A technological enhanced self-assessment activity to reduce university drop-out

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ABSTRACT. Passage from secondary school to university can be difficult for our students if they are not properly followed by instructors. To curtail the high university drop-out rate detected in various countries, a set of self-assessment activities must be devised by teachers to furnish students an important help in organizing their personal study-method and to gain 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 inserted into the Learning Management System and 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, Future developments, Physics, Self-assessment*

E-Learning growth and future development

The last decade has assisted to a worldwide tremendous development of request of distance education. At the very beginning of this occurrence, technological based materials (video conferencing, online lessons, animations, etc.) had represented only a complementary option to support traditional courses. Currently, due to the compelling technological improvements and thanks to a huge R&D work done in the field, a large number of institutions offer completely

online courses. This "modern" educational model does not concern only university courses but also professional update seminars, life-long education and massive open courses (MOOCs). Therefore under some respects to cope these technologies is becoming a compulsory path.
The reasons that drive up this evolution are self-evident. Distance learning offers the possibility to attend a course satisfying different (suitably tailored) learning styles and schedules. This allows a variety of communication methods and, moreover, leaves to the worker students to attend university courses at their will.
The future scenario for the e-learning, from the point of the different involved resources, must be properly itemized.
Without any doubt, the creation of e-tivities to simulate traditional events of laboratories is an important field to be pushed (Salmon, 2013).
As otherwise discussed in various articles (Martini, 2014a), laboratory activities have an important pedagogical role in the preparation of our students (not only in scientific courses). Especially when STEM courses are concerned.
Multimedia products can represent reliable substitutes to the traditional lab since to a different level they can simulate virtually all aspects of a traditional experience.
Unfortunately, having "didactical valid" solutions implies big investments from institutions but this can be bypassed creating dedicated university networks to realize specific shared database.
Today, always thanks to solutions coming from technological development, real hands-on activities can be created for distance learning. Boards like Arduino and Raspberry Pie can be exploited to realize custom laboratory equipment involving different skills: mechanical drawings, electronics, project, etc. Moreover, interesting and useful laboratory experiences can be realized exploiting devices like smartphones and tablets using their internal sensors to build didactical lessons. Results of these activities are real home-made instruments usable to organize laboratories (Martini, 2014b). Last but not least, especially when considering distance learning, students, with a very small cost, can even conduct these experiences at home.

Present comparison between traditional and e-learning

When comparing traditional and distance learning, another aspect to be kept into consideration is the creation of a well-defined set of quality parameters (Phipps, 1999). Despite the large activity developed in this field, we have not yet succeeded in the creation of a reference standard (Kidney, 2007). As discussed for the creation of a didactic laboratory, the assessment of parameters measuring the quality of the distance learning remains an important field on which R&D activities ought to be focused.
Looking for an objective comparison between e-learning and traditional education the acknowledgment of basic quality parameters summarizing all aspects of distance education remains a mandatory step.
Although firmly established milestones are still missing today, we can state that distance learning is fully comparable with traditional education. Actually most of pedagogical aspects normally grounded on traditional learning can be well reproduced virtually.
As a consequence, nowadays students can choose their education including "the distance university option" not as an ancillary escape but, rather, as the main course in what is normally defined as the

"shopping list" (i.e. the set of institutions considered desirable by a student). As otherwise suggested, anyway, the definition of quality parameters is unavoidably mandatory to let to strictly compare (i.e. one-by-one) traditional and distance universities.
Notwithstanding these considerations are well known, as one thinks about the future of e-learning, one possible solution is to concentrate investments (research development budgets) on those aspects in which traditional university have failed. In other words, we can focus ourselves to contribute to the solution of historical problems (never solved or even signaled). Under this respect, especially for some countries, students drop-out rate still represents an hard to manage problem.

University drop-out: OECD situation

To fully understand the entity of the problem connected to the university drop-out rate, we report in Figure 1 these values for some countries as reported in the annual report of the Organization for Economic Co-operation and Development (OECD, 2013).
For a single country, the value represents the percentage of student starting a university level course but dropping out before its completion. The average drop-out rate for these countries is around 30%. This means that one student over three decide to continue after secondary school but he interrupts his course before completion. The situation is even worst looking at countries like Italy, US, New Zealand, etc. where the rate is almost two times the average.

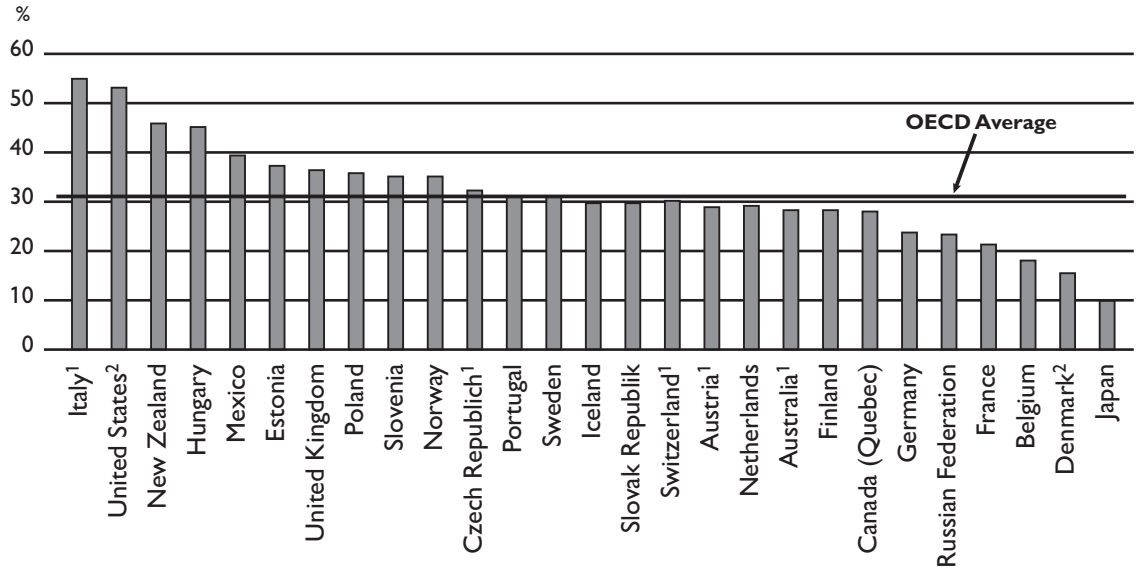


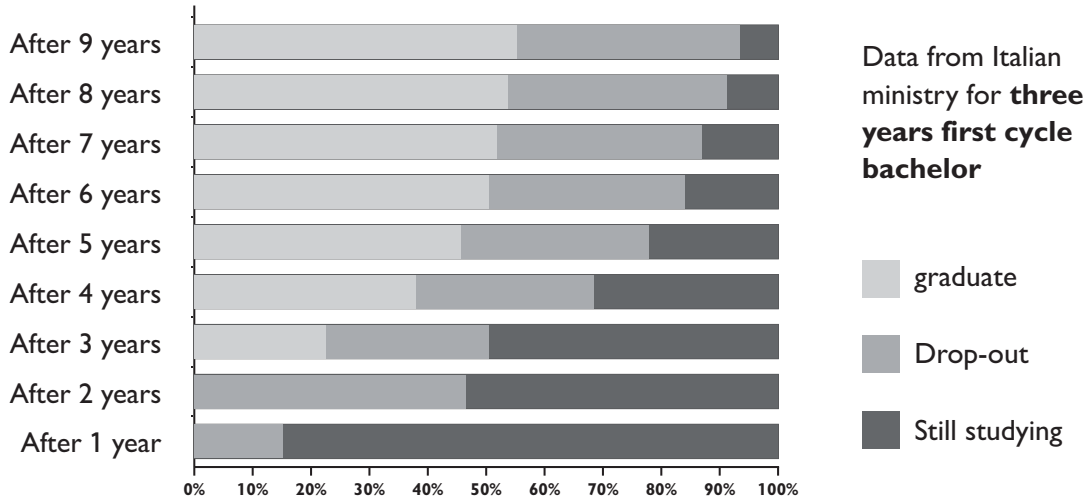
Figure 1. University drop-out rate for OECD countries

If the average value is too high, these last considerations are completely not acceptable for developed countries.
The high drop-out rate is a still unsolved problem of the traditional university system. Obviously, consideration about these numbers had been carried out and a vast literature exists on this field (Rumberger, 2012). Since, as already discussed, comparison between traditional and distance learning

has always driven the development of this latter modality, a deep analysis of the origin of this high drop-out can be fruitful to draw the possible e-learning development future scenario.

Italian situation and students opinion

As discussed in the previous paragraph, Italy represents an important example to understand what pushes the high value of the drop-out rate and, eventually, to understand what the institutions could do to decrease this trend.



(Fonte MIUR - Anagrafe Nazionale Studenti)

Figure 2. Italian data for the three years first cycle bachelor

The Italian Ministry of Education, MIUR, has deeply analyzed this problem reporting a good set of statistical parameters on the annual report published by an external agency (Anvur, 2013). In particular, as shown in Figure 2, when considering the three years first cycle bachelor in use in Italy, only 23% of students graduate after the scheduled period of three years. This aspect is even worst when considering that after 9 years, about 7% of the students is still studying i.e. they have not yet completed their course after three times the expected duration. Concentrating on drop-out rate, about 40% of initial students leave their first cycle and, even more important, half of these students leave during first year. As reported in Figure 1, the situation is even worst when considering the entire university system for which the drop-out rate is slightly higher.

When discussing this aspect, strategies and plans are always welcome but surely the most important opinion to be considered is the one coming from students.

A dedicated survey has been conducted at Bari University, a traditional institution with a wide number of different courses, asking to students what can be the aspects to be improved to prevent drop-out. Results of this interview can be summarized as (Bari University Annual Report, 2010):

- Better quality of learning objects
- Specified solution for workers-students

- Greater availability of teachers
- Personalized tutoring

In other words, these are the aspects felt weak from the students of a traditional university and that participate to keep high the drop-out rate we are discussing.
Analyzing one-by-one these suggestions it is clear how distance learning is, by definition, not potentially sensitive to these problematic (as traditional university is). A system specifically developed without time-schedule is perfect for workers-students. Moreover, using technology, teachers and instructors can personally follow students offering a "personalized tutoring at will" and obtain, from their feedback, suggestions and observations to increase the quality of learning objects (as well as to improve the teaching procedures).
The last aspect to be analyzed is the high drop-out rate during first year. Surely, all the considerations already presented contribute to this problem but this aspect must be deeply analyzed to understand its origin.

First year drop-out

Passage from Secondary school to an Academic Level could be not a quite easy step for the majority of students. A vast literature exists on this aspect and we report in bibliography some explicative examples (Cromer, 1997; Hillman, 2005; Arons, 1995). While in secondary school students are settled in uncrowded classes, at University, usually, they are hosted 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, 1998). The most important consequence of this disease is the high drop-out rate (mainly during first years of their academic course) (Gerdes, 1994).
From the point of view of students, university organization must offer simply accessible services and provides 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.

Self-assessment activities

The considerations presented in previous paragraphs push teachers activity in a well-defined direction. As suggested directly from students, to improve learning quality, duty of the instructors cannot be only lessons preparation. As already discussed, technological based learning can be the optimal solution to offer: personalized tutoring, better quality of learning objects and, moreover, to create specific solutions to follow students, especially during first year. In this sense, these activities

must allow our students to evaluate their progress during study, creating, step-by-step, a personalized study method. These learning tools are also known as "Self-Assessment" activities (Boud, 2003).
Self-Assessment exercises must be realized step-by-step permitting students to measure their progresses 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.
Well-defined self-assessment activities can strongly motivate students permitting a more complete preparation (McMillan, 2008). Obviously, results of self-assessment activities must be simply interpretable avoiding confusion and precisely indicating parts in which students preparation is not sufficient.
As far as the first year subjects, 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 monitoring 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.
In our experience, the "pass-rate", intended as the number of successful examinations over the total, of General Physics courses is quite low. This is either due to the difficulties of students to follow a fruitful study-method and to organize their work in autonomy.
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 products 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.
In this context, we have realized a multimedia product with the twofold skill of self-assessment during "reading period" and self-evaluation before final exam. Following students observation already discussed in the previous sections, the structure of our didactical tool must satisfy a certain number of initial requirements that can be summarized in:

- Activity with different questions every time
- Possibility to choose arguments to act as self assessment during study
- Possibility to integrate the entire course program to have a self-evaluation tool to be used before final exam
- Possibility of interaction with teachers
- Direct teacher control

While most of these conditions have been justified in previous sections, 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.

Test choice and realization

Trying to fulfill 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.

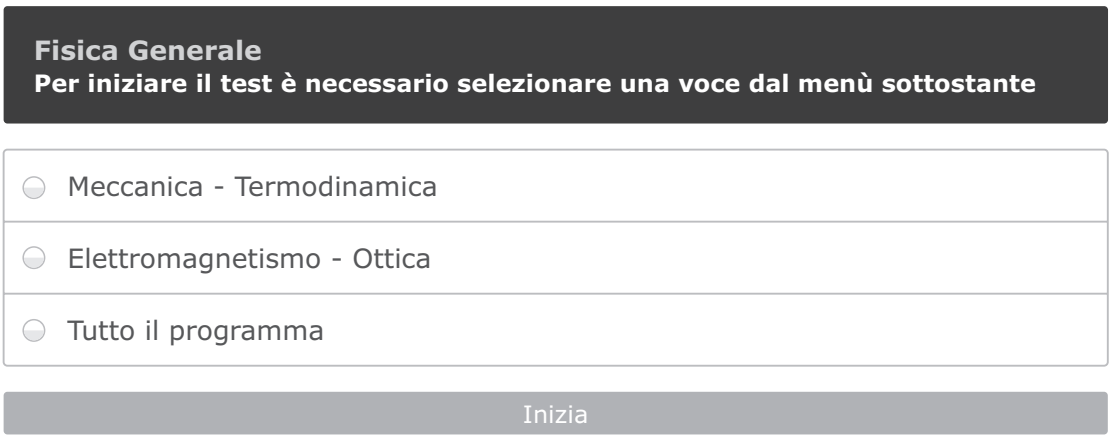


Figure 3. Pre-selection of arguments for questionnaire

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.

To satisfy our initial request to have always different test, we realized a database of 500 questions from which the 15 questionnaires are randomly selected. Each questions is identified by a code permitting arguments selection.
In the specific case of Physics courses, we decide to initially 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

The arguments pre-selection menu is shown in Figure 3. 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 arguments.

Code and fruition

As already discussed in previous section, the core of the code is relative to database interpretation and questions selection.

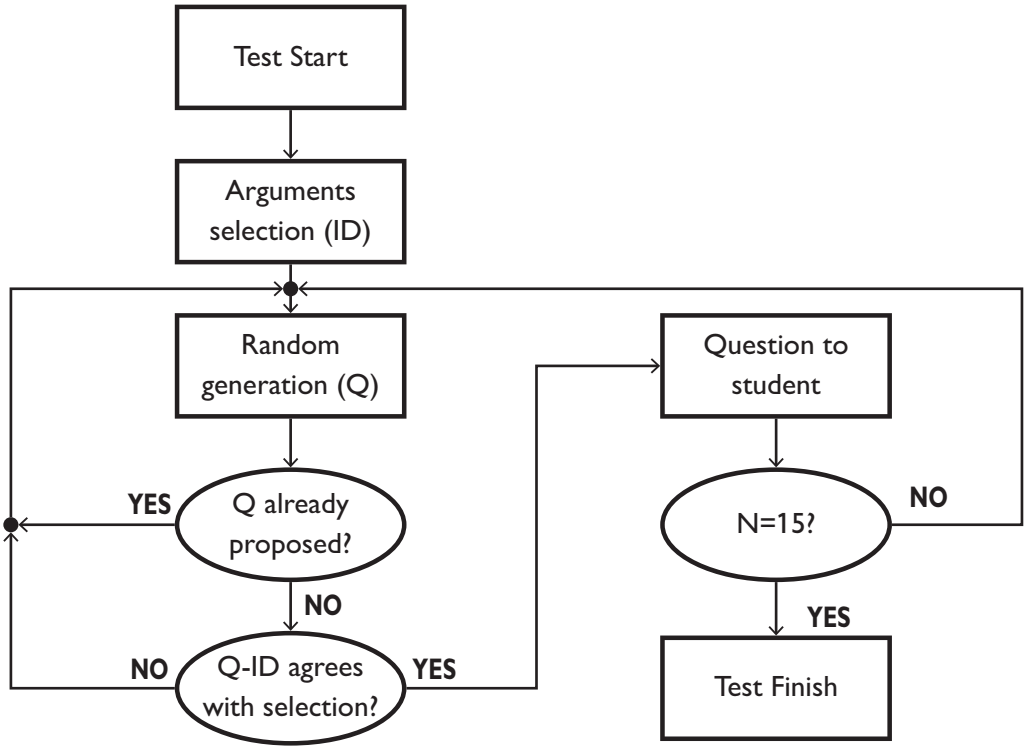


Figure 4. Schematic flowchart of the proposed TEST

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 exploits the standard random generator included into JAVA compiler with an output between 1 and 500 (question's number) (Niederreiter, 1978; Shaykhian, 2005). 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 4. Obviously, our code also checks the a priori selection about the part of the course or the entire program (user input).

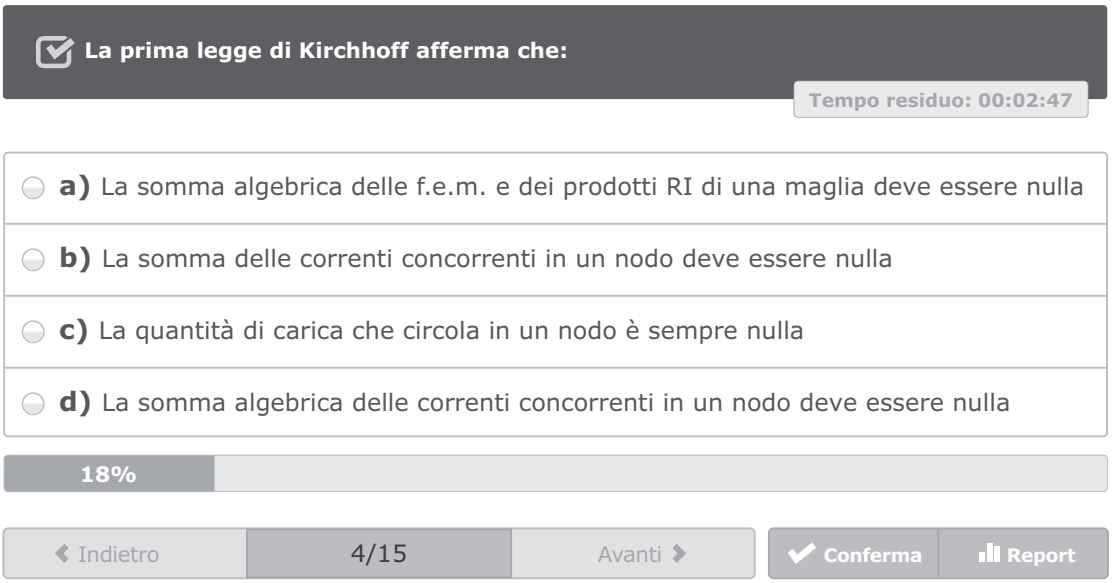


Figure 5. Question example. Even if the test has been realized in Italian, in the scheme are clearly reported: question text, the four possible answers, navigation toolbar and time remaining to answer

Once selected the arguments, test starts, and the procedure submits to student one question a time on screen (see Figure 5). 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 only definitions but also 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.
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.

Final 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, teacher task is to contact student to explain 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.

Questionnaires analysis

As already discussed, test reports are not only dispatched to teachers but are also stored in a dedicated database where a search-engine has been realized exploiting time information, course and matriculation number.
Collect the entire tests sample permits important didactical considerations. While a single report is important to establish a fruitful personal contact between student and instructor, analyzing the questionnaires history of a single student permits the analysis of his learning progress. Moreover, the whole dataset coming from students' community is important to perform statistical analysis either about students 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. In particular, this last aspect will be better analyzed in following sections.
For the sake of clearness, in the following section we will report the result of the statistical analysis performed on the preliminary sample of questionnaire analyzed for Physics courses.

Physics course analysis

Collecting the entire set of completed questionnaires, an objective analysis can be done on the results obtained by students. As already explained, this system permits to correct immediately a single error thanks to the direct connection established between student and instructor.
Moreover, the realized database permits also to have an indirect and objective quality parameters for didactical materials. 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 not sufficient.
Let us better explain this stuff presenting a real example. Even if we implemented this self-assessment activity only since few months, the number of completed questionnaires collected is sufficient to perform a preliminary statistical analysis.

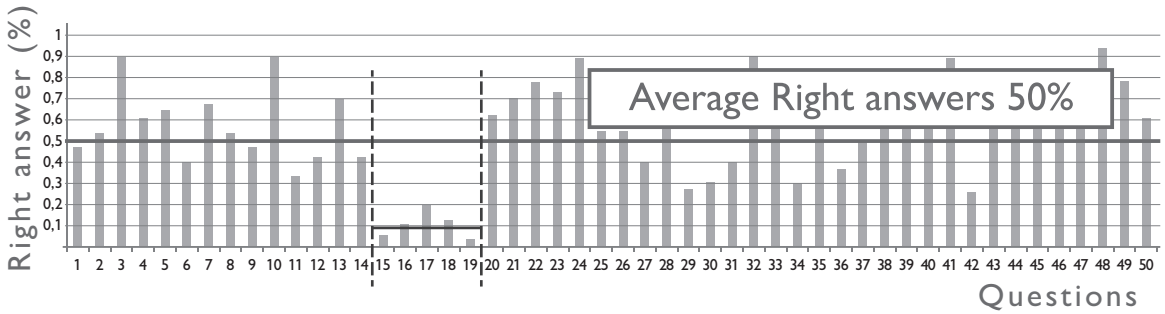


Figure 6. Percentage of right answers for a sub-sample of 50 questions over 500 (entire database).

In Figure 6 we report the percentage of correct answers given by students selecting a sub-sample of 50 questions over the entire database (500 questionnaires). This selection was done to show clearly the effect we want to emphasize. Looking at this picture, we have an average right answers ratio of 50% i.e. every time a question have been inserted into a questionnaire, one student over two has given the correct answer. Obviously, since the questions are randomly selected the number of occurrences for each question is slightly different.
Analyzing Figure 6 we identify a set of questions (from 15 to 19) for which the average right answers is around 10% i.e. only a student over ten has correctly answer to these questions. Studying database, we realized that these questions are all relative to a single argument of our course that is, to be precise, Entropy.
Even if Entropy is one of the most difficult arguments for Physics Course, especially considering its implication in transversal subjects, the difference observed in Figure 6 is not negligible and push to a specific reasoning. If only a student over ten is able to correctly answer to questionnaires on this part, this means that the didactical material proposed for this argument is unfriendly to our student and/or is not sufficient to fully understand this concept.
Following statistical results, we decide to add to our material a new series of didactical lectures regarding Entropy and its importance into Thermodynamics. During next months we will constantly re-analyzed and update Figure 6 to study the effect of our solution. Surely, if the material becomes "more friendly" we will observe an increase in the average right answers ratio for the sub-sample considered.

This simple example clearly shows how this self-assessment activity has a double role useful for both students and instructors. In other words, the simple idea to add to this learning tool a database to collect completed tests permits to follow directly the progress of each student but contemporary provide, through a specific data mining, an objective and precise quality parameter for didactical materials. Surely, the starting point to have a good product is the construction of an ad-hoc questions database. Each question must include a set of possible answers not trivial but including what we previously defined as "urban legends" i.e. historically bad understood concepts.

Conclusions and future improvements

Still today, students drop-out rate from university is too high especially during first years. This is in part due to the difficult passage from secondary school to university where we ask to our students to create a study-method and gain a self-government that permits to study in complete autonomy. The high drop-out rate, as reported in literature, can be contrast offering a step-by-step growth followed by instructors that offer a personalized tutoring. In particular, self-assessment activities can be the simplest solution to satisfy all these requests.

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. The importance of these solutions is clear both for traditional and distance learning. In this last case, the support coming from modern technologies permits to better exploit self-assessment activities creating an immediate feedback for students and permitting a simple connection between student and instructors.

To give to our students an always different, but comparable in difficulty, test, we create a large database containing 500 questions. A random generator then select 15 questions to create a test. Students have also the possibility to decide arguments creating a tool usable both as self-assessment during study and as self-evaluation before final exam.

The real additional value of this learning tool is in the database added in which the entire set of completed questionnaires is stored. Identifying each student by his matriculation number, we can follow and check the evolution of each student correcting each doubt or error. Moreover, this database can be exploited to perform statistical analysis on the entire student community. As shown, the analysis of the number of the right answers for each question permit the identification of hard-understandable arguments identified by simple and well-defined quality parameters. Results of this analysis can be an important guide for instructors that can use these evidences to integrate/change/modify learning materials.

The important results obtained with this activity pushed our university for the creation of a dedicated web-portal for the realization of self-assessment questionnaires. Thanks to the simplicity of this solution, multiple answer questionnaires can be used for every subject. The realized web-portal, now in test as beta-version, simply permits: the creation of the questions-database, decide a maximum time different for each question, the insertion of specific tag to identify test arguments and to ask for the publication of the test into the Learning Management System. Moreover, the portal permits the analysis of single students and of the entire community delivering a small number of significative plots simply interpretable also by instructors not skilled in statistical analysis. This last item is fundamental to provide, in a graphical mode, the trend of the variables useful to follow students and to make consideration on learning materials.

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Sintesi

Uno dei principali e mai risolti problemi delle università tradizionali, specialmente per alcuni corsi di studio, è l'alto tasso di abbandono degli studenti. Tale effetto appare notevolmente marcato durante il primo anno di corso raggiungendo percentuali molto elevate in alcuni paesi dell'OCSE, Italia in testa. I motivi alla base di tale fenomeno sono molteplici e tra questi, come evidenziato da alcuni studi condotti sugli studenti frequentanti, la difficoltà di organizzare lo studio in modo autonomo e la mancanza di una guida da parte dei docenti.

Per contrastare l'elevato tasso di abbandono, un test di auto valutazione è stato costruito sfruttando la moderna tecnologia informatica, prerogativa dei corsi a distanza. Tale test è basato su una batteria di domande a risposta multipla, ma integrate con un database specifico e una piattaforma dedicata. Per prima cosa, il sistema seleziona in maniera casuale le domande da un database molto vasto (e facilmente estendibile) mescolando casualmente anche l'ordine delle risposte. Inoltre, lo studente ha la possibilità di selezionare gli argomenti sui quali esercitarsi oppure scegliere l'intero programma del corso, realizzando in questo modo sia un'esercitazione che lo accompagni durante lo studio sia un test di auto valutazione prima dell'esame finale. Al termine di ciascun questionario, il discente ha la possibilità di inviare il report delle risposte al docente in modo da stabilire un contatto diretto e correggere immediatamente eventuali errori o false convinzioni.

L'aspetto più innovativo di tale questionario è che tutti i test completati vengono archiviati nel database consentendo una valutazione rapida dei progressi di ciascuno studente, ma anche una analisi statistica dei risultati. Tale strumento offre un'analisi qualitativa del corso al docente, evidenziando parti poco chiare e che richiedono integrazioni o modifiche per essere fruite al meglio dagli utenti finali.