AC 2009-1665: PREFRESHMAN STUDENTS GEARING UP WITH EARLY BIRD

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Akiko Kato studied physics, computer science and human medicine, and received both her Diploma in 1999 and her Ph.D. in 2004 in physics from the Berlin Institute of Technology. She wrote her dissertation in the field of statistical physics and quantum-thermodynamics. She has been doing research and teaching mathematics and physics at the same university since 1997, from 1997-1999 as a student assistant, from 1999-2004 as a research assistant and since 2006 as a postdoctoral researcher and assistant lecturer. Her recent field of research is focused on new didactic and educational methods in teaching mathematics and engineering sciences.

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Olivier Pfeiffer received his M.Sc. in Mathematics at the Berlin University of Technology in 2002. His thesis in numerical mathematics investigated “Error Control using Adaptive Methods for Elliptic Control Problems in Matlab”. He has been working in several eLearning projects at the TU Berlin, beginning as a student assistant in the Mumie project - a platform using new pedagogical concepts to support teaching of mathematics for mathematicians, engineers and natural scientists - at the TU Berlin in 2001, as a research assistant at SFB609 in Dresden from 2002-2004, and is now part of the Team of the MuLF (Center for Multimedia in Education and Research) at the TU Berlin). In the past three years, Olivier Pfeiffer focused on the organization and coordination of the involved teams and contributed to several other eLTR related projects. He is also involved in the planning and application of future eLTR projects at the Berlin University of Technology and the local coordinator at the TU Berlin of the EMECW3 project. His research interest focuses on the development of interactive mathematical objects especially supporting the visualization of complex mathematics and physics related problems.

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Pre-Freshmen Students Gearing up with Early Bird

Abstract

We are offering a freshmen course called “Early Bird” where students have the opportunity to take the mathematics courses of the first semester (Calculus I for Engineers and Linear Algebra for Engineers) before they are enrolled at our university. Participants accomplishing sufficiently many homework assignments are qualified to take the final written examinations even if they are (still) not enrolled. The grades of these examinations may be accepted if the students will be enrolled afterwards. In this 9 weeks course the regular calculus I and linear algebra lectures are taught in the same lecture/tutorials together. Though the workload in this course is very high for students, 99% are recommending this course to other prospective engineering students.

The intention of this course is to provide the first semester students with the mathematics that will be usually used in non-math classes before it can be taught in the math classes. As mathematical knowledge and skills are some of the most important tools for engineers the Early Bird course has proved as very effective to prepare engineering students for their engineering courses. Before winter term 2008/09 we successfully offered this course for the third time. This year we had no additional financial resources to offer very small classes. On the other hand, in the week between this course and the final examinations a summer camp has been organized where recitation lessons were voluntarily offered by teaching assistants.

In this article, we are comparing the final examination results of Early Bird students and regular students. We are presenting the results of the Early Bird courses of the last three years. The results will be compared with the data of regular students who took the same written exams.

1. Key Features of Early Bird

At the Berlin Institute of Technology we offer an intensive course in mathematics called “Early Bird” during summer holidays. Within this course the content of the regular courses “Calculus I for Engineers” and “Linear Algebra for Engineers” are taught together during nine weeks. Our target group is the students of engineering departments who have to attend these two courses in their first (or first and second) semester at university. They are allowed to attend Early Bird in advance in summer directly before their enrollment in autumn. If they successfully attend the course and pass the final exam, the earned credits can be applied to their engineering studies. We offered this course in the last three summers in 2006-2008 teaching about 300-400 students per course.

2. Motivation

In the freshman courses in engineering or natural sciences we observe all too often that engineering students do not have sufficient mathematical skills to understand the subject of the classes. However, sound standing knowledge in mathematics is a basic tool for every engineer. There are at least two possible explanations for this phenomenon. It is possible that the students have poor knowledge of high school mathematics. Surely it is not the task of a university to

make up for the failures in high school mathematics lessons. Nevertheless, our school of mathematics and natural sciences, as well as many other universities, offer remedial courses in high school mathematics, so called bridge courses, to prepare high school graduates for their studies. The other reason may be found in the mismatching curricula of the subjects of the studies. The understanding of non-mathematical subjects often requires knowledge in mathematics which has not yet been taught in the mathematics classes. At the Berlin Institute of Technology, an attempt has been made in the past by the lecturers to adjust the curricula of different classes. Although many improvements have been achieved regarding the choices of the relevant topics and their chronological order, there are still problems left which are difficult to resolve. As an example the freshman course "Introduction to Classical Physics for Engineers" starts with basics of classical mechanics, including Newton's laws as a matter of course. However, to understand, e.g. Newton's second law ("Force is the first time derivative of momentum"), one has to have basic knowledge of calculus. However, one-dimensional differential calculus will not be discussed until the middle of the first semester, not to mention the differential calculus in higher dimensions. Now this may not be a serious problem because most students have already learned how to differentiate real differentiable functions in high school. But, for instance, the line integral to calculate work is treated in mathematics within the scope of vector calculus in second semester, at the earliest. The same course covers the topics "oscillations and waves" as well, whereas the course "Ordinary and Partial Differential Equations for Engineers" is intended for third semester students (sophomores). In practice, lecturers of engineering classes manage this situation by inserting exercises on relevant mathematical topics when needed. This is mostly dissatisfying for both professors and students because of the loss of time, and because, therefore, the mathematical topics cannot be discussed in detail as the matter requires.

This is a fundamental problem: Mathematicians wish to teach the mathematics starting with foundations and explaining every detail. Engineering teachers do not want to wait one or two semesters, but they want to teach "their own" subjects to engineering students starting from the beginning to give them hands-on experience as soon as possible. On the one hand, engineering students are happy when they can understand the mathematical concepts thoroughly and do not have to use recipes without comprehension. On the other hand, these students would be very frustrated if they had to deal only with mathematics for one or two semesters. Therefore, this fundamental problem will probably never be resolved. As learning is a "non-linear" process students will profit most by a good mixture of mathematics and engineering classes.

Students who participated in Early Bird already have knowledge of the first semester mathematics courses at their disposal when they start their studies. This may help them to get along better with their studies in the first semesters. Another advantage of Early Bird is the fact that the students can focus on learning mathematics during nine weeks without any other classes at the same time. Additionally, students starting their study in winter term have the opportunity to use the time between high school graduation (German Abitur) and their first semester.

3. Implementation

At the Berlin Institute of Technology approximately 27.000 students are enrolled. Every semester there are about 1400-2400 (most students are starting in winter term; thus, more first

semester students are attending the courses in winter term) participants attending the courses "Calculus I for Engineers" and "Linear Algebra for Engineers" that are compulsory mathematics courses of first semester engineering students. Since it is not possible to teach them all by one professor, we offer a set of parallel lectures with 300-500 participants each. In addition smaller exercise/recitation classes are offered where the students attend lessons by Assistant Professors and student tutors. The idea of Early Bird is to shift two first semester lecture and associated exercise classes into the semester break. Concerning the high school graduates who attend Early Bird in summer, first term mathematics is already available at beginning of their studies in autumn. They get the opportunity to pass the course and final exam before start of studies. In case of failure, there will be no negative consequences for the students because they are not yet formally enrolled. At beginning of Early Bird it is not yet decided who will get admission to the university. Therefore, there is always a certain risk by selecting the Early Bird-participants, because some of them will be readmissioned. By accepting only persons who applied for a university place at Berlin Institute of Technology and who have high chance for admission (high school marks), we effectively can reduce this risk.

Figure 1: Lecture hall with Early Bird students.

We want to point out that the Early Bird course is not a remedial course of high school mathematics[2,3,4] : Many universities are offering a variety of "bridge courses" or preparatory courses. These courses are offered to bridge the gap between high school and university, and many of them are dealing with mathematics or physics. At least at German universities, as far as the authors know, these are additional courses, and they are intended as a repetition of the subjects that (should) have been learned at high school. Additionally, some courses are designed to give the beginning students the opportunity to discover their strength and weakness[1]. The aim of Early Bird is not to offer a remedial course with main emphasis on the repetition of the

mathematics from high school, but to give the opportunity to take standard courses of mathematics for first semester students before the first semester starts.

Figure 2: Early Bird Students discussing mathematics after the recitation session.

Figure 3: Early Bird students at the summer camp discussing mathematics during lunch break.

4. Early Bird vs. Regular Courses

One semester has the duration of about 15 weeks. The regular semester course “Calculus I for Engineers” includes two lectures and one exercise class per week, “Linear Algebra for

Engineers" one lecture and one exercise class per week. The total number of lectures is the same in Early Bird, since every day one lecture is given during nine weeks. Shorter exercise classes take place every day, and the students have to solve (short) homework assignments every day, while the students in regular semester courses get one larger homework assignment per week in both courses. The overall amount of work is therefore the same, but Early Bird lasts only nine weeks and thus has to be considered as a full-time course. Since the participants don't have any other courses during Early Bird, they can fully concentrate on mathematics and prepare well for both final exams. In the last two years we managed to give the students one free week between the end of the course and the examinations so that they can learn sufficiently. This time, in this free week a summer camp has been organized where for instance recitation lessons were voluntarily offered by teaching assistants. The relaxed atmosphere between the teaching team and the Early Birds has always been conducive to good learning success. For the first and second Early Bird course we had additional funds by the university to have smaller exercise classes (16 students per teaching assistant/student tutor). This time without additional funds we had 24 students per exercise class. Teachers who have been involved in this year's and the last years' Early Bird courses have the impression that the negative effects of the larger classes have been compensated by the summer camp.

5. Results

The immediate success is quite evident when we analyze the exams' results. The Early Birds take part in the same written examinations as the students of the previous summer term so that we easily can compare the results of both groups. The following table shows the percentage of students who passed the exam.

Year	Subject	Exam passed (Non-Early Birds)	Exam passed (Early Birds)	Ratio (Early-Birds/Non-Early Birds)
2006	Calculus I	54%	78%	1.44
2006	Linear Algebra	73%	89%	1.22
2007	Calculus I	47%	63%	1.34
2007	Linear Algebra	55%	59%	1.07
2008	Calculus I	46%	63%	1.37
2008	Linear Algebra	71%	73%	1.03

Table: Comparison of the examination results of Non-Early Bird/Early Bird students.

Obviously the intensive and exclusive dealing with mathematics by the Early Birds shows its effects on these results.

Furthermore, though the workload in this course is very high for students, 99% (211 out of 213 who answered to this question in a poll at the end of the course) are recommending this course to other prospective engineering students.

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