Mathematics Reform and Introduction of Computer Aided Instruction in an International Liberal Arts College

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Abstract

Two interlinked themes are presented in this paper. First, we review our past experience in reforming the mathematics curriculum and introducing computer aided instruction at the American College of Thessaloniki, Greece. This review leads to our second theme: the presentation of an experiment (supported by the Mellon Foundation, USA) in computer aided instruction for Business Calculus. We pay particular attention in presenting the ways in which past experience guided us in setting up the Mellon experiment, especially in the areas of assessment, selection and presentation of material and selection of appropriate technologies.

1. Introduction

The American College of Thessaloniki is an English-language Liberal Arts college operating in Greece. The college is populated by an international and diverse student body coming from various educational systems. In particular, mathematical preparation and performance varies widely among the students.

While we pride ourselves in the pluralism and multiculturalism of ACT, as mathematicians-in-the-classroom we face a daunting task, namely, to design courses which will impart to the students basic knowledge of discrete mathematics and calculus, will convince them of the relevance of mathematics to their work and life and will be neither too technical for inadequately prepared students, nor too tedious for mathematically sophisticated ones. An additional factor which complicates the picture is that, in some of our classes we have to concurrently teach two groups of students: one group will major in the Liberal Arts and another in Business Administration.

2. Past Activities

In tackling the above problems, we have found it necessary to engage in continuous curriculum reform. We have been especially drawn to computer aided instruction as a possible means of enhancing both the learning material and the teaching process. In the last two years we have experimented with the use of software packages such as Microsoft Excel, MathCad, Scientific Notebook as well as WWW-like hypertexts. In all such efforts we have adopted an approach which emphasizes conceptual understanding, mainly through graphical and numerical approaches and use of concrete examples and word problems (without however neglecting the analytical approach). Especially in the Calculus course we have used numerical and graphing experiments (in Excel and, lately, in MathCad) to demonstrate the relationship between the definition of the derivative and its interpretation as instantaneous rate of change. We have also experimented with various teaching strategies. For instance, we have taught traditional, classroom-based courses, as well as courses almost exclusively taught in the computer lab. We have assigned collaborative assignments and individual take-home projects.

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Assessment of the above activities has been performed in various ways: using quantitative measures of student performance (both on classical and concepts exams), subjective evaluation questionnaires as well as institutional data analysis. Since our conclusions regarding these activities are mostly based on informally collected data, let us present them briefly. Our impression is that students are in general attracted to the computer; even the occasional computer-phobic student is a much more acute math-phobic. This observation agrees with our distinct perception that students are more eager to participate in classroom activity in computer-intensive classes. On the other hand, we have found that teaching a computer-intensive class may lead us in the wrong direction; namely, the students may become quite knowledgeable about computers and mathematical software, but still fail to grasp the mathematical concepts behind the symbol pushing and number crunching**.** Finally, we should remark that we have not noticed a perceptible differential of math grades between computer-intensive and traditional classes.

It should also be mentioned that our colleagues from the Psychology Department have investigated the connection between high school GPA, competence in the English language, self perception and performance in mathematics and have reached the conclusion that self importance is one of the most significant factors in determining mathematics performance **[1, 2]**. Of course, we did not find this surprising at all .

3. The Mellon Project in Computer Aided Instruction

In late 1996 we decided to embark in a more formal investigation of the themes discussed above. A Mellon Foundation grant was obtained to support assessment of computer aided teaching of Business Calculus, through a controlled experiment. The project is taking place in the Fall 1997 and Spring 1998 semesters with the goal of evaluating the efficiency of CAI in enhancing the understanding of important mathematical concepts and in developing the students' problem solving skills. A total of nine sections (approximately 180 students) is involved: a test group of five sections and a control group of four sections.

Two pilot sections (one test, one control) were taught in Fall 1997. The main emphasis during this phase was to familiarize ourselves with teaching in the computer lab, using the symbolic math software MathCad. We found particularly attractive the capability of MathCad to combine symbolic math with "live" computation; namely, changes made at some part of a document result in immediate update of the whole document. We found this feature very useful both for demonstration by the instructor and for experimentation by the students.

The main phase of the project is taking place in Spring 1998 and, at the time of writing this paper, is not yet finished. The control sections are taught in the traditional, non-computerized way, with classroom lectures and using a paper textbook. Regarding the test sections, approximately 50% of the teaching time is spent by the students in the lab, with hands-on experimentation using MathCad. Another 25% of teaching time is used for lecturing in the lab, again utilizing MathCad for demonstrations by the instructor. The remaining 25% of teaching time is used for conventional, classroom activities. We have prepared interactive hypertext notes (again in MathCad) to be used by the students for self study. We also make extensive use of a Web system for distributing information about the course, such as syllabus, weekly schedule and assignments, homework. We have found this to be a very efficient method of information dissemination.

Assessment of the experiment results will be based on the following three components. (a) Student performance in conventional testing procedures. (b) Student performance on weekly computer assignments (applies only to the test section). (c) Performance in a ``concepts'' exam; this contains material not necessarily taught in class, with emphasis on conceptual understanding and problem-solving. Both the test and control sections have taken the concepts exam in the beginning of the semester, and will take it again at the end of the course. The goal is to measure the differential in conceptual understanding, both from beginning to end of the semester and across the test and control sections.

Additional data used for assessment include high school math grades and GPA, and ACT math grades, computer science grades and GPA. The students' point of view will also be considered by (a) including course-specific questions in the standard course evaluation form completed by the students and (b) using “perception” questionnaires designed especially to record student attitudes toward computers and mathematics.

4. Conclusions

At the time of writing this paper (March 1998) the final results of the project are not available (we will announce these in the ICTM 98 conference). However, preliminary results are available, regarding the students’ performance and attitude. Test-section students appear to have higher morale than control-section students and they have had no difficulty in mastering MathCad in a very short time since the beginning of the course. In fact, it appears that computers exert an appeal to students, which eases acceptance of the mathematical content of the course. In addition, students appear to definitely prefer hands-on experience from conventional lecturing in the classroom. They also use the Web-based info system regularly and prefer it over more conventional methods of information dissemination.

Generally, the test section students take a more active interest in the course and it appears that this interest can be channeled in constructive ways. Also, we find that the technology enables us to teach mathematics better through demonstration and experimentation. Of course, the active role played by students through computer experimentation is also enhancing the learning process. On the other hand, exactly because the CAI classes have developed so much momentum, it is particularly important to plan class activities and teaching strategies very carefully so that the learning process does not degenerate into an exercise of computer gaming **[3]**. In addition, we believe that some lecturing is still necessary, even in the CAI course; we do not want to revert to 100% lab course.

Teaching MathCad has created an overhead, which will be partly compensated by spending less time in teaching traditional techniques of differentiation and integration **[4]**. We believe we will be able to cover approximately the same material in both the control and test sections. It should be stressed that at the beginning of the semester the test and control sections were at the same level, as measured by the concepts exam and the perception questionnaire. It is too early at this stage to judge what the net effect of the above factors will be. It is clear that a fine balance is required between the technical and the conceptual component of the course.

References

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