;

1. Sufficient information about a complete code-source for real projects is not available [15].
2. There is no final executable file that could provide greater stability to the software resolution.

After evaluating VBA, the feasibility of EES as teaching method was analysed. Consequently, two different teaching methods were compared.

The first method was the traditional class based on tabular fluid properties and manual solution of equation systems. In the other course, the students learned the same concepts through the EES software after attending some lessons to learn the program.

These results showed that the reduction in the time spent to solve the typical exercises is up to 60% of the time spent in the manual method, and in some cases such as psychometric studies, the reduction is up to 30%.

This must be due to the fact that the time used to obtain the main fluid’s properties causes a lot of delay because a psychometric chart is used instead of tabulated data.

These results could be related to the fact that this method allows students to acquire a deeper and clearer understanding of thermodynamic concepts and not merely of the fluid properties or solutions to equations.

Therefore, we can conclude from this study that both professors and students will benefit from the use of the EES because;

1. They can easily obtain the properties in a considerably shorter time. To benefit from all these, professors must employ a part of the reduced subject teaching time to teach students the use of the software. Therefore, the time required for teaching the rest of the subjects in syllabus is shorter than that required by the traditional method.
2. This enhancement in marks and performance can be related to the fact that there were books that helped students in either attending the course or to work so that they could continue their studies and still attain the adequate standard, whereas with the traditional teaching method, it would have been more difficult.
3. The examination procedure. In the last few years, the traditional resolution method compelled the professors choose between two options: a general and not too deep analysis or a deeper analysis of only one typical cycle, whereas now, as already explained, with EES the reduction in time needed to solve the same cycle rose to, at least, 60% of that needed with the manual methods.

This will result in future exams of only four hours duration [16] with wider choices and a deeper understanding for the students.

In summary, we can say that the previous thermodynamics course employing the traditional approach is sufficient for teaching the second course of applied thermodynamics that employs this new method.

Therefore, work must be done in future on how to employ this methodology to interrelate different courses studies and quantify this reduction in time.

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References:
[4] RD 1044/2003 por el que se establece el procedimiento para la expedición por las universidades del Suplemento Europeo al Titulo.
[5] RD 1125/2003 por el que se establece el sistema europeo de créditos y el sistema de calificaciones en las titulaciones universitarias de carácter oficial y validez en todo el territorio nacional
[6] RD 55/2005, por el que se establece la estructura de las enseñanzas universitarias y se regulan los estudios universitarios oficiales de grado.
[7] RD 56/2005 por el que se regulan los estudios universitarios oficiales de postgrado.