A computational tool for supporting the evaluation as a mechanism to improve learning

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Abstract. It is no secret that the importance which evaluation has acquired, lately, in the educational world is of primary magnitude. However, examinations can also be used for learning, especially if collaborative learning activities can be integrated into them. We present a collaborative evaluation technique we have used as well as the software tool we have designed in order to deal with the problems we have found when this technique has been used without computational support.

Keywords: evaluation, tool, collaborative examination technique

1. Introduction

It is a fact that the evaluation is a constant worry in the educational world at all levels, and a remarkable institutional and legislative development has been experienced recently along with an abundant amount of pedagogical literature and frequent investigations of their application [9, 10]. According to Hay, the objective behind the realization of an evaluation can be (a) to measure the real level of the students' knowledge, and (b) to measure the students' capability to relate and integrate the acquired knowledge [5]. As Meanwhile et al. have argued the objective of evaluations is to measure the students' achievements, to motivate and direct their process of learning [3]. These are the most accepted interpretations of the evaluations main goal. However, Ochoa et al. stated examinations can also be used for learning, especially if collaborative learning activities can be integrated into them. We think one of the most important instances to support learning is the evaluation stage, because this step corresponds

to the period where students are most prepared about a certain topic. In order to demonstrate such hypothesis an evaluation technique was designed and tested: *CET (Collaborative Examination Technique)* [8]. CET has been used in some courses of computer science area and the obtained results have shown this technique is able to deal with some of the typical problem in the evaluation process: the ambiguity of the test, anxiety of the students, and lack of uniformity in correction criteria and sensation of injustice about the exam or correction. As we show in a previous work, our student thinks the evaluation instances performed using the CET technique are more useful and fair [8]. However, CET has shown two main limitations that jeopardize its applicability: (a) the inefficiency to support the building and sharing knowledge processes carry out by students during part of the CET application process, and (b) the high cost in time required by instructors to apply this evaluation technique. These limitations are a consequence of the manual methods used by instructors to conduct each CET phase and the poor mechanisms used to record and share the knowledge among the people involved in the examination process. In order to deal with these limitations and trying to keep the benefits shown by CET, a mobile collaborative application named MOCET (Mobile Collaborative Examination Technique), has been designed to be used on Tablet PCs and PDAs and interact with the users using a pen device. This tool keeps the metaphor of the student's paper notebook during exams and supports students and instructors in every phase of the examination process. The usability and usefulness of MOCET has been tested in two computer science courses and interesting results have been obtained. The main goal of this paper is to present the collaborative evaluation technique we have used as well as the software tool we have designed in order to deal with the problems we have found when this technique has been used without computational support. Some experiments were done using our software tool and technique, and the main results are also shown.

Next section describes the phases of the examination process. Section 3 presents the developed software tool and describes its functionality. Section 4 shows the experimental results. Finally, section 5 presents the conclusion and the further work.

2. Examination Process

The concept of evaluation is very broad with various meanings that impose themselves or not on the practice of the function of the necessities in which they serve as well as the different ways to achieve them. The evaluation process we have designed involves three stages: *pre-test*, *test* and *post-test* as is depicted in the Figure 1 [8]. Each phase is carried out in a consecutive lecture time space (in our experimentation, every phase is realized in a whole lecture). The pre and post test phases include a collaborative learning activity. The test phase is the traditional one.

The pre-test main goal is to help students to understand and assimilate, in an early stage, the knowledge that is going to be considered in the traditional test

phase. This stage seeks to reduce the pre-test anxiety and is not graded, but constitutes an important aid when it comes to answering the exam. In order to do that, students follow a collaborative process similar to Jigsaw [1] to find consensual responses to questions/test items provided by the instructor. The process performed during this stage is: (1) Teacher assigns groups; (2) each students receives a task that must be performed in an individual manner; (3) students who have the same task organize a group and share their responses trying to convert them in experts in a certain topic; (4) students come back to their original groups and expose their task, and (5) finally the students elaborate a final inform. These questions should be related to the knowledge considered for the test (exam) and they should have a complexity similar to that ones. During the ordinary classes, the instructor transmits the knowledge and, surely, the concepts in an isolated way. According to Novak, human beings need to relate their knowledge to make it more understandable and in that way, more usable [11]. The goal of the pre-test is thus to help the student to organize and relate the knowledge, to make it easy to understand and to apply it. It is important to mention the pre-test activity we have developed is a collaborative one, because it involves the three fundamental aspects in a collaborative activity: (1) equal participation; (2) individual accountability; and (3) positive interdependences [12].

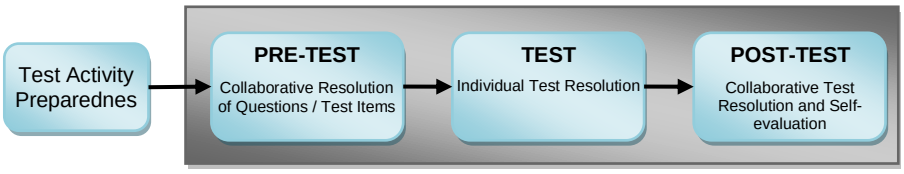

Figure 1. Phases of the Evaluation Process

The test phase involves an individual resolution of the exam, similar to a traditional examination process. Our Faculty educational system is accustomed to individual evaluations for the students. In that phase, each student answers his/her test individually. Typically six questions (or problems) are included in most of the exams, and the students have 90 minutes to respond it. The main objective of the test should be to state challenges that require the application and relation of concepts in order the student to give a solution. The examinations should not reward writing speed or memorization capacity, but creativity and ability to apply the acquired knowledge. During the test process the students can consult some bibliography if they wish, because this is a scenario similar to what they will find in real life. If the student solved the exam successfully, it means that he/she was capable of understanding and applying the course knowledge in a domain that was initially unfamiliar to him/her.

Finally, the post-test intends to reach two main goals: (1) students find the right answers to the test questions/items through a conducted discussion, and (2) students can identify the right points and the mistakes in their answers. During the post-test, the students receive a photocopy of their exams. Then, groups of four or five students are formed to solve the test questions using discussion and

negotiation. These groups can be or not the same conformed during the pre-test phase. Then, in an individual manner, each student grades his/her own exam. Each group must hand the solutions to the instructor. For the correction of their own exams, the students use the solution outline constructed collaboratively by the group. Finally, the students grade the exam as a whole, in accordance with the individual grades assigned to each of the questions. The assistants evaluate the copies of the students' exams, which have been graded by them. The student's answers are examined and graded. If the final grade assigned by the corrector differs in no more than 0.5 points from the grade assigned by the student, the grade for that question will be equal to the corrector's grade, plus a bonus of 0.5 points. Otherwise, the final grade will no change. The assignment of the bonus in the correction of the item is to reward the student for having understood what the correct answer was. Even though the student did not answer the test well, the post-test phase gives him the chance to learn and improve his grade. This bonus shall not be assigned to those grades that required a justification but do not have one. Nor will it be assigned to those answers that agree with the grade, but have a wrong or insufficient justification. This technique has been recurrently applied in Computer Science and Engineering courses at University of Chile and University of Cauca (Colombia). The obtained results have shown students increase their knowledge during these collaborative examination activities and they feel these techniques are fair evaluating the acquired knowledge [8]. However, the evaluation technique has shown two main limitations that jeopardize its applicability: (a) the inefficiency to support the building and sharing knowledge processes carry out by students during part of the CET application process, and (b) the high cost in time required by instructors to apply this examination technique. Next, these two limitations are briefly explained.

- *Inefficiency to support the building and sharing knowledge processes*. The knowledge building and sharing processes carry out by students doing pre-test and post-test activities are currently supported by hard copy and verbal information. This type of support limits the students' capability to represent, keep and distribute the knowledge among their partners. Typically, the people memory and motivation play an active role when they need to share the knowledge with the partners. When students try to share their knowledge after the individual activity, it is possible to lose some information due to the volatility of the memory. In addition, the knowledge building and evolution process require co-located teammates provided the information synchronization is slow and difficult to do when the knowledge is recorded in a paper and in the students' mind. However, students feel comfortable with the free writing style allowed by the paper and pencil, and they think these are the best tools they have to support the building and sharing knowledge processes.
- *High cost in time for instructors.* In addition, the effort required by instructors to plan, execute and analyze each examination phase is high because they need to organize two kinds of test, during the pretest and test phases. They also need to copy the test of the students. If instructors want to get detailed information about the examination process execution in order to adjust it or improve it,

they have to record the information in video and then analyze it in a manual manner. On the other hand, the rating process of a student's exam requires considering his/her contributions during the test and post-test phases. Such information is recorded in paper and it should be manually processed in order to get the final student's score. For that reason, the process becomes time-consuming and prone to instructor's mistakes. Similar to students, instructors feel comfortable using the free writing style allowed by the paper and pencil when they are rating an exam.

These limitations are a consequence of the manual methods used by instructors to conduct each CET phase and the poor mechanisms used to record and share the knowledge among the people involved in the evaluation process. In order to deal with these limitations, we have developed a software tool that support students, assistants and instructors in such process. The tool is called MOCET (Mobile Collaborative Examination Tool), and it is presented in the next section.

3. The Mobile Collaborative Examination Tool

MOCET has been designed to overcome the limitations mentioned in the previously section, but keeping the advantages of our CET technique. This tool systematizes the examination process and supports students/instructors during every phase of the process (see Figure 2). It provides four main functions for instructors: (1) examination activity preparedness, (2) monitoring of pre-test, test and post-test activities, and (3) rating support for every exam. The tool also provides three main functions for students corresponding to the support for (1) pre-test, (2) test and (3) post-test activities.

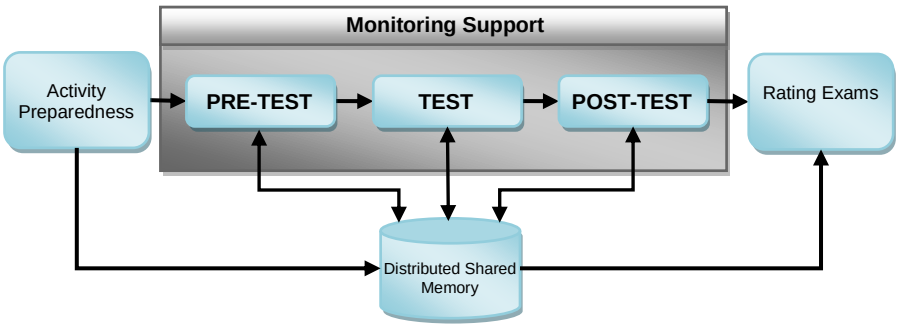

Figure 2. Examination Support Using MOCET

Services for both students and instructors use the asynchronous data sharing support, the persistency and the synchronization mechanisms provided by the SOMU (Service Oriented Mobile Units) platform [7]. Shared objects, such as images, text documents or exams, represent basic pieces of information that can be

shared on-demand among members of a Mobile Ad-hoc NETwork (MANET) session. Such objects are distributed among the mobile devices used by students, which compose an ad-hoc distributed shared memory systems. Each object is shared with a set of information layers (XML files) linked to it. Each layer represents a voice or textual comment from a student to the knowledge represented in the shared object. During the pre-test every participant is able to send a shared object to anybody else. During the test and post-test the MOCET allow students to interact just with the instructor.

There is a MOCET-Server which is responsible for the sending/reception of the students' tests, data repositories and the monitoring of the students activities. The MOCET Client recovers, edits, and gives the tests to the students. It is the responsible for the local data storage (didactic material and tests). It is important to mention that students can synchronize local information among them only during pre-test phase.

Provided that students and instructors feel comfortable using free writing style, MOCET was conceived to be used on Tablet PCs and PDAs (see Figure 3 and 4) with a pen device. Therefore, particularly relevant was the support included in the tool for using hand-written information and multimedia resources (images, audio/video records, text and strokes) during each phase of the examination process (*pre-test*, *test* and *post-test)*. The system design assumed each student will use his/her personal computing device to do the exams. In such cases the tool provides more flexibility and capability to create/evolve/share the information in several scenarios (traveling, visiting or wandering) [4]. However, students can also use mobile computing devices provided by the education institution they belong, just to do the exams. Students have to export the knowledge built and shared in each phase of the process to a remote personal computer in order to use such knowledge as study material or backup. In both cases, students are able to evolve the shared knowledge in asynchronous way. In addition, they can synchronize on-demand such knowledge with one or more partners just pushing a button in the MOCET user interface. This mechanism works in one-hop and multi-hop networks. This synchronization process can be done in a large range of physical scenarios (e.g. on the street, a bank, a library or a coffee shop). This feature becomes flexible the process of sharing information.

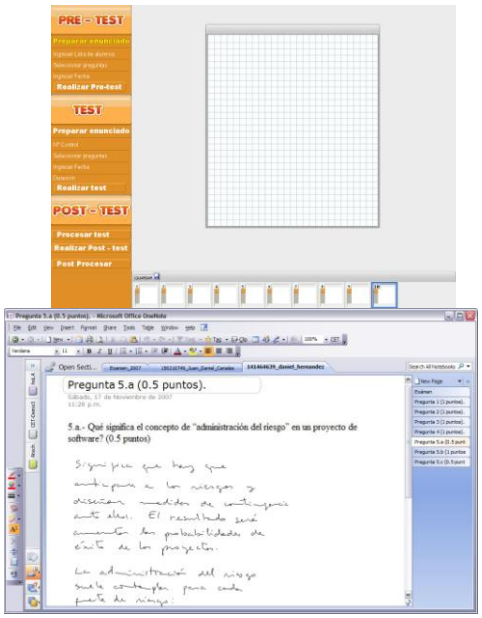

Figure 3. MOCET version for a Tablet PC

Some of the main functionalities provided by MOCET for supporting instructors/assistants are: (1) to design the pre-test, test and post-test activities, (2) to group the students, (3) to deliver the documents (e.g. exams) among the students and to receive their responses, (4) to correct the exams and to determine if a student gets the bonus or not, and (5) to monitor the students' activities. On the other hand, some of the main functionalities provided by MOCET for supporting students are: (1) to share the knowledge and the questions included in the pre and post-test through a student mobile workspace, (2) to receive, respond and return an exam to the instructor, and (3) to receive the instructor corrections. Next section presents the experimental results we have obtained while applying MOCET in Computer Science courses at our Engineering Faculties.

4. MOCET Experimental Results

MOCET tool was used once in a course corresponding to the sixth semester, and three times in other course corresponding to the ninth semester of the Computing Engineering carrier at University of Chile. Each experiment involved 10 students using computing devices (6 using Tablet PCs and 4 using PDAs), 20 students using paper and pencil, and two instructors (one using a Tablet PC and the other using a PDA). These computing devices were lent by our Computer Science Department to students and instructors for ten days in order to execute this

experiment. Students and instructors had previous experience using CET without technological support.

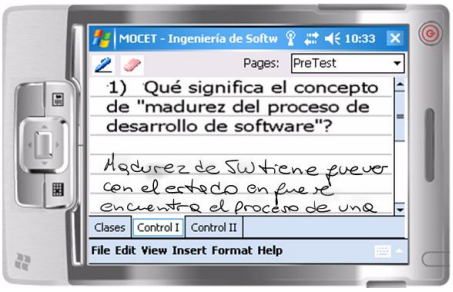

Figure 4. MOCET version for a PDA

The pre-test and test were based on 6 questions. The obtained results were similar in every experience. The later analysis shown that about 80% of the students increase their knowledge during the examination process, especially during the post-test. This percentage is similar to the CET historical values we have registered. After the exercise an opinion poll was conducted to get the students' and instructors' opinions. Most of the students (87%) think the evaluation process is easier to use when MOCET tool is utilized; particularly for sharing information.

Figure 5. Experimental application of MOCET

People using Tablet PCs said that hand-writing functionalities allowed them to operate in the similar way they use a paper and pencil. However, people using PDAs found hand-writing functionalities worse than paper and pencil, but still usable. In addition, approximately 80% of the students considered the examination and rating process were fair, which is a value similar to our CET historical records. If we consider these students know how to use CET, but do not MOCET, we could expect these percentages will be improved in the future.

On the other hand, the instructors considered the tool have reduced, at least to the half, the effort required to apply the examination technique. All of them

considered the examinations and rating processes were fair. Furthermore, the knowledge sharing services and the hand-writing support were also the most relevant features for instructors.

In order to evaluate the adequacy of MOCET user interface for students and instructors, the eight items proposed by Nielsen [13] were used to measure usability (items 1 to 8). Besides, four additional items were defined by our development team, based on their experience (items 9 to 12). The considered items are the following ones (the obtained results are shown in Table 1):

1- Use of simple, natural language.
2- Minimization of required memory load from the user.
3- Consistency in terminology and symbols used throughout the interface and compliance with the domain norms and standards.
4- Degree and quality of system feedback.
5- Provision of clearly marked exits and undo.
6- Provision of shortcuts for experienced users.
7- Informative error messages.
8- Prevention of errors.
9- Effort required to share knowledge.
10- Performance of the application.
11- MOCET functionality versus the required support.
12- Level of satisfaction when using the tool.

Table 1. Obtained results for every evaluation item

Item / Concept	1	2	3	4	5	6	7	8	9	10	11	12
Instructor's Average Marks	9.0	7.5	8.1	7.0	8.5	6.0	7.5	7.0	8.9	8.8	9.0	9.1
Student's Average Marks	9.2	7.8	9.4	6.5	7.8	6.1	6.8	6.5	9.0	9.0	9.2	9.5
Instructor's Standard Deviation	0.2	0.2	0.1	0.4	0.6	0.1	0.6	0.4	0.2	0.2	0.3	0.3
Student's Standard Deviation	0.4	0.2	0.2	0.6	0.5	0.9	0.5	0.4	0.1	0.2	0.4	0.1

The mark is a value that qualifies an item and the weight indicates the importance of it according to the instructor or expert. The range of assigned values was from 0 (worst) to 10 (best). A score of 5 is considered as "enough". The obtained results permit us to induce there is an implicit favorable perception by the students and teachers about the developed system (MOCET). In a general way, all the aspects evaluated have obtained a result higher than the "enough" score, and in some cases closer to the excellent score. The lowest item is the number 6 (use of shortcuts for experienced users), due to the users of the application do not need such kind of mechanisms. On the other hand, the highest rated item was the satisfaction while using the tool, rated with 9.5.

6. Conclusions and Future Work

Collaborative Examination Technique (CET) has shown good results in our Engineering Faculties as examination and learning activities. However, this education technique has also presented two main limitations: (a) sharing information among students is inefficient and (b) an important effort should be invested in order to carry out the examination process. Clearly, these two limitations jeopardize the applicability of such examination technique. This paper presented a mobile collaborative examination tool called MOCET, which helps overcome these limitations. MOCET keeps the metaphor of the student's paper notebook. In addition, it provides solutions to overcome the two previously mentioned limitations. Although MOCET is able to run on several computing devices, it has been specially designed to be used on Tablet PCs and PDAs. The experimental results using MOCET are still not enough to get strong conclusions, however the preliminary data indicates this solution could be producing the following benefits to students and instructors/assistants:

Benefits for Students. Students using Tablet PCs and PDAs could execute part of the pre and post-test in a distributed and flexible way (traveling in a subway, waiting the bus or just walking), taking advantage of the mobility of these devices, their capabilities to form ad-hoc networks and to share information in an easy way. Because the shared information (strokes, images, text, and audio) is stored in XML format, the knowledge distribution among participants can be easily done using XML file synchronizations. It means the effort a user has to spend to be synchronized with the instructor and his/her partners is just pushing a button on the users interface. Because the tool supports for hand-writing, students are able to complete an exam in a similar way to the traditional exams (like writing in a sheet of paper), avoiding being victims of the change of paradigm. Once completed each phase of the examination process, students and instructors can get immediate evaluations and download the results in their mobile devices for a later analysis/study. In addition, we expect students can get the benefits reported in [8]: (a) an increment of their knowledge because of these collaborative examination activities and (b) a feeling this technique is fair to evaluate the acquired knowledge.

Benefits for Instructors/Assistants. Instructors/assistants use mobile devices (Tablet PC or PDA) to collect, review, and correct the students' outcomes in every phase of the examination process. The correction process and the delivery feedback can be done by the instructor in several places (like traveling in a bus or staying in a waiting room) and circumstances (like talking in the sidewalk or in a coffee shop). Instructors can use such devices during preparedness of the activity and during the analysis of the obtained results. Because the process phases are automated by MOCET, the effort the instructor has to spend in order to apply the examination technique is low. In addition, the settings defined for an examination process can be reused of mixed with other ones. It allows instructors to share these setting with the partners and to get new ones, reducing thus the examination preparedness effort. We expect these advantages can be

reach by students and instructors/assistants in a broad range of instructional scenarios: from middle-school courses to postgraduate programs.

According to the obtained results, we can say the examination process is a good opportunity to introduce collaborative learning activities into the classrooms. Testing is incorporated as an additional learning activity. The number of testing instances of MOCET is still low because this is a recent developed tool. Although, it is not possible to get strong evidence of the tool contributions, the preliminary results are encouraging. Therefore, we envision this proposal can provide a transversal solution able to support examination on several educational institutions (from middle-school to universities) and adhering to several instructional strategies, such as: Computer-Supported Collaborative Learning (CSCL), Computer-Integrated Classroom (CIC) and Active Learning, among others. In the short term, we have planned to apply MOCET in other Engineering courses in Chile and Colombia.

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