

CALCULUS COURSES AT THE COMPUTER SCIENCE FACULTY, THE UNIVERSITY OF INDONESIA

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ABSTRACT

Computer Science students at The University of Indonesia are among the top high school graduates. However, two years ago a report showed that for several semesters around twenty percents of them failed in calculus courses.

The responses to questionnaires given by students and lecturers said that the students have lack of enthusiasm and they have low motivation in learning calculus, they questioned about the importance of calculus for their subsequent work in computer science, and they found that calculus is difficult and less challenging.

This paper presents a new approach in teaching calculus given in the last three semesters, its effects, and obstacles. The approach is devoted to give students strong background in calculus and greater capacity to use the methods and hence better prepared to complete their degree in computer science. The approach is focused on helping students to better understand calculus conceptually, having higher problem solving and computational skill, and appreciating the relevance and the importance of calculus.

The effort to achieve the goals includes encouraging independent learning, presenting relationship between calculus and computer science, providing computer related examples, using Maple for calculus projects, using computer science terms and style in explaining some calculus concepts.

This approach has improved the grades and the students' perception about calculus. However, there are still some obstacles faced by both students and the lecturers.

Introduction

Due to the wide spread use of computers in modern public and business institutions, computer science graduates become more and more needed in the job market. As a result, schools that offer computer science programs become very popular among high school graduates and getting into such schools become more competitive. One of the schools that attract more and more top high school graduates is the Faculty of Computer Science, University of Indonesia. It offers the best program, has the best lecturers and facilities, and the tuition fee is affordable (much lower than tuition at private universities).

The calculus courses given at the CS faculty are two four-credit courses; calculus I and II are offered in the first and second semester consecutively. Two two-hour per week was dedicated for conventional way of lecturing followed by problem solving and discussion. One hour per week for tutoring, which is focused on problem solving. One hour per week for computer laboratory work, even though, in practice, the students require a lot more than one hour. Calculus for remedial classes is offered during the semester break. It is an intensive course given six hours each week in the form of conventional lecturing.

The average entrance test scores of the computer science students at the University of Indonesia is always within the top three among the thirteen faculties. The entrance test to enter state universities is held nationally once a year, taken by more than 500,000 high school graduates and the competitiveness to be admitted into the CS program is one out of 40.

Two years ago, a report revealed that around twenty percent of the CS students failed in the calculus courses. Even though no thorough investigation had been done yet, the problems seemed real. The high percentage of failure in the course contradicted the fact that the students are among the best. To identify the main factors to this failure; I gathered information by listening to complains and suggestions from students, lecturers, tutors, and members of the faculty. Other good source of information is the course feedback from the students. The feedback is given in two forms. The first one is the standard questionnaire and the second one is a narrative comment on a piece of paper. They are free to anonymously express their opinion about the course or the lecturers in a piece of paper at the end of the course.

Most of the students wrote that they were not well motivated. They found that calculus was only a list of formulas and rules need to be memorized. They were not aware of the importance and relevance of calculus for their future work, especially for other computer science courses. There were two boxes in students' heads, one contained calculus the other contained other computer science and nothing connected those two.

The students were hard working. They spent hours in front of computers doing programming and other computer related homework. However, they gave much less time doing calculus work or any other subject for that matter; they were just computer freaks. They found that calculus was less challenging. They did not know that they were expected to have problem solving and computational skill. They were not aware that understanding the concept, given in class alone, was not enough. They needed to build problem-solving skill by doing exercises.

Other problems were big classes, the heavy teaching load of the lecturers, and the differences between high school and university learning environment. It was difficult to maintain a big class consists of about one hundred and thirty students. Not every student got enough attention from the lecturer. As a result, students felt they were not part of the learning process. Moreover, they were used to more spoon-fed teaching style as opposed to student-centered learning.

In order to address the above problems, several approaches have been devised. The following are some of them.

1. The Beginning

There are profound differences between high school and university learning process. The main difference is that in high school the teaching material were spoon-fed to them and they had scarcely had any opportunity to express themselves. All teaching and learning process is done in the run of the mill mode; the school and teachers act as the conductor. In the university, the process is very much independent; the students are expected to be proactive and independent. Therefore, when the University admitted about one hundred and ten new students, it somehow is responsible to change the incoming students' paradigm and mindset. Normally, the responsibility rests on the shoulders of the lecturers of the freshmen classes, including calculus. Students will encounter many kinds of problems when they have not gone through an adequate preparation process.

It is a standard practice that lecturers have to inform clearly the rules of the game on the first day of the lecture. Students should be well informed about the purpose of the course, the expectation of the lecturers, outline of the courses, the marking scheme, and the importance and relevance of calculus in their future work. Hopefully, the students will understand the direction of the course and prepare themselves to succeed in the course.

The purposes of calculus courses are to make the students have strong foundation in mathematics for their subsequent work in computer science. Thus, students are expected to understand conceptually, be able to solve various problems, and have computational skills. The problem solving skill can only be accomplished through exercises. They should realize the importance of doing exercises.

Students are encouraged to be proactive in class. Reward are given to those who asked good questions, give suggestions or do in-class exercises. Class participation contributes to final scores. Therefore students need to be well prepared not only for final examination but also for attending the class. The preparation is the responsibility of the students, and this is one of the changes that they must be accustomed to.

2. Instructors and Students Interactions

Healthy and productive relationship among students and the lecturer makes it easier to motivate them and generate a discussion. The lecturer should make the initiative, and then this relationship should be maintained inside and outside the classroom. Students having good relationships with the lecturers outside the classroom tend to be "nicer" in the class compared to those having no contact to the lecturers outside the classroom.

However, remembering the names of more than one hundred students is difficult. A list of names with photographs attached is very helpful. Every student was asked to give her or his personal data with a photograph attached. By the end of the third month, I know most of them individually. To give more attention to students and to keep tract of their progress, more tutors are assigned. There are four tutors, each responsible in helping a group of consisting around thirty students. The tutors should have good communication skills.

The questions, exercises, and examples given in tclass are easy ones, so that students can solve them. This will increase students' self-confidence and make them more comfortable with the subject. The level of difficulties is increased gradually. Moreover, there will be no punishment for a bad questions or false solutions. Never embarrass students in front of their friends. It is important to convey a message that we learn more from other people's mistakes. Sometimes, mistakes arises from miscommunication, in such a case the mistake is the responsibility of both the students as much as the lecturer. The lecturer should make an effort to rectify such miscommunication, since the she or he is the one who presenting the teaching material. Often, students' mistakes invite more

profound discussion. They must realize that making mistakes is part of learning; so, they must not be afraid to try new methods and to express their opinion.

3. Course Preparation

Copies of transparencies notes are given in advance. It gives student a chance to review the last lecture and prepare for the next lecture. The transparencies contain important concepts and problem solving procedures without examples of solutions. Solutions are given step by step in the whiteboard. Students are encouraged to adjust themselves to taking note skills, since the explanation in the lecture is fast. Therefore, students need to attend the lectures to get the explanations in details and the examples how to apply the procedures. Students sometimes feel that having the notes (from the transparencies) is good enough, no need to attend the class. It is a great mistake! Notes are not substitute to classroom lectures. The following is an analogy between the calculus course and a jigsaw puzzle. Course material transparencies, references, lectures, quizzes, homework, and class projects are pieces that resemble the puzzle. Students should take all the pieces to make it a complete.

4. Concept to Natural Phenomenon Relationship

To make it challenging and interesting, the calculus courses should be brought closer real life, especially to other computer science courses. Most importantly, it should be presented in such a way that will challenge students' mind, make it easier to understand and more enjoyable. Students love stories. Historical stories related to mathematics and mathematicians are both entertaining and bringing calculus close to everyday life. For instance, story about Tantalus and the removable discontinuity of a function, the story behind the witch of Agnesi, the derivative songs, proofs without word, and proof by poem. Students are given chances to share their calculus related stories during the last five minutes of the class.

5. Calculus-Computer Science Relationship

Bringing calculus closer to computer science courses can be done in three correlated ways: first we use computer science terms, such as algorithm and program, to explain the concepts of calculus. Second, students are asked to investigate the application of calculus, third, we use computer to do calculus projects. For example, the procedure for divergence and convergence of infinite series is given in algorithmic manner using flowchart. Students understand this topic more easily than if we give them a long list of theorems. The words "theorems" often intimidate them. Moreover, students with enough programming experience will be interested in implementing such algorithm into a program. First year students are not expected to do numerical programming, but, at least, they must be exposed to it. They should know that many mathematical solutions are done by using computers. Numerical treatment of Ordinary Differential Equations and Partial Differential Equations are both major mathematicians and computer scientists' great works.

Preliminary Results

The approach had been applied for three consecutive semesters since September 2000. Students get better grades. The percentage of students failed in the class is around ten percents. Even though improvement in students' grade is debatable, the students' response to questionnaires is getting better. There is no complain about the lecturing style, but there are complain about the size of the class and the final examination. As for the final examination, some of them wrote that the questions are too many and too difficult. More in depth study is needed to measure the improvement and standardize the grading methods.

Obstacles

There is no thorough research in the calculus teaching at the University of Indonesia. It is hard to get up to date and comprehensive data about calculus teaching. Therefore the approach designed to meet computer science students' needs were heavily dependent on the comments and suggestions given by students, lecturers, and faculty members. To design the best approach in improving the quality and standard of calculus, an adequate and specific data are required.

The lecturing style should always be adapted with the new demand and technology. The lecturer must have enough background in computer science. It needs a lot of preparation and hard work.

The response to the approach varies between freshmen and the repeaters. It seems that the repeaters are not responding well in classical lecturing. They get bored, and hence more difficult to motivate. They got lower marks in the examination. However, they did very well in programming-related homework. Students who have taken more computer science courses, often asked about implementing computational procedures given in class in a program.

It is difficult to get qualified tutors. The financial reward for tutors is not competitive. Qualified final year students prefer to find part time job outside the campus. To invite more students for becoming a tutor I asked the faculty to increase the reward, to give them certificates, as a reference to find a job in the future, and to make them realize that they benefit much more than just the money they received.

Ideally, one tutor takes care of fifteen to twenty students. With small number of students in a group a tutor have enough time for preparing the tutorial and correcting homework and quizzes. Some actions should be taken by the faculty to increase the number of good tutors.

Future Plan

So far, no intensive talk between the calculus lectures and the CS lecturers about the applications of calculus in their field. Such information is needed to strengthen the bridge between calculus and various fields in computer science. Hopefully, this kind of talk will take place soon.

Some plans have not been optimally applied. Careful investigation is needed to design a more innovative and suitable lecturing methods and using technology to support the lecturing. The improvement will be done step by step. First, we will concentrate in helping students to build problem-solving skills. Qualified lecturers instead of student tutors will give tutorial class. We will provide a more organized and comprehensive worksheets. The problem sets will be renewed annually since students tend to learn from previous year solutions, done by their seniors, without actually doing the exercises by themselves. Finally, we want to provide a lecture note and a project guide, a guide to do the projects by computers.

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