VIRTUAL WEB FOR THE ASSESSMENT OF TRAINING OF
TECHNICIANS IN METAL STRUCTURES (MECES-1 EQF-5) WITHIN
THE TECHNICAL COLLEGE SPANISH EDUCATION FRAMEWORK

M. Peinazo Morales¹, P. Aparicio Martinez², G. Pedros-Perez¹, S. Pinzi³,
A.J. Perea-Moreno¹, M.P. Martinez-Jiménez²

¹ Dep. Applied Physics, Albert Einstein Building, Rabanales Campus, Universidad de
Cordoba (SPAIN)
² Nursing department, Medicine and Nursing Center of Universidad de Córdoba (SPAIN)
³ Physical Chemistry and Applied Thermodynamics, Universidad de Cordoba (SPAIN)

Abstract
Lab practice is essential in the industrial subjects learning process. The use of the Tensile Strength Trials Virtual Web Laboratory for the industrial technicians training assessment allows reproducing the conditions of an experimental workplace. This web is a very significant educational resource, overcoming some of the real limitations and improving the flexibility and accessibility to practice. The research main purpose is focused on establishing a relation between the use of this Lab and the improvement in the students learning process. This lab has been used by experimental in the opposite of control groups. The methodology has been based on the results analyze of the assessment, which has been represented and compared according to the aims. The total grades (N=288) statistical assessment has shown the effectiveness using this software. Finally, a satisfaction questionnaire to evaluate the usefulness filled by students whose give it a positive evaluation (mean 6 points on 7). All this implies that the use of the afore mentioned software together with the practice sessions have contributed to improve the development of the necessary procedures and skills to solve the practical problems related to these destructive tests and to draft reports on them. In the same way, it is possible to affirm that the methodology based on the use of the software improves the acquisition of personal and social competences

Keywords: Virtual laboratory, b-learning, tensile strength tests, vocational training.

1 INTRODUCTION
In the last decades a significant increase of the use of the new technology in the engineering teaching domain has been the development and spread of educational computing tools through the internet and new platforms such as the mobile web and apps [1]-[3]. This has resulted in a wide range of interactive teaching tools accessible from a computer, mobile phone, or tablet. These types of applications improve the performance of the educational process and the self-learning abilities among the students, enabling the self-assessment of their knowledge and validating the teaching/learning process involving both the student and the professor [4]- [5].

In this context, it is necessary to take into account the fact that some social changes linked to globalization, such as the European Higher Education Area (EHEA), have created a nurturing environment for the development of new methodology strategies in the teaching and learning process based on competence development.

Deriving from this, the web based learning environments have become very popular in technical college education, being one of the most important educational resources the VL and the Interactive Virtual Platform (IVP), which is a b-learning training platform including VL [6]. Many studies [7]-[12]; have shown the usefulness of the b-learning platforms with VL as a means to enable interactive communication, allowing the access to all kinds of information (texts, images, graphs, videos, etc.) [13]. In these working conditions, the teaching quality has been proven to notably increase [14].

Currently, the VLs and the Interactive Virtual Platforms (IVP) are some of the most widely used computer applications in subjects related to Engineering fields in Technical College Education programmes [6],[12],[15]-[19]. In this context, the Spanish Ministry for Education has promoted, within the programme “Internet en el Aula” (Internet inside the classroom), framed within the Plan Avanza, the development, preparation, and validation of Virtual Labs on Mechanical Tensile Strength testing. The computer app has been developed by the Instituto Nacional de Tecnologías Educativas y de
Formación del Profesorado (INTEF), and the preparation, verification, and validation have been executed by different mixed teaching groups formed by teachers from Secondary and University education programmes within the European Higher Education Area.

The aim of this work has been the verification and validation study of the computer tool, as well as the analysis of the influence of this software in the learning-training process of the Technical College Education Vocational Training students (MECES 1-EQF5), High Level Technician in Metal Structures, in the following subject: *Definition of Mechanic Manufacturing Processes*.

The High Level Technician in Metal Structures (HLTMS) studies correspond to a Technical College Education Vocational Training (TCEVT) lasting for 2000 onsite hours during 4 semesters, which provides the specific formation in order to be able to work in the industry field [20]. In HLTMS programmes, the subject “*Definición de Procesos de Fabricación Mecánica*” (*Definition of Mechanical Manufacturing Processes*) is taught in the first year and lasts for 192 hours. The main objectives of this subject are: to establish mechanization, the joining and mounting processes, the mechanization, forming, and mounting costs; to organize the distribution of the resources in the production area relating their physical layout with the manufacturing process and to define the test and trial plan so as to check the reliability and quality level of the product creating the inspection procedure.

An important practice will deal with procedural content for the preparation of the test tubes and the implementation of non-destructive and destructive testing in the lab of the school. The programming of this lab consists of 12 hours of the total number of hours of the whole subject.

### 2 METHODOLOGY

As previously commented, the Spanish Ministry of Education, through the Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado (INTEF), has developed different interactive and multimedia digital teaching resources, which have been published in their educational website ([http://recursostic.educacion.es/fprofesional/simuladores/web/](http://recursostic.educacion.es/fprofesional/simuladores/web/)). These resources adapt to the curriculum of different areas and subjects of Vocational Training programmes and where the authors have been invited to take part in the preparation, verification, validation, and assessment of the quality of such VLs.

#### 2.1 Description of the Testing Strength Testing Virtual Lab (VLTS)

The Tensile Strength Testing Virtual Lab (VLTS), belonging to the Mechanical Manufacturing professional area is a web application which reproduces with a great visual, sound, and functional reliability the environments, work tools, and in general, the different situations which take place in the execution of tensile strength testing with metals. It is conceived in order to help the students with their training as users of a universal testing machine and for this, it realistically replicates the characteristics of the machine and guides the students through all necessary steps to correctly execute a tensile strength test. The graphics, sounds, and processes imitate those of an actual work environment.

When a given material is subjected to any stress, the most characteristic responses are called mechanical properties. Some testing is implemented in order to observe some of these properties such as ductility, elasticity, fragility, and plasticity. These are very important properties due to their applications for a wide range of processes and industrial developments.

The actual tensile strength test consists of stretching a test tube of normalized dimensions in a machine whose clamps (fixing elements of the test tube) move at a constant speed. In this way, it is possible to obtain graphic registers for *stress-elongation* or *stress-deformation* corresponding to the characteristic curves of each analyzed material. These experiments are inconveniently destructive as they break the material. This, joined with the cost of the work and measurement equipment and with the fact that there is just one workplace for each school (Figure 1a) causes a remarkable increase in the price of actual practice sessions.
To solve this problem and to be able to go over the operation mode as many times as the student may consider appropriate, the use of VLTS (Figure 1b) as a complement to experimental practice sessions is suggested in some cases and in other, as an alternative to the lack of these experimental workplaces.

For the execution of these stress tests, the VLTS is developed as a support tool to the educational action with an advanced technological base, where high quality graphic environments converge with software solutions which allow traceability and as a result, a feedback with the user.

The access screen to the VLTS shows two use profiles: teacher and student and includes a block of educational content (with didactic units, glossary, and didactic videos) and three simulation options (Observe, Test, and Prove), each of them divided into five stages. In the same way, there is a help area for the users. The five stages of the simulation are: Stage I. Reception of the order, Stage II. Analysis of the work process, Stage III. Substage I. Preparation of the material to be tested, Stage III. Substage II. Preparation of the test machine, Stage IV. Development of the actual test. The necessary initial parameters in the development of the practice are loaded, the test is executed, and a visual monitoring of the stress-deformation graph is shown while the tensile strength test is being executed and Stage V. Failures, maintenance, and results (Figure 2).

Both the teacher and the student have a settings panel where they can select the use case to be studied, allocate to it a given level of difficulty (average or high) and introduce, if they wish to, any incidences complicating the process in option Prove.
2.2 Teaching experience and methodology

The VLTS, due to the fact that it is a tutor system, is a “learning by doing” methodology, enriched with the constant supervision of the system, which registers traces of all actions implemented by the users [21].

The educational methodology consists of the development of an active learning which promotes the settling of concepts, procedures, and attitudes in the students’ minds through practice in realistic environments and with realistic means, guided or free, continuous or discontinuous, of the concepts and processes to be learnt. [22].

2.2.1 Experimental Research

The teaching work line has been mainly developed in the verification, validation, and later evaluation of the VLTS The main purpose has been set: to study the Virtual Labs for Tensile Strength testing (VLTS) influence in the specific technical students’ training.

To be able to quantitatively assess this main purpose, it has been divided into four more specific objectives. These are:

1. To identify the tensile strength of metals and their elastic and plastic behavior.
2. To select the test tube material to mechanize according to the stipulations of ISO regulations.
3. To interpret the obtained graphs and to calculate the tension and elongation of each of the materials.
4. To methodically plan the tests, to pay attention to order and cleanliness during the different stages of the process, to maintain rigorous calculations, to show their own initiative and personal autonomy in the decision making process and to show a will to participate and collaborate with the rest of students.

To assess the achievement of such aims, with the help of the created VLTS and without it, the learning results achieved by different groups of students in different school years of the second year of a technical college education vocational training cycle regarding mechanical manufacturing were compared ( N=72). In the first stage of the study, data from two groups of students, belonging to years 2010-2011 and 2011-2012 respectively, known as control groups were collected. These groups followed a traditional teaching methodology, not using the Virtual Lab. In the second stage, the evaluation results of another two groups of students, belonging to years 2012-2013 and 2013-2014, which have developed the same theoretical and practical contents but using the described VLTS as a complementary tool were collected.

The students accessing these types of academic studies do so after passing the common access tests for the whole Spanish territory. The average ages of both samples did not show any significant differences. Thus, is possible to deduce that previous knowledge and the learning capabilities of all groups are very similar. The comparative study of the results (N=288) of the training developed with the control and the experimental groups was implemented.

2.2.2 Description of the Educational Experimentation Process

The learning methodology followed with the two control groups (GC1 and GC2) is as follows: together with theoretical onsite lectures, a set of practice sessions to be carried out in the experimental workplace was designed, providing for the students of these groups previous theoretical information and an activity programme for their execution during the practice sessions.

At the end of this process, the students presented a written report stating and analyzing the obtained results, extracting conclusions and answering different questions related to the interpretation of the studied processes. After this, the students underwent an evaluation test based on a written questionnaire where they had to answer several questions related to the learning process of the previously mentioned content. The methodology followed with the experimental groups (GE1 and GE2) was identical to the one implemented with the control groups, both as regards the theoretical content and the experimental sessions carried out with the actual experimental workplace. However, the experimental groups completed their training in virtual practice sessions with the VLTS. Although the educational content on concepts and procedures is the same in the actual and in the virtual workplaces. Nevertheless, the training of the experimental groups was complemented with virtual practice sessions carried out with the VLTS. Although the educational content on concepts and
procedures is identical in the actual and in the virtual workplaces, the number of examples of treated materials is much higher in the VLTS (copper, structural steel, cast iron, stainless steel, duplex stainless steel, lead brass, and aluminium).

The time devoted to the development of the experimentation was similar in both stages, as the students of the experimental groups replaced the theoretical operational training by the first work session with the VLTS. This is a Learning by doing methodology, enriched by the constant supervision of the system (tutor system).

After working with the VLTS, the students belonging to the experimental groups have carried out the same tests in the actual lab as the students belonging to the control groups, but with the advantage that the former were already familiar with the necessary procedures to execute such test practice. Finally, these students also drafted a written report of the implemented test procedure.

2.2.3 Educational Experience Assessment

To evaluate the development of this experience in order to find out the effectiveness of the proposed objectives, the results by each of the students belonging to the control groups (GC1 and GC2) and to the experimental groups (GE1 and GE2) were studied. In this evaluation, the following aims were assessed:

1. The quality of the practice reports drafted by the students at the end of the experience.
2. The results of an experimental exam where the student is suggested a practice case of all cases seen during the learning course.
3. The results of a written test consisting of different questions.
4. The results of the assessment, analyzing the degree of acquisition of personal and social competences (initiative and personal autonomy and collaborative work).

The assessment process has been the same for the control groups and for the experimental ones.

The partial grade, from 0 to 10 points, integrates the evaluation about the specific performance achieved for each aim.

From these partial marks, overall learning categories or levels can be defined, which allows to represent graphically performance differences among the groups.

Finally, the students filled out a satisfaction questionnaire to evaluate the VL usefulness. The questionnaire items focused on five main issues: documentation, ease of use, ability to motivate, content quality and promotes learning.

3 RESULTS

To study the results of the evaluation of each of the aims, the partial marks allocated to the students of the different groups and established five learning categories or levels according to the following classification: category I corresponds to very low marks (very poor), category II corresponds to low marks (fail), category III corresponds to average marks (pass), category IV corresponds to high marks (good), and category V corresponds to very high marks (excellent). This classification has been based on the following criterion: for the highest mark of 10 points, a very low learning rate represents a mark between 0 and 3, a low one corresponds to between 3 and 5, an acceptable mark corresponds to between 5 and 7, a good one, between 7 and 9, and an excellent learning rate would correspond to a mark over 9. Insofar, in order to obtain an overall mark, the marks for the four aims have been summed, so that each subject is allocated a mark between 0 and 40 points. For such purpose, four total performance categories have been established: I (total mark between 0 and 10 or poor learning level), II (total mark between 10 and 20 or semi-acceptable learning level), III (total mark between 20 and 30, which represents a good learning level), and IV (total mark between 30 and 40, which corresponds to an excellent or very good learning level).

The Figure 3 shows the results from the evaluation of the four aims (1st, 2nd, 3rd, and 4th) distributed by categories (I, II, III, IV, and V) corresponding to the control and experimental groups. The figure shows the relative frequencies for each aim and group corresponding to each one of the four established levels.

This figure shows that the obtained results of both groups are quite similar in the four analyzed aims.
It is possible to see in the figure that the results obtained by all groups present noticeable
differentiation between control and experimental groups. Nonetheless, the results also present a
similar distribution of frequencies between each subgroup (GC1 and GC2, GE1 and GE2) in the
different categories of the analyzed aims.

In addition, the Figure 4 represents the total objective results from the four groups, showing the
percentages for the four general performance levels in each group.

**Figure 3. Aim Results for each group.**

**Figure 4. Objective Results for each group.**

Firstly, it can see that control groups GC1 and GC2 show very similar results in all four categories.
The same happens with the results of experimental groups GE1 and GE2, although these groups
present a higher total performance than the previous ones. In fact, categories I and II represent a
higher percentage in the control groups than in the experimental ones (with variations close to 19%
and 14% respectively). On the contrary, in category III, very similar results are obtained by the
experimental and control groups (although with highest variations of around 18% between GC2 and
GE1). Lastly, in category IV, the control groups obtain low percentages, whereas the experimental
ones obtain higher figures. This proves the success of the used methodological experience, achieving
a high performance level in the experimental groups (with highest variations of around 27%).

When comparing the results from the control groups, GC1 and GC2, for each of the four aims, the
differences among the means of each of them can be disregarded due to the fact that they are not
significant (Correlation coefficient, CC 0.972). The same happens with the experimental groups, where
the differences among the means are completely insignificant (Correlation coefficient, CC 0.996). This is due to the fact that the groups, both the control groups and the experimental groups, have had the same initial characteristics, have developed a similar learning process and have obtained a similar performance level.

Furthermore, the good correlation coefficients indicate that both the control and the experimental groups are similar at the beginning between them, as the experimental ones more homogeneous.

However, the differences of the means of the experimental groups as compared to those of the control groups are indeed very significant. This implies an improvement of the results of the marks of the experimental groups as compared to those of the control groups, and as a result, of the validity of the VLTS as a complementary learning tool.

On the other hand, from the detailed analysis of the results of the marks by aims in the control groups, (Figure 3) it can be appreciated that categories IV and V, good and excellent, show much lower values than categories I, II, and III, very poor, fail, and pass, which shows that the achieved learning level is not perfect, but it is acceptable. This figure shows that for the four aims, the relative frequencies of categories I and II (very poor and fail) have decreased as compared to the values of the control groups. On the other hand, the frequencies are higher in categories III, IV, and V (pass, good, and excellent) in the experimental groups, which means that a higher number of students from groups GE1 and GE2 have passed those aims as compared to those who have not passed the subject in groups GC1 and GC2.

Moreover, the Figure 4 presents that the similarity of the results obtained in category IV is due to the fact that there is always a number of students in all groups with a higher level of specific knowledge and a high interest in the topic, regardless of the teaching methodology.

However, the movement of students from categories I and II (control groups) to the upper categories (experimental groups) in aim 3 (ability to solve theoretical-practical issues) is not as significant, due to the complexity in the solution of practice cases and to the fact that the use of the VLTS does not imply a significant improvement in the abstraction capacity of the student.

Also, these figures, 3 and 4, show that the average marks by aims of the experimental groups have increased towards the highest quartiles as compared to the control groups and that the results have moved towards the highest average marks.

Furthermore, the values obtained by the Krukal-wallis test [23] that relate the overall grades and the use of the VLTS (Chi-square=27,629, df=1 and p-value=1.47e-07) show the improvement on the final results.

All this implies that the use of the aforementioned software together with the practice sessions have contributed to improve the development of the necessary procedures and skills to solve the practical problems related to these destructive tests and to draft reports on them. In the same way, it is possible to affirm that the methodology based on the use of the software improves the acquisition of personal and social competences as regards the degree of initiative and personal autonomy together with the cooperation in the group work. The work has ended with an assessment and categorization of the general performance of all the students of the different groups, analyzing the set of obtained data throughout the experience.

Finally, the questionnaire results of the assessment of use of the virtual lab regarding the opinion of the participants were rated on a seven-point Likert scale, ranging from strongly disagree (1) to strongly agree (7). In general terms, the survey showed that the experience was positively evaluated by students, the mean score for all questions being around 6 points (strongly agree).

4 CONCLUSIONS

This paper study an empirical educational research, from which it can be deduced that the use of Tensile Strength Testing web laboratories is useful for better understanding the main concepts and topics used in the work of this subject.

A software with a strong pedagogical character oriented towards the comprehensive achievement of the destructive tensile strength tests both for the students of vocational training courses on mechanical manufacturing and for students of the Mechanical Engineering degree has been developed and validated.
The described software constitutes an effective new tool for presenting students with some initial
tensile strength testing concepts and practice study. The simulations on the computer of the main
concepts and devices are an essential part of this software.

This software has been used by undergraduate vocational training students with good results. Indeed,
the teachers could compare, with satisfaction, the learning achievements of students throughout
different years.

The implemented study to assess the degree of educational effectiveness concludes that:

- The used assessment process provides similar results for the considered control groups. As
  results, it can be consider reliable.
- The similarity in the obtained results by both experimental groups leads to conclude that the
designed learning process is homogeneous.
- The similarities found among the levels achieved by the experimental groups and by the control
  ones lead to state that the used software is an adequate training tool for learning by doing and
  significant learning processes by the students.

Based on the results, this study demonstrates that the use of suitable educational software helps to
improve the scores in the partial assessment of the aims and the general evaluation of the subject, the
number of failed exams and the dropouts of students have also been reduced by including the VLTS
in the proposed methodology.

The observation and evaluation of the development of this VLTS has brought up some practical
advantages regarding their use and a significant influence in the motivation and concentration of the
students in their tasks, favoring an autonomous learning, administer their help, and reflect on their
mistakes. In addition, it allows a necessary feedback through the actions implemented by the students
for their learning progress.

The opinion of the participating students and teachers is very positive, highlighting many educational
advantages, some of which have been reflected in the degree of achievement of the training aims.

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