THE BEGINNING OF LEARNING BUILDING STRUCTURES: ICT FOR AN EXHAUSTIVE CONTINUOUS EVALUATION

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Abstract

The first steps of learning building structures uses to be especially difficult because students have to assimilate a number of structural concepts that are completely unfamiliar to them. In this way, the consolidated group for innovating in education E 4 (Exploración de Enseñanzas en Estructuras de Edificación) plan experiences that incorporates exhaustive and continuous evaluation systems for learning in building structures.

The experience presented in this work has been carried out in two different student groups of the Structures I and Structures II subjects at the School of Architecture (Technical University of Madrid). The experience consists of incorporating a continuous evaluation system that every week allows the students to check the results of different structures problems. These weekly tests must be customized, assigning different values for each student. The purpose of personalizing is twofold: it is focused to minimize the possible student scam that could succeed if the same exercise is on-line resolved by students. On the other hand, it is a good learning to compare the different results obtained by some students in the face-to-face lessons in order to provide some valuable knowledge about the variation of the final results in comparison with the initial values of the structural problem.

It is well-known that exhaustive continuous evaluation methods must be carried out under an automatic correction process to make them viable. On the contrary, the correction process becomes unattainable for teachers. The process used in this work consists of an automatization of the checking process. Students have to introduce the numerical values of the solutions (ten numerical values approximately on-line) and they are automatically checked by an internal software. It is important to mention that this software is able to receive the results by a smartphone app.

Two conclusions are worthy of mention. First one is that exhaustive continuous evaluation used in this experience is an effective method for learning process and for evaluation procedure. The second one is that the automatic evaluation method presented in this article is a powerful assessment tool that is able to automatically check several students tests in short time.

Keywords: ICT, automatic evaluation, exhaustive evaluation.

1 INTRODUCTION

The first steps of learning building structures uses to be especially difficult because students have to assimilate several structural concepts that are completely unfamiliar to them. In this way, the consolidated group for innovating in education E 4 (Exploración de Enseñanzas en Estructuras de Edificación) [1, 2] plan experiences that incorporates exhaustive and continuous evaluation systems for learning in building structures.

The continuous evaluation method presented in this work has been used in “Structures I” and “Structures II” subjects during the last ten years at the School of Architectures of the Technical University of Madrid (UPM). Different variations has been applied and the educational results obtained have been comparable.

1.1 Objective

The main aim of the evaluation method presented in this work is double. First, is to promote the continuous self-study of students. In this way, exercises about the content previously exposed in face-to-face teaching are taught and immediately evaluated.

On the other hand, the specification of these exercises allows to define different requirement levels of each topic of the subject.
2 DEVELOPMENT OF THE COURSE

2.1 First step: presentation of the problem

Every week is presented an exercise, in which the main structural aspects have been previously explained at class with similar models. These exercises consist of a building structure that must be individually analysed by each student. The structures proposed can vary from a steel-girder frames, beams, or beams and columns, to a complete structural model of a small building.

The educational process of these exercises is as follows. First, a basic structural model is presented in which the general data of the problem are defined: geometrical data, materials characteristics, loads and constrains, security coefficients etc. From this first step, students have one week to study and provide the solution of the structure. It is important that students still ignore the questions which will be answered, and later evaluated. In this way, students must to solve every important aspect of the structure.

![Figure 1: example of first step exercise.](image)

Fig. 1 shows an example of these structural models. In this case, the problem consist of a funicular structure in which the loads and basic geometry is presented, and students have to study mechanical behaviour of the structure.

2.1.1 Variable data

In order to promote the individual effort of students, the original data of exercises are variable, depending on the file number of student (alternatively, the data corresponding to the questions can depend on the number of the class list, or National Identification Document –DNI–, etc.). The exercise shown in figure 1 shows that original data depends on the X, Y and Z numbers of the file number of each student.

The use of variable data is an important resource, because in this way students understand that they must address their individual answers under their own responsibility. However, this process does not block the team-work, which is a powerful learning method.
2.2 Second step: questions presentation

When a week has been expired, in face-to-face class and under the supervision of the teacher, the second exercise is presented. This second version of the exercise is composed of ten numerical and specific questions and, in general, from six to eight questions are directly related with first exercise. In this way, if students have worked at home they would be able to correctly answer without additional work. In addition, some new questions are proposed. The aim of these new questions is to evaluate the capacity of students to solve problems that they have not been previously understood or studied.

Fig. 2 shows an example of these final questions. It can be observed that six out of the ten questions are directly associated with the self-study already done. In this way, students who have worked well at home and who are able to understand the syllabus week to week will pass these weekly exercises. However, students who wish to get remarkable or outstanding califications have the opportunity by solving new questions based on the knowledge achievements. The authors of this article are convinced and have already checked that this is a good method to reward the excellence and encourage student work.

3 THE CHECKING PROCESS

It is well-known that exhaustive continuous evaluation methods must be performed under an automatic correction process to make them viable. On the contrary, the correction process becomes unattainable for teachers. The process used in this work consists of an automatization of the checking process. Students have to introduce the numerical values of the solutions (ten numerical values approximately) on-line and the results are automatically checked by an internal software. It is important to mention that this software is able to receive the results by a smartphone app which facilitates and encourages student work.

It must be noted that there are between 60 to 90 students in each class group at the School of Architecture. In order to evaluate the numerical answers of students, a new software tool has been developed. The internal operation is elemental: each student answers every question introducing a
numerical value into a computer with the questionnaire, as can be observed in figure 3. In that case, the student has answered to 4 out of the 10 questions (namely 1, 3, 5 and 8).

This software tool has the great advantage of well working in personal computers and in smartphones and tablets. The communication from students to software can be done by the own wifi of the university (UPM), by other wifi or using the data service of the smartphones. In all cases, the software records the communication method in order to check the place where the answers have been sent.

Thus, in all cases system requires identification of each student, using the same parameters that university employ in administrative procedures.

During the questionnaire is active, students can answer and modify the answers of the questions as many times as they want. When the established time is concluded, a data table is automatically generated with the identification of each student and with their numerical answer.

An example of this data table is presented in figure 4.

![Figure 3: example of questionnaire model.](image)

![Figure 4: data table of students results.](image)
3.1 Automatic checking process

The correction and qualification of these exercises is automatically obtained by a software tool that has been developed in visual basic. In order to simplify the use of this process, the software tool is divided in two different sections. First one corresponds to the base of the software, and users do not need to know about it. The second one depends on the questions of every exercise; it correspond to the code lines that calculate the numerical solution of each question, and they are programed according to the variable data of each student. Thus, the evaluation criteria established in each question are defined in this second section of the software.

3.1.1 Evaluation criteria

The software tool employed in this work allows to define the evaluation criteria as follows:

- Evaluation of the question regarding to the global qualification of the exercise
- Possibility to evaluate two or more values as correct
- Possibility to evaluate value and sign or unsigned values
- The option to incorporate the relative tolerance level (as a percentage of error)
- The option to incorporate the absolute tolerance level (as a percentage of error)
- The possibility of negative judge a wrong result

When these parameters are defined, the software tool automatically evaluates the exercises according to the numerical answer of students and the evaluation criteria established. Then, the qualification of each student is generated and two files “asci” and “pdf” are created with, amongst other information, as follows:

- Statistical summary of qualifications, and correctly answered questions (figure 5)
- Detected errors (when a student is not included in the list, or when a student is included two times)
- Number of answered questions by students
- Number of correctly answered questions of the students who have introduce an answer

This last solutions are shown so the students can verify its own correct or wrong answers. In this way, they have the opportunity to continue working in the exercise.

3.1.2 Advantages and disadvantages

One advantage of this automatic evaluation method is the great speed of the checking process. When the answering time expired, the solution and qualifications can be immediately published. In general, this period of time is around an hour. It has been proved that this short time period enhances the motivation. The publication of both qualifications, wrong and correct solutions, allows students to check their answers and to continue working until the correct calculation process is obtained.

However, when this method is applied to numerous students groups it can be appreciated that influence of punctual errors can be hidden into all the numerical solutions. This fact is tolerable, considering that around 15 exercises are presented in an academic course, and every exercise has around 10 questions.

On the other hand, this evaluation method has the disadvantage of the limitation to numerical answers. The importance of numerical answers is essential in technical subjects. However, other types of results, for example the schemes of the mechanical behaviour of structures, are not allowed by the continuously and automatic evaluation method presented in this work. In order to compensate this deficiency, an A-4 format document with a graphical summary solution of the weekly exercise is demanded every week. This graphical summary usually corresponds to schemes of the mechanical behaviour of building structures.
This A-4 is an indispensable requirement before they can answer the telematics questionnaire. In this way, teacher can follows and monitor the assistance to face-to-face learning.

In Fig.5 a statistical summary of qualifications is shown including average qualification of the students and percentage of correct answers for each of the questions.

### 3.1.3 Global qualification

Actually, this questions method represents the 30% of the final qualification. The other 70% is represented by the weight of the partial exams. In this way, this evaluation method allows to considerate numerical results and include also other important student facets such as reasoning, argumenting and providing graphical information (schemes of the mechanical behaviour of building structures).

### 4 CONCLUSIONS

In conclusion, the evaluation method presented in this work can be considered as a learning tool useful for self-study and to guarantee the continuous work of students along the academic course. Thus, it can be considered as a fundamental evaluation method.

Two conclusions are worthy of mention. First one is that exhaustive continuous evaluation used in this experience is an effective method for learning process and for evaluation procedure. The second one is that the automatic evaluation method presented in this work is a powerful assessment tool able to automatically check several students tests in short time.

### REFERENCES
