Lessons Drawn from Implementation of Online Tutoring System in Physics Courses

Itzhak Goldman
Department of Basic Sciences
Afeka, Tel Aviv Academic College of Engineering
Tel Aviv, Israel
email: goldman@afeka.ac.il

Abstract— The online tutoring system CAPA was implemented at Afeka College in the academic year 2000-2001 in calculus based physics courses. It was used also in the academic year 2001-2002 and was very successful in improving understanding and achievements of the students. The paper describes the system features and the case study of its implementation. Lessons drawn from use of the CAPA system are discussed. The system no doubt contributed significantly to increased understanding and higher achievements in the final exams. This was at a price that students felt that they had to devote more time to study than traditionally required. The instructor has to invest more time than traditionally done in composing new problems and managing the system. However, the increased interaction with the students makes the teaching process much more interesting and rewarding.

Index Terms — Elearning, Asynchronous Systems, Physics Education

I. INTRODUCTION

The CAPA system (Computerized Asynchronous Personalized Assignments) has been developed, in the 90s, at Michigan State University (MSU) [1]. The developers were physicists that confronted difficulties with teaching physics to large undergraduate classes. The difficulties were

• The "loss" of the individual student in such a large class
• Lack of real-time feedback to the lecturer
• The not simple task of ensuring a uniform level for the recital classes given by teaching assistants

The motivation was to develop a, simple to use, computerized system that will supply personalized exercises and provide immediate grading to the students. It turned out that the system had many additional benefits, notably improved achievements in exams [2 – 6]. This effect was more pronounced for the weaker students. The system’s relative simplicity and reported success made it a favorite of many universities and colleges in the US and it was used also in other disciplines, e.g. [6,].

Following the positive reports about CAPA I implemented it at Afeka College in the academic year 2000-2001. It was used in calculus based physics classes for engineering students. An additional motivation was due to the lack, at the time, of teaching assistants for correcting homework assignments. Given the success of the system, I have used it also in the academic year 2001-2002. In the following year, it was decided that a uniform format for the physics courses must be employed by the different instructors. Not all instructors were willing to invest the effort required in using the system and preferred traditional teaching. This brought to end the use of CAPA, in spite of its success.

II. SYSTEM FEATURES

The system was implemented on a Linux machine (Pentium 2) running RedHat 6. Support from the technical stuff at Afeka was very important. A passing note - the server proved extremely stable-running uninterrupted for months despite heavy load occurring near the due time of the homework.

The system is:

• A framework capable of delivering personalized assignments
• Content independent - the content is supplied by the instructor
• Web interfaced - each student had a personal user number, and for each exercise sheet there was a capa-id consisting of 4 digits. The students could retrieve their capa-ids from the system
• Asynchronous - allowing students to pursue the assignment at their preferred time-schedule, subject to the constraint of due time
• Immediate feedback is provided to the student on his performance
• A useful tool is a report assigning a measure of difficulty to each of the problems. This provides the lecturer with real-time feedback on what is well understood and what

Fig. 1. Relative difficulty of problems.
is not, so he can take corrective measures immediately. An example of such a report is shown in Fig. 1

- Various statistical analyses, such as the grades distributions demonstrated in Fig. 2, can be readily obtained and provide real-time feedback
- The system comes with a web forum that is useful in enhancing collaboration between the students and provides the instructor feedback on how well the students are doing

![Fig. 2. Grades distribution for a given assignment.](image)

Each student receives the same problem but with different numerical data, or different questions to answer. These features promote cooperation and discussion among students while rendering mechanical copying much less likely. There are two main types of problems:

- Numerical problems, as in Fig. 3. Each student receives different numerical data
- Multiple-question qualitative problem that tests understanding. Each student receives different combinations of the questions or altogether different questions relating to the same situation. Fig. 4 represents such a problem and Fig. 5 shows a variant of it

- The system responses are Y, N or U. Y means a correct answer, N means an incorrect answer and U, (in case of the numerical problems) means wrong units. The allowed precision is set by the instructor. Typically, it was $1 \div 2\%$
- Each problem can be tried several times. Normally, 10 tries were used. The multiple tries facility was intended to compensate for misclicks or imprecise calculations. The U replies do not count in the number of tries
• It is possible to build the problems so that after a few wrong answers, there will be a hint or a short explanation.

III. CASE STUDY

The system was implemented and used in the Physics 1 course, which is taken by students in their first semester of the academic studies. At 2000-2001, the physics lecturers were also giving the recital classes. There were two classes totaling of 86 students. There were 10 exercise sheets during a semester of 14 weeks. Overall, there were about 140 different problems, the best 120 answers were considered. Each problem had 10 tries and each problem set was open for 7-10 days depending on the work involved. An online forum was set up. I reviewed it on a daily basis - reading comments, questions and occasionally throwing in guiding clues.

• At the beginning there was quite an enthusiasm from the students part. They worked willingly and accordingly achieved very high scores on homework assignments. I heard comments from lecturer’s of other subjects that the students asked them why they are not employing CAPA too
• At about mid-semester complaints had started. The fact that the system language is English and not Hebrew was one of them
• The fact that the system checks only final answers but not the detailed solution was regarded as unfair, even though the 10 tries availability should have compensated for calculation errors
• However, the most serious complaint was that they are forced to devote too much time to physics on the expense of other courses

A survey that I conducted showed that they devoted 3 ÷ 6 hours weekly. The course was 3 weekly hours of lectures and 2 weekly hours of recitals. In physics studies, is usually assumed that on the average a student should put 2 hours of self-study for each hour of lectures. By this measure the time was more than reasonable, but the students truly felt that they are overburdened. I’ll discuss this point in the discussion section.

• The good news were the success in the final exam: the grades were higher than in previous years - the median grade was higher by 8-10 points out of 100 - increasing from ∼ 60 to ∼ 70
• Moreover, most of the improvement was in the lower grades of the distribution. This came as no surprise as similar results were reported in the US

In the subsequent semester, the same students took the course Physics 2. In response to the complaints in the previous semester, the students were offered two options: continue with CAPA as in the first semester, or have traditional homework assignments.

• To my surprise (given the complaints) about 80% chose CAPA
• The students who chose CAPA said that in the final exam they felt that they were much better prepared than in other courses and attributed it to CAPA. So in the new course there were willing to pay the price of investing extra time
• In Physics 2, the grades in the final exam correlated positively with the use of CAPA. The small number of non-CAPA students renders statistical assessments not very significant; but the trend was qualitatively obvious
• Not few students continued to solve the problems even after they had 120 correct answers and they knew that the grade won’t increase. A typical answer to the question why they did so was that they wanted to have a “perfect score” - from the system in addition to getting 100 from the instructor
• Some students regarded the CAPA assignments as fun - sort of a computer game - especially so because they received immediate assessment

As instructor, I benefited from the feedback utility that gave me in real-time a report on how the students progressed with each exercise sheet. Moreover, I found out quickly which of the questions are in particular difficult and could explain once more the relevant material, before the exercise sheet was due.

The fact that each student received a personalized version of the sheet was very helpful with students that were absent from college because of justified reasons such as illness or reserve army duty. To these students the sheets were opened and closed when they returned to the college.

Given the success of the system, I have used it also in the academic year 2001-2002. In the following year, the physics courses given by different instructors, had to be identical. Not all instructors were willing to invest the effort required in using the system and preferred traditional teaching. This brought to end the use of CAPA, in spite of its success.

IV. DISCUSSION

In what follows aspects relevant to the student, to the instructor and to the academic institution will be addressed.

A. The students

• Achievements as measured by scores of the final exam improved significantly
• Equally important was the fact that the students devoted more time for self study than they would have otherwise
• Another advantage was that the students were encouraged to collaborate and discuss the exercises, but mechanical copying was not simple as with traditional homework.
• However, students felt (justifiably or not) that they are required to work harder at the expense of other courses

The first point is impressive, especially so since not only were the scores higher but also the level of understanding was higher. Also encouraging is the fact that weaker students seem to have benefited the most. This last finding is in accord with similar findings in the US[4, 5]. In the US, it was also found [5] that the improvements among female students was larger than among male students. In our case the small number of female students didn’t allow a meaningful test of this point.
B. The instructor

- An important advantage for the instructor is the ability to obtain real-time feedback on the assimilation and understanding of the study matter by the students
- The instructor has to invest significantly more time than traditionally done
- He should be willing to be involved in a computerized project where composing and checking out new problems is time consuming
- However, the increased interaction with the students makes the teaching process much more interesting and rewarding for the instructor compared with the standard way

C. The academic institution

There is an obvious advantage in using the system for all classes, studying with different instructors the same course. Otherwise, some students will regard it as unfair that they are required to perform additional duties, while others will consider unfair that they don’t have access to the system.

- The system can be quite valuable in many disciplines of engineering studies
- It is free and can be used under a GNU license

A condition for success is a firm commitment of the institution to provide the necessary support. This should translate to:

- Establishing a support team that will handle technical problems and will adapt into the system, the academic material developed by the instructors
- This will reduce the extra load from the instructors and will encourage even computer-shy instructors to join
- A policy requiring all instructors, of the same course, to use the system

V. CONCLUDING REMARKS

In Israel, students are typically older by 4-5 years than in the US or Europe. Most of them work, at least part time, some are already married, and a some are parents.

It is plausible that this is the reason for the complaints about the time burden. In a traditional way of homework assignment they could devise all sort of strategies that will allow them not to put in the time required. With CAPA they were forced to invest the time.

This brings up the possibility that the improved achievements are not due directly to the use of technology but indirectly through its role as forcing the students to devote a minimal amount of time for self study.

The system provides the student with immediate feedback, explains briefly the relevant subject and gives an opportunity to correct mistakes. This is a very positive educational process.

A related important element is that many students regarded working with the system as fun with elements of a game. For a generation brought up on computer games this may be indeed an advantage.

In conclusion, technology doesn’t make the educational process easier, but can be very efficient in enhancing it.

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