A powerful learning object based on multiple answer test

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ABSTRACT. One of the principal, and still unsolved, problems for the worldwide university system is the high drop-out rate that is observed especially for STEM courses. The causes of this trend are various but many of them are directly related to the sense of abandon felt by students especially during first years. This trend can be inverted providing a set of self-assessment activities to organize students personal study-method and to transmit them a proper self-government. In this context, we realized a self-assessment activity for Physics courses based on Multiple Answers Questionnaire. The most intriguing features of this tool are: the possibility to choose arguments that makes this product useful during study and as self-evaluation (prior of final exam), the large number of questions in the database (and a simple way to enlarge it at will). The questionnaires are randomly selected (from the database), and the possibility to send a final report to instructors for discussions and suggestions is also allowed. From a technological point of view, this activity has been integrated with a database to store the entire set of completed questionnaires. As a consequence it is possible to perform (the most deep) statistical analysis either on single student/teacher/topic or on the entire community/program, which offers an innovative objective evaluation of didactic materials.

KEYWORDS: *Drop-out, E-learning, Multimedia products, Quality, Self-assessment*

Introduction

Passage from secondary school to an academic level could be not a quite easy step for the majority of students[1]. While in secondary

1 A vast literature (namely in the United States) has been developed to deal with this, which has been definitely acknowledged as a real obstacle toward a professionally adequate formation. Just few examples among a boundless literature: Hillman, 2005; Feynman, 2011; Cromer, 1997; Arons, 1995; Swartz, 2003.

school students are settled in uncrowded classes at university, usually, they attend lessons in very crowded rooms with not too many possibilities of interaction with their teachers.
Surely, this implies a personal growth of pupils that must first learn a study-method and organize their work in complete autonomy. Nevertheless, student's response is not standardized and in many case they can feel left to themselves as they start the academic course of study (de Guzman et al., 1998). The most important consequence of this disease is the high dropout rates, mainly during first years of their academic course (Gerdes, Mallinckrodt, 1994).
From the point of view of students, university organization must offer simply accessible services and provide well-identified knowledgeable and organized offices to satisfy every request.
On the contrary, teacher's commitment must be oriented toward learning aspects.
As anticipated: gain a proper self-government is part of student's growth. However this path must be gradual. To achieve this, a set of learning activities must be suitably prepared allowing students to self-evaluate their progress. These activities must necessarily take place during first years (of each academic curriculum) i.e. before these errors consolidate themselves as ways of working (Hillman, 2005; Feynman, 2011; Cromer, 1997; Arons, 1995; Swartz, 2003).

Self-assessment activities

Let us focus on the first year of the academic courses: teachers have the compulsory duty to prepare specific activities permitting students to evaluate their progress.
As stated before, student's study must proceed autonomous (i.e. under his or her own responsibility). Nevertheless, each teacher must provide a set of solutions specifically devised to enable students to measure individually their own progresses. These learning tools are also known as "Self-Assessment" activities (Boud, 2003).
Self-Assessment exercises must be realized step-by-step to permit students to measure their progress not only at the end of the course, but also during study. As clear, once identified a problem on a sub-part of the program, students can correct their study or concentrate on specific arguments before going ahead in preparation (McDonald, Boud, 2003).
Well-defined self-assessment activities can motivate students permitting a more complete preparation (McMillan, Hearn, 2008). Obviously, results of self-assessment activities must be simply interpretable by students avoiding confusion and precisely indicating parts in which their preparation is not sufficient.
As far as the first year courses, feedbacks of intermediate activities are even more compulsory.
First year students, usually, have not yet acquired a sufficient autonomy to understand how to evaluate their preparation neither to estimate if they are ready to go ahead in course arguments since the previous have been firmly learned.
In this case, an active role of the teacher must be suggested. Instructors should act as supervisors while "self-assessment" procedure develops. Teachers must monitor student results and, if necessary, signal to them the arguments in which they appear weaker.

The Physics course case

General Physics is a first year course for a large number of scientific Faculties. This teaching represents an important and difficult stumbling block for students since its role is to give to them important knowledge, also fundamental to understand next years courses. Moreover, the number of arguments in General Physics is very high passing through Classical Mechanics, Thermodynamics, Electromagnetisms and Optics. The vastness of the program together with the difficulty of the arguments makes this course one of the most dreaded by students.
To pass Physics course, a good study organization must be implemented and students' learning has to follow a gradual process. In this context, use of self-assessment activities is fundamental to give to students the possibility to check their knowledge and to measure their preparation before final exam. Moreover, as already discussed before, these activities should be monitored by teachers allowing an individually interaction with single student.
Even if these problems are common for both traditional and distance courses, in the latter case we can develop product to be delivered online exploiting computer resources. This obviously permits a high personalization of the adopted activities allowing also the exploitation of online potentialities. Moreover, using responsive technologies, we can realize something that can be used everywhere and every time from our students, also using mobile devices.

Initial requirements

To our experience, the "pass-rate" (number of successful examinations over total of examinations) of General Physics courses (first year of academic curriculum), is quite low. This is due either to the difficulty of students to follow a fruitful study method or to organize their work.
To cope these difficulties, we have realized a multimedia product with the twofold skill: self-assessment along the "reading period" and self-assessment before final exam.
From a didactical point of view, a certain number of "ab initio requirements" drove the adopted solution:

- activity with different questions every time
- possibility to choose arguments (learning evaluation) or entire program (assessment before final exam)
- self-evaluation by students
- possibility of interaction with teachers
- direct teacher control.

Most of these requirements have been already justified in previous section. The special request to have "activity with different questions every time" becomes clear if one consider the ultimate aim of this test. Proposing to our students a set of "static" questions it usually results in the following behavior: they face the test once and having learnt from their errors they do not perform the test anymore. Aimed to avoid this, we devised a testing procedure that always proposes different questions. In other words: each time a student asks to be tested, he receives a set of comparable but different questions.
Furthermore, the self-assessment test we want to set up must be easily integrated into the Learning Management System, LMS, used to deliver ordinary lessons. In this way we integrate this test as an

"additional learning tool" and we can even exploit LMS record system to collect students statistics. This last feature is important to evaluate material fruition and statistically study course itself, as it will be discussed in the following sections.

Test choice and realization

Trying to fulfil all requirements discussed in previous section, we decide to adopt a Multiple Answer Questionnaire as starting point. We refer to this as "starting point" because even if the final interface to students is only a simple multiple answer test, the realized IT-architecture transforms this tool into a powerful learning object inside LMS i.e. in the context of distance learning.
The proposed test is composed by 15 questions with 4 possible answers, only one correct. The test is considered passed if more than 11 answers are correct (greater than 70%). Passing test do not ensure any advantage during final exam and, at the same time, students not passing test can even decide to participate to final exam. This solution is clear considering that we are talking about a distance learning course in which students are free to use proposed material or to study using different books or material. For this reason, learning tools are strongly suggested by instructors but not mandatory to pass the exam.

Database preparation

In order to satisfy the initial request to have "always different test" the preparation of the database of questions is fundamental since it must provide a huge number of possibilities. Moreover, the database must be structured to identify questions related to single course part. This additional request arises from the possibility to have custom questionnaire relative to the entire program or to single arguments.
In our case, we prepared a database of 500 multiple answer questions with four possible answers. Obviously, this can be considered as a starting database, always updatable with the inclusion of new questions.
The initial chosen value is determined by statistical consideration on the selection mechanism. Starting from the requirement that students must have different questionnaire every time they ask for a test and the test itself is composed by 15 questions, using a some hundreds entries database (greater than 300) satisfies our starting requirement.
In order to distinguish questions relative to different arguments, each question must be identified using a "tag". In this first version of the product, we decided to give to students the possibility to choose between 3 different possibilities:

- Test on first course part: Mechanics and Thermodynamics
- Test on second course part: Electromagnetisms and Optics
- Test on entire program.

Obviously, the first two choices will be used by students to test their knowledge during preparation while the third choice will be used as self-evaluation before going to final exam.
The division of the program into two main blocks was driven, as usual, by statistical and didactical considerations. Starting from a database of 500 questions, about one-half for each part, we have,

even choosing one part, a sufficient number of different possible tests i.e. our database is able to satisfies the request "always different test". Obviously, a database upgrade will allow a finest division permitting also the selection of single argument.
During database preparation, we only add a different "ID-Tag" to each question:

- ID:1, for part 1
- ID:2, for part 2

This tag will be then interpreted by code to select desired test (see next section).
For the sake of clearness, we report in Figure 1 an example of question. Since our tool was developed for Italian students, we translated this question to show clearly an example of database entry.

The motion equation for a uniformly accelerated particle can be written as:

a) $x(t) = x_0 + v_0 t + a(t - t_0)^2 / 2$
b) $x(t) = x_0 + v_0 t + a(t - t_0) / 2$
c) $x(t) = x_0 t + v_0 + a(t - t_0)^2 / 2$
d) $x(t) = x_0 + v_0 + a(t - t_0)^2 / 2$

Right answer: A
ID:1

Figure 1. Example of database entry

As shown, each database entry consists of:

- Text of the question
- Four possible answers (a, b, c, d)
- Indication of the right answer (to be read and interpreted by source-code)
- ID-Tag (1, 2)

The entire database consists of a "text" file simply readable using different programming languages.

Code and questions selection

As already discussed in previous section, the core of the code is relative to database interpretation and questions selection.
For this part, as already discussed, our initial requirements are: possibility to select single part of the course and random selection of 15 different questions. The code developed in our case exploit the standard random generator included into JAVA compiler with an output between 1 and 500 (question's number) (Niederreiter, 1978; Shaykhian, 2007). This solution guarantees a sufficient periodicity in the generated numbers since the length of the pseudo-random sequence is long

enough to ensure "always different test".
After first question selection, during following steps, even if the statistical occurrence of this possibility is very low, the code check if the random generated number corresponds to an already chosen question. This mechanism is better illustrated in Figure 2. Obviously, code also checks the a priori selection about the part of the course or the entire program (user input).

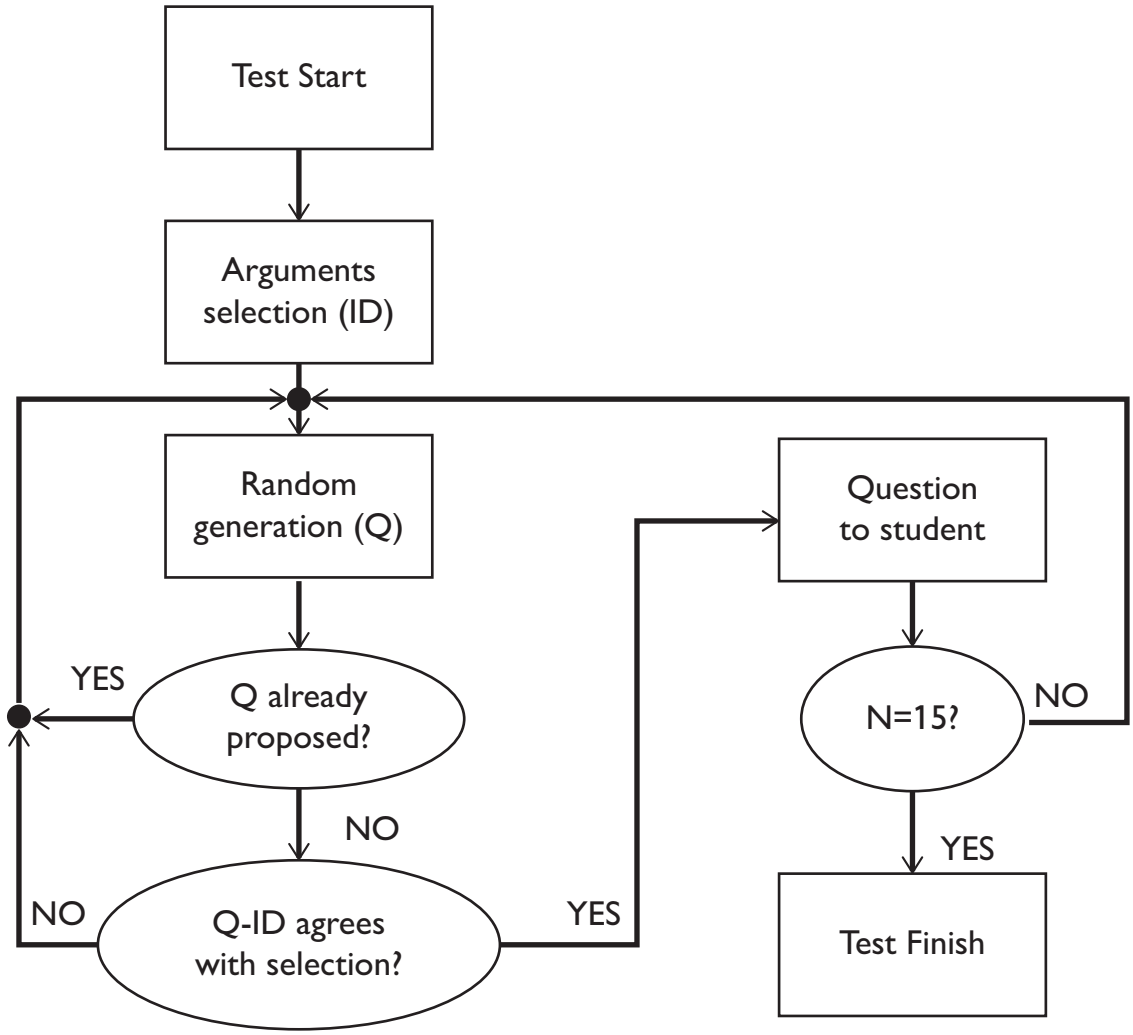

Figure 2. Schematic flowchart of the TEST code

At the end of the questionnaire, i.e. when student has completed the fifteen scheduled questions, user is redirect to final part for report and communication. This part will be discussed in the following sections.

Student's fruition

The realized Multiple Answers Questionnaire has been added to our LMS together with the others learning objects. When asking for a test, and before first question, a detailed instructions page has been created to explain test importance and functioning.

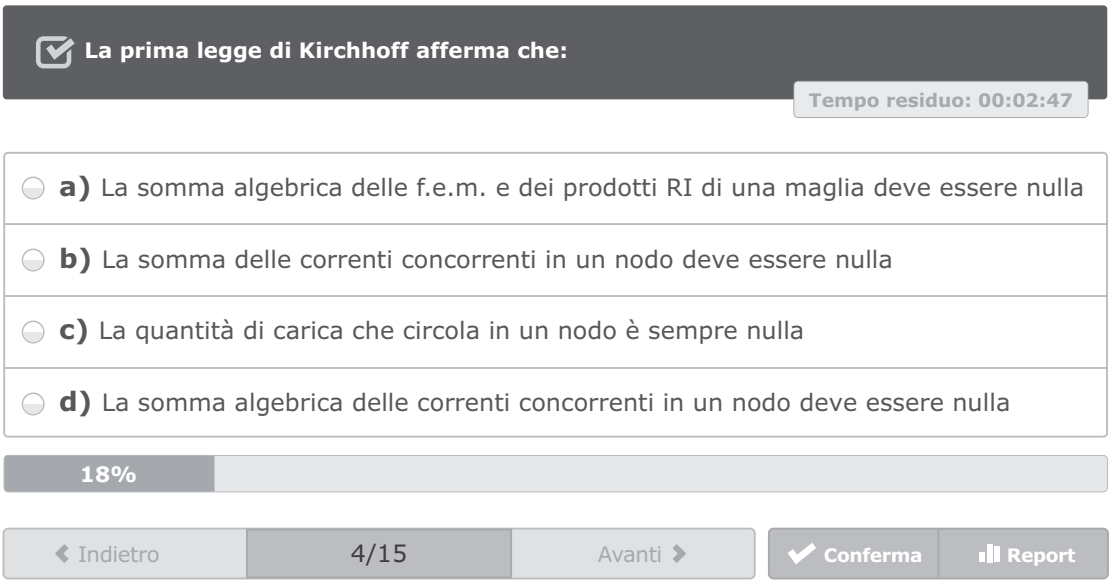

Figure 3. TEST fruition for students.

Once selected the arguments, test starts, and the procedure submits to student one question a time on screen. The maximum time to answer to each question has been fixed to 3 minutes. This value has been chosen taking into account that some questions are not definitions but simple exercises requiring thinking and ability with formulas and theorems. Moreover, this time has been fixed to give to students the possibility to meditate on questions avoiding stress due to time but also to do not give to students the possibility to consult course materials.
In Figure 3, an example of "student fruition" is shown. According to the figure, in the top of the screen appears the text of the question and below the four proposed answers (among which the student must select the one he assumes correct). In the top-right part a chronometer indicated time remaining to answer. In the bottom part of the page, navigation buttons are present together with test progression (question X over 15). A colored navigation bar is also present to show test percentage progression.

Student report and interaction with teacher

Once completed the fifteen questions, as anticipated, student is redirect to the so-called "report page". Here a summary of the given answers, together with the correct/wrong indication is present. At the end of the page, a button is present to "send email" to himself inserting a private mailbox, in order to have an activity record, and to teachers. The possibility to send the report to instructors is left optional but for not passed test a pop-up is visualized to suggest using this feature.

The summary report eventually sent to teacher includes: name of the student, date and time of the completed test and a detailed report of the single questions: question number in database, student answer, correct answer and time spent on each question.
Once received the report, the teacher task is to contact student to explain his errors, to indicate course arguments not fully understood or to suggest additional readings and material. This aspect is fundamental in both self-assessment during study and for a better preparation before final exam.
Using this test, teacher can establish a direct and efficient touch with students.
To our experience, ordinary students can exhibit difficulties in contacting the instructors. This could due both to timidity or because they fear to show weak aspects in their preparation.
As a matter of fact there may be topics that students erroneously consider properly understood (we can call these topics: "urban legends").
Using the test here proposed, students have an objective assessment tool and meanwhile an indirect communication method to establish a contact with instructors.

Statistical analysis

Test reports are dispatched not only to teachers but are also stored in a dedicated database.
While a single report is important to establish a personal contact between students and teacher, the whole dataset can be used to perform statistical analysis either about student community or about the effectiveness of learning material (Fontana, 2005).
Analyzing reports, Instructors can evaluate to which extent the learning materials are unfriendly (i.e. not easily understandable) to the community of students. Thus, as already remarked, this procedure works not only as a tool to check students preparation but also teaching quality.
As an example, if the analysis of reports returns that a remarkable portion of students give wrong answers to given questions, we are warned that the related part of the program is not well explained or the learning material provided is insufficient.
Once again, to our opinion this result must not be intended as an exam for teachers but, rather, as an objective estimate of course quality and a precise suggestion for improving teaching.
To perform a simple statistical analysis of data sample, reports are stored into database in csv format. These files can be managed simply using ordinary "spreadsheet software" permitting the creation of tables and graphs.
The first version of the test has been released to students on early December 2014. Once a statistically reliable data sample will be available, a large number of considerations may be performed.

Conclusions and future perspectives

The simple idea of a "multiple answer" questionnaire (a testing approach widely diffused in a large variety of fields) has been just a propeller to develop a powerful (original and new under several aspects) "learning tool/self-assessment" for students.
Using this test, the increase of the "level in preparation" along the "reading period" or just before final exam can be self-evaluated (avoiding either misleading self-confidences or overvaluation).
The realized architecture allows a straightforward "PtoP" contact between students and instructors.

The actual results of our proposal are: a "dedicated mentoring", a useful help and a global reinforcement of student autonomy toward his study method.
It must be underlined that collecting test reports in a dedicated database results in the possibility to tightly check and evaluate also the course quality. The proposed tool is important to check clearness and completeness of broadcasted teaching material. It can suggest continuously also where and how modify or add new readings, laboratories, multimedia products, etc.
Future releases of our database (with a larger number of questions) will permit not only the division of the submitted questionnaires in two (or more) parts but it also will give the possibility to ask for test on specified arguments according to student special needs. Obviously the number of questions is always driven by the statistical need to ensure sufficient combinations of different questions.
One of the most favorable aspects of this development is that the realized IT-architecture can be replicated, without code changes, for every course and for large varieties of teaching areas. Since this test is fully integrated into the LMS of Guglielmo Marconi University, it will be used for different subjects asking teachers only to prepare a sufficiently big questions database.
We are also working to organize a well-defined set of request for reports analysis. Our idea is to realize a dedicated page inside LMS teacher area, to allow a fast and clear set of DB-queries to show parameters able to measure both students and course quality. This aspect will be important especially considering an extension of this test for different courses and for different teachers, not necessarily skilled with statistical analysis.
A further development lays in the possibility to preserve questionnaire reports for each student. This corresponds to the possibility to store in a detailed way formative pathways. The proper analysis of these pathways has a great informative potential either for each student or (mainly) for teachers.

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Sintesi

Il passaggio dalla scuola secondaria all'università può rappresentare un momento ostico per molti studenti a causa della transizione da un sistema fortemente presenziale e comunicativo ad uno, necessariamente, più dispersivo e anonimo. Sotto diversi aspetti, questa transizione è un momento di crescita per i ragazzi che, trovandosi a dover organizzare il loro studio in modo completamente autonomo, si responsabilizzano. Molto spesso, però, questo passaggio, che non è sempre immediato, causa l'abbandono dei corsi, soprattutto durante il primo anno di università. Per contrastare gli effetti appena citati è utile fornire agli studenti una serie di attività di autovalutazione. Il compito di tali strumenti consiste nel fornire ai discenti, in modo continuo, indicazioni chiare relative al loro livello di apprendimento.

In questo articolo, viene presentato un prodotto multimediale appositamente sviluppato per fornire un sistema di autovalutazione. Grazie alle tecnologie informatiche proprie dell'insegnamento a distanza, tale prodotto offre una serie di vantaggi tra cui quello di stabilire un continuo ed efficace collegamento tra studente e docente, al fine di monitorare e incrementare la qualità non solo dell'apprendimento ma anche dei corsi erogati.