A Take-home Exam to Assess Professional Skills

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Abstract – **Professional Skills, such as the ability to communicate effectively or the ability to gather and integrate information, are not easy to teach or to assess. A traditional exam is not the best way of assessing these skills because it is limited both by time and by the resources students are able to consult. Moreover, in a traditional exam it is difficult to assess if professional skills have been acquired in depth. In this paper we propose to substitute the traditional exam by a take-home exam in which students have more time to solve the questions and are not restricted by the sources they can consult, thereby providing a highly educational task in which students experience a deep learning process. We also analyze what kind of questions should be asked to evaluate professional skills, as well as analyzing the potential drawbacks of these kind of exams (such as inappropriate student behavior). Finally, we show the results of one subject at the Barcelona School of Informatics, in which the take-home exam replaced the traditional exam. This course has been taught over 11 terms with good results.**

Index Terms – Assessment, Comprehensive Exam, Formative Assessment, Professional Skills.

INTRODUCTION

In the European Higher Education Area (EHEA) the new curricula must be defined by the skills the students are expected to acquire. There are skills like applying knowledge of mathematics, but also other skills like critical thinking, the ability for oral and written communication, and the ability to gather and integrate information.

Skills can be classified into hard and professional, although some organizations list them together (as in the ABET engineering criteria). Assessing these skills is not an easy task, especially in the case of professional skills. A traditional exam is not the best choice in this regard, because it is limited both by time and by the resources students are able to consult, and students themselves are placed in a stressful situation. Therefore, it is not possible to ask questions that require the gathering and integration of information, or questions which require complex thinking to process multiple data.

In this paper we propose a take-home exam in which students have more time to solve the questions (for instance, one week), so they are not restricted by time and by the lack of information resources. This enables us to evaluate some skills that are quite difficult to assess with a traditional exam. The exam lasts for several hours spread throughout the week, providing a highly educational task in which students perform a deep learning process. In fact, a traditional exam is mainly aimed at assigning grades, while a take-home exam is designed for both assigning grades and learning.

In the paper, we analyze what kind of questions should be asked in a take-home exam in order to evaluate professional skills such as critical thinking, written communication, information managing, or ethical and professional responsibility.

While the take-home exam has several advantages, it also involves some drawbacks, such as the risk of inappropriate student behavior or the need for coordination between simultaneous courses to avoid possible peak overloads. In the paper we also analyze how to overcome these potential drawbacks.

Finally, we present the implementation of all these ideas in the "PC Architecture" (PCA) course of the Barcelona School of Informatics. This course has already been taught over 11 terms, with good results in terms of goals achieved. In the paper we also present the results of an exhaustive survey answered by the students.

RELATED WORK

Our proposal is closely related with constructivism, following the idea of shifting the educational perspective from the teacher to the student, from teaching to learning. Constructivism, developed among others by Vygotsky and Piaget, holds that the most optimal learning environment is one where there is a dynamic interaction between instructors, students and activities that provide opportunities for students to create their own truth, thanks to interaction with others. This theory, therefore, emphasizes the importance of culture and context for understanding what is happening in society and for building knowledge based on this understanding.

For example, constructivism tells us that if you, dear reader, read this text, you will probably forget it in a short period of time. On the other hand, if you explain the concepts of this paper to a third person in your own words, pausing to meditate (and study) when you find a gap in your speech, then the concepts you are reading about will remain more deeply imprinted in your mind.

Criticisms of constructivism are mainly based on the assumption that students want to learn, and also ignore the cognitive abilities of memory in learning. However, many studies indicate that the methods developed from

constructivist concepts have a very positive influence on learning.

As regards assessment, several authors use the distinction between summative and formative assessment [1][2]:

- Formative assessment: the main objective is learning. Information is used to identify strengths and weaknesses, motivate students to study, create learning activities and provide feedback to both students and teachers.
- Summative assessment: the main objective is judgment. Information is used to assign grades and certify mastery.

Gibbs and Simpson [1] present ten conditions under which assessment supports student learning. In that work, the authors demonstrate the influence of assessment on the volume, focus and quality of studying and learning.

Biggs [2] emphasizes that "learning takes place through the active behavior of the student: it is what he does that he learns, not what the teacher does". In this sense, we believe that students work out for themselves what counts – or at least what they think counts – towards passing the course, and they orient their efforts accordingly. Quantitative assessment on teaching and learning then leads to what Biggs names the *backwash effect*: he describes a scenario in which the student learning is governed by their need to know how to pass the assessment, rather than by the curriculum. Thus, "students in their search for marks fail to see the structures being learned; in counting the trees, they get lost in the wood" ([2], p.233).

Felder and Brent [3] state that "Another well-known educational principle is that the assessment drives the learning. If the students know they are going to be held individually accountable for course material, most will make a serious attempt to learn it; without the individual accountability, many overburdened engineering students will choose to spend their time in more productive ways."

Entwistle [4] makes a distinction between "deep learning (transforming)" and "surface learning (reproducing)". When deep learning takes place, students are able to relate ideas to previous knowledge and experience; to look for patterns and underlying principles; to check evidence and refer it to conclusions; to examine logic and argument cautiously and critically; and to become actively interested in the course content. On the other hand, when surface learning takes place, students study without reflecting on either purpose or strategy; they treat the course as unrelated bits of knowledge; they memorise facts and procedures routinely; they find difficulty in making sense of new ideas presented; and they feel undue pressure and worry about work.

Finally, the well-known Bloom taxonomy [5] distinguishes six levels of competence in the acquisition of educational objectives: knowledge, comprehension, application, analysis, synthesis and evaluation. The first three levels are supposed to be achieved by all students at the end of their Degree studies.

THE TAKE-HOME EXAM

I. Why a take-home exam?

In our experience, a traditional exam makes it difficult to work on formative assessment. Students find themselves in a stressful situation and focus their attention on a task restricted by time, in which they have access to a limited amount of information (often only the information they have memorized) so their efforts are devoted to passing the exam rather than learning. Thus, since assessment drives the learning, preparation for traditional exams conditions students to surface learning, thereby leading to the backwash effect previously described. Moreover, with a traditional exam it is difficult to demonstrate what level of competence (according to Bloom's taxonomy) students have acquired.

We are therefore of the opinion that the traditional exam is oriented toward summative assessment, and has little positive influence on deep learning. This does not mean that summative assessment lacks importance: it allows us to certify the mastery of our graduates, which is one of the fundamental objectives of the university. Furthermore, students who have acquired a deep knowledge of the course concepts will succeed in the traditional exam, and probably with a good mark. Nevertheless, while many students make an effort to prepare for a traditional exam and are able to learn by rote in order to retain sufficient knowledge to pass, their learning will be a superficial and quickly forgotten within a short period of time.

Our point is that summative assessment can be achieved just as well with a take-home exam as with a traditional one, with the difference that the take-home exam is more conducive to a deep learning process and a more accurate assessment of the level of acquisition of the skills we wish to assess, especially where professional skills are concerned.

There are several ways of assessing such skills, such as oral presentations, work deliverables, etc., but the traditional exam is usually confined to the assessment of hard skills. This is because the traditional exam is an unfair tool for assessing professional skills: students are under stress, which makes it difficult for them to demonstrate these skills in just a few hours. How can they search for, filter and summarize information? How can they demonstrate their ability in written communication when they often do not have the time to go over what they have written?

Our proposal not only aims to use take-home exams to assess professional skills, but also to demonstrate that it is an effective where hard skills are concerned. With take-home exams, teachers can answer questions that require more time and resources that are not available in a traditional exam. Students will not simply learn "by rote" in order to pass, but will be guided in the learning process:

they are encouraged to express in their own words what they have learned, without time pressure, thereby filling the gaps in their learning process. At the same time, the lifting of time and resource limitations allow the teacher to ask much more sophisticated questions, and also to demand far greater rigor in the answers.

II. Professional skills

According to Smerdon [6], the ABET engineering criteria [7] can be divided into two categories: hard skills and professional skills. These latter include communication, teamwork, understanding ethics and professionalism, engineering within a global and societal context, lifelong learning, and knowledge of contemporary issues. The rapidly changing technology, particularly information technology, outsourcing and globalization make professional skills more critical every day, so how to teach and assess these skills have been the focus of several works in recent years (see, for instance, the comprehensive review by Shuman *et al* [8]).

There are other classifications of these skills, such as those published by SCANS [9] (where they are called *Foundation Skills*), but there is a consensus about some basic skills:

- Information management: the ability to find, select, integrate and synthesize information
- Teamwork: the ability to function in teams (and multi-disciplinary teams)
- Communication
- Critical thinking
- Ethical and professional responsibility, as well as sustainability and social commitment
- Holistic vision of society, especially the impacts of engineering solutions in a contemporary context

In this work, we focus on these six skills.

III. Questions in a take-home Exam

What kind of questions should be asked in a take-home exam? First of all, the exam must consist of questions that cannot be answered by multiple choice, a number or a simple phrase. There must be open questions, with more than one possible solution, in which the way of arriving at the solution is as important as the correctness of the solution itself.

Open questions enable us to assess students' ability to organize, integrate, synthesize and argue the information available. In addition, we can assess their ability to use the vocabulary and concepts in our area of expertise, so we are able evaluate the communication, information management and critical thinking skills.

We recommend questions that oblige students to seek information from various sources to generate their response, and the number of sources and information is very extensive. It is especially interesting to ask questions where the first result offered by the most popular Internet search engine contains erroneous data. Thus we are able to determine whether the student has stopped his/her search at the initial information obtained or whether he/she has compared that information with other sources. Furthermore, most of the information one can find on the web concerning state-of-the-art technology consists mainly of assumptions and misinformation written by non-experts. Learning to decide which sources can be trusted is fundamental nowadays.

As the exam is not bounded by time, students can be obliged to give short, clear, complete, reasoned and concise answers. To avoid the practice of "cut & paste" employed by some students, we can ask for handwritten answers, in which spelling, calligraphy and grammar are all evaluated. Also (as is done in our subject) exams can be printed with watermarks to prevent students from copying them, so they must prepare their answer before writing it down in the exam.

Other types of questions are those in which students are required to express their opinion about a product, system or protocol; questions in which students are asked to compare different products by selecting the most important features and contrasting the advantages and disadvantages of each, as well as questions in which students must choose a product (and justify their decision). This kind of questions enables us to assess critical thinking as well as information management.

Other useful questions for assessing critical thinking are those where students must select 2 or 3 of the most important characteristics of a product from among all its features, and justify why they believe these are the most important. It is also interesting to ask questions in which students are required to choose between multiple options and indicate which is the best solution under certain circumstances (different students may be subject to different circumstances).

The characteristics of the take-home exam allow us to work on some parts of the syllabus that students may sometimes overlook when preparing for a traditional exam. For instance, part of the agenda of some courses is devoted to issues such as sustainability, ethics, or safety and health. Students avoid these issues when preparing for a traditional exam, because they occupy only a small part of the syllabus, and teachers tend to be more interested in the technical aspects of the syllabus. Therefore, questions addressing these issues seldom appear in the exam, and if they do so at all they account for only an insignificant part of the final mark. The inclusion of such questions in the take-home exam obliges students to devote more effort to them, which in turn helps us to assess the skills associated with them.

In addition, questions that require a holistic vision of the subject (i.e. those requiring a lot of information and time to think about the answer) are difficult to include in the limited traditional exam, but fit perfectly in a take-home exam.

Finally, due to its very nature, the traditional exam makes it impossible to assess teamwork. In a take-home

exam, the same question can be asked of different students, making collaboration obligatory, while requiring them to play a different role in their answer. For instance: we can ask students to decide what kind of storage system should be used in a Data Center. They put their heads together to decide which system is the most appropriate, but each student will justify the decision from a different point of view: that of the security chief, the network manager, the systems manager, etc.

IV. Advantages and drawbacks of the Take-home Exam

In a traditional exam, questions cannot be asked about all the contents on the syllabus, neither in quantity nor in depth, since time and resource restrictions do not allow it. Thus, some students simply devote their study time to learning some lessons (those that are traditionally asked in the previous term's exams) and applying ready-made "recipes" to some types of problems. This is clearly surface learning, and is quickly forgotten in a few days. Who has not been criticized because some students have gaps in their learning - gaps in lessons we know they should have studied, but have failed to assimilate?

On the other hand, in a take-home exam, study can be guided. For instance, let us assume that a student dedicates 10 hours to studying a week before the traditional exam, plus 3 hours to doing it. During this time, the student swots up on some lessons, but probably not all, and not at the desired level of depth. If the same student completes a take-home exam in the same amount of time (13 hours), the questions will guide the student's studies, helping him or her to understand more fully the most relevant concepts for the subject in question (according to the teacher's point of view), making it more likely that these concepts will be assimilated in depth.

A take-home exam enables teachers to formulate questions that oblige students to read other students' projects or chapters from textbooks, as well as solving the types of problems that overburdened students would probably have left out in their study planning.

The take-home exam undoubtedly has some drawbacks, but fortunately these can be solved.

All teachers are concerned that students taking an examination should do so without recourse to unethical methods. When it comes to a take-home exam, this concern is greater. The problem of cheating or copying can be avoided by selecting the type of questions in which the student has to argue the proposed solutions in their own words. This kind of question makes it almost impossible for two responses from two different students to be the same. Copying is therefore not only easier to detect but largely prevented, since students realize that any inappropriate behavior will quickly be revealed. In the case of questions being answered by students who are not enrolled on the course (thus no copying), cheating can be thwarted by a short validation test aimed at checking that the student has completed the exam without assistance; the mark for this test is binary: pass / fail , i.e. students demonstrate that their knowledge of subject content is sufficient to prove that they are indeed the author of the exam.

A further consideration is the time and effort required by the teacher to draw up a take-home exam. In our experience, this is not much greater than for a conventional exam, and once it has been done a few times it becomes easier. Furthermore, exam marking, one of the tasks that is often the most boring for the teacher, becomes quicker and more rewarding, since answers tend to be clear, orderly, well written and coherently reasoned.

The high demands that this kind of exam place on students do not pose a problem if we take into account the amount of time students take to completing it; it should be considered that part of the time that would previously have been devoted to studying is now devoted to doing the exam itself. The take-home exam also requires coordination among subjects: students cannot be asked to complete several take-home exams simultaneously (unless there are no master lessons or lab classes during this same period of time). Our experience shows that while slightly greater effort is required, this effort is clearly rewarded.

Finally, a more general concern refers to the assessment of professional skills; at the university where the authors of this paper work, some teachers consider that, should professional skills be assessed, and should such assessment form part of the final mark, then some students may successfully complete a particular subject thanks to their mark for professional skills, without necessarily possessing a deep knowledge of the technical content. Mechanisms exist to overcome this drawback, such as setting a minimum mark for the technical content of the subject, or other solutions described in the following section.

A CASE EXAMPLE

I. The "PC Architecture" (PCA) course

The PCA course is a free configuration subject in the Computer Science degree at the Barcelona School of Informatics, whose main goal is to provide the students with knowledge about the past, present and future of Personal Computers and their components (see López *et al.* [10] for a detailed description of the subject). However, some other objectives are also defined in this subject: improvement in critical thinking; the ability to manage information; decision-making, and gathering and integrating information. The course is based on master lectures, and students are required to develop and present a project during the course, which can be related to technical issues or to ethics and solidarity (i.e. "Interfaces and devices for disabled persons" or "The One Laptop per Child Project"). The students also carry out a lab assignment which accounts for 20% of the final mark. This lab assignment is based on Service Learning principles, and is also aimed at acquiring some professional skills. A detailed description of the lab class can be found in

Franquesa *et al* [11]. Because it is an elective course in the final year, there is low enrollment (between 12 and 20 students per course, with a mean of 15 students).

Students' projects (which account for 40% of the final mark) are oriented towards state-of-the-art technology, but also to developing professional skills, so part of the project mark is derived from the technical content. However, an important part of the project is concerned with clarity of ideas, the quality of written expression, the quality of the public defense of the work, quality of the information retrieved or the quality of the conclusions presented.

In this subject, a take-home exam replaces the traditional final exam, and accounts for 40% of the final mark. Students have between 7 and 10 days to answer the 16 questions posed. In order to do this, they are required to consult the class slides, the projects undertaken by other students, the recommended bibliography and also the gathering of information on the Internet. The information gathered must be processed in order to write a clear, reasoned, concise and complete answer. The exam must be handwritten, and in addition to the technical contents, concision, clarity and completeness of the answer, spelling, calligraphy and grammar are all evaluated. The exam is printed with watermarks, so students are required to think through their answers before they start writing.

The final mark for the exam is obtained from the assessment of both technical and professional skills. The ability to find, select, integrate and synthesize information, to argue and justify decisions as well as to communicate them effectively are all evaluated, together with the technical aspects of the answers. Each of the professional abilities has an assigned score, which yields a multiplication factor of between 1 and 2. On the other hand, technical content is evaluated with a mark of between 0 and 5 (at our university, marks range from 0 to 10, 5 being the pass mark). The final mark is the result of multiplying the technical mark by the professional skills multiplication factor. This means that even though a student scores the highest mark for professional skills, he or she will fail if the technical mark does not reach the required minimum.

We calculate that at least 10 working hours are required to pass the exam (students may devote more time if they wish to improve their mark). To enable them to plan their time efficiently, students know from the start of the course the day on which they will be given the exam, the day it must be handed in and the number of hours they must devote to completing it. In fact, the longer period of time required to prepare for and complete the exam helps students to plan their work and study time. On the days students are doing the exam, we want them to focus their time exclusively on the exam itself, so in our subject there are no master classes or project defenses during the time it takes for the students to complete the exam.

II Results

PCA has been taught over 11 terms, and we have used the take-home exam from the very beginning. We use anonymous surveys in order to find out the students' opinions about the assessment methodology, and the results so far have been positive. Six terms ago, it seemed to us that more information was required in order to carry out a fair analysis of the methodology, so we decided to split the survey into two parts. On the one hand, we conduct a short, anonymous survey in which students express their opinion about the subject, the teachers, etc. On the other hand, we conduct an exhaustive survey (more than 100 questions, 14 of which concern the take-home exam) containing more specific questions such as "How much time did you spend answering the exam questions?" or "How many web pages did you consult to help you do the exam?" These questions do not involve personal opinions, so anonymity is not a condition of this longer survey in order for the survey information to be compared with the mark of each student. It should be pointed out that the non anonymous survey is entirely voluntary.

We then analyze the results of these surveys. We have data from the last six terms, in which 90 students (almost all of the enrolled students) answered the surveys.

- Students spend several hours searching for information online: 76.7% said they spend more than 4 hours on this task.
- Students consult many websites: 58.9% claim to have consulted more than 20 web pages, 35.6% consulted between 11 and 20 pages.
- A high percentage of students (61.5%) say they have consulted no books for the exam. Only 4.4% claim to have consulted 3 or more books.
- Other students' projects are consulted: 83.4% of students claim to have consulted one or more projects.
- 76.7% of students dedicate 2 hours or less to consultation of course material (course slides).
- Almost all students (93.7%) write a draft of the answers before writing them on the watermarked pages. Only 6 students claim to have written the exam directly, and they are the ones with the worst marks.
- 68.9% of students claim to have spent more than 10 hours completing the exam. As expected, students who spend less time working on the exam are also those who obtained the lowest marks.
- 82.2% of students agree with the idea of assessing professional skills. Only 5.6% (5 students) are opposed to it.
- A high percentage of students, 89%, prefer this type of examination to a traditional exam. However 63.7% consider it to be very demanding. Only 6 of students (6.6%) would prefer to do a traditional exam.

- 46.2% of students considered a week as sufficient for completing the exam. This number increases to 80.3% in the case of 10 days.
- 59.3% of students consider that they have learned a lot with the exam, and that it can be considered the "last lesson" of the course.
- At the time of their enrollment in the subject, most students (83.3%) were not aware of the emphasis placed on professional skills. However, 81.1% believe that this emphasis greatly improves the subject, and even find it essential.

In the light of data from both surveys, we are able to conclude that PCA has become a subject that is highly regarded by students, in terms of both usefulness of content and expectations fulfilled, and also that the introduction of the take-home exam has fulfilled our objectives.

CONCLUSIONS

Given the difficulty of assessing professional skills (such as written communication, or the ability to search for, select and integrate information), we propose the use of a take-home exam that is bounded neither by time nor the resources that students can consult. This type of exam means change in the way that questions are posed, and also involves risks such as inappropriate behavior by students. However, mechanisms such as a "validation test" may be sufficient to overcome these problems.

Our experience gathered over 11 terms of the "PC architecture" course enables us to assert that the take-home exam is a powerful tool for assessing all types of skills, but especially professional skills. In addition, it does not involve an increase in teacher workload, and is greatly appreciated by students, who perceive this exam as highly accessible while providing them with a deeper learning process.

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