Adapting to the Fast Increasing Demands for Microelectronics: Curriculum Design and Teaching Strategies

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Abstract

This paper gives a general view of the curriculum design and teaching strategies for undergraduates majoring in Microelectronics, with a view to introducing students to the contemporary development in the discipline. Proposals are given on making necessary changes to courses, based on the current situations of the Institute of Microelectronics. The current teaching strategies are reconsidered on the basis of the author's own teaching practice, and new ideas and strategies are incorporated.

Introduction

The Institute of Microelectronics used to be a division in the Department of Physics, and has developed into a separate disciplinary unit in which systematic programs are offered to students at all levels of university study. However, the courses offered to undergraduates in Microelectronics remain almost the same as to the students in Physics, except for a few courses for senior students. This makes it difficult for students in Microelectronics to prepare well for their future careers, whether they go into academic research or other professional activities. Therefore, changes to the current courses for undergraduates are necessary.

Microelectronics has developed very rapidly in the past few decades (refer to Moore's Law, which is specific to the development in Microelectronics). And the subjects within Microelectronics have developed in many directions. This demands that students in Microelectronics be able to master a great number of both fundamental theories and laboratory skills before they become creative and competent in their future professions. To meet these demands, in addition to necessary changes to the currently offered courses, it is also very important to reconsider the teaching strategies, and to enhance the student learning.

In this paper, the author presents an overall view on changing the courses and modifying teaching strategies, based on his own teaching practice and the current situation in the Institute of Microelectronics.

Changes to courses

Motivations for making changes to courses

The major drawbacks of the current courses offered to students in Microelectronics are as follows:

Some courses are less relevant to the discipline of Microelectronics. The Institute of Microelectronics has grown from the Department of Physics; the curriculum should be changed accordingly to focus on the features of Microelectronics. The current courses lay particular stress on Condensed Matter Physics rather than on Microelectronics.

Some courses are inappropriate for students in Microelectronics. One criterion in modifying curriculum is the consistency of course objectives with the learning outcomes. The current courses do not provide students with sufficient discipline-related training.

Some courses are more or less overlapped in content.

Some courses lag far behind the development in Microelectronics. Some courses do not reflect the front-edge theory and technology.

Some new courses are needed for the discipline of Microelectronics. The students in Microelectronics should be able to design or create new types of devices, including discrete devices and integrated circuits, thus new courses should be added to include the design and analysis of electrical circuits.

Laboratory and tutorials are less emphasized. Laboratory and tutorials are currently not strongly emphasized. They should be renewed or modified to enhance students' problem solving skills.

The purpose of making changes to courses

Microelectronics is a typical cross-disciplinary subject. It identifies and uses various mechanisms in micro-scale structures, and, at the same time, it directs to many possible applications.

The purpose of making changes to courses is to deal with the great amount of knowledge in a more effective way. Microelectronics acts as a junction between theory and application; it involves the fundamental theories and applicable technologies. Thus, the courses should be concise but comprehensive specifically for the student in Microelectronics. Some courses, such as Theoretical Mechanics, Electrodynamics, Quantum Mechanics, and Statistical Physics, should be introductory for the major of Microelectronics, because the relevant concepts in these courses are discussed intensively in the third year course Physics of Semiconductors and Physics of Semiconductor Devices, where the students find these concepts are easier to understand because these concepts are usually closely integrated into concrete problems. Some courses, however, should be intensive for the first year. For example, the course General Physics can be designed to include not only Classical Mechanics, Thermodynamics, Electromagnetic, and Wave Optics, but also fundamentals of Quantum Mechanics. In general, making changes to courses should allow more time for teaching and learning the contemporary advancements in the discipline; this is especially important for the major of Microelectronics.

Proposed changes to the courses

We will make changes to the courses in the following ways.

Introducing contemporary textbooks to replace old ones: we will introduce the newly released (2001 version) Textbook of Courses for the 21st Century into the teaching of General Physics for the first year undergraduates. We will also introduce the English version textbook (2001 version) into the teaching of Solid State Electronic Devices for senior students. Solid State Electronic Devices is also a replacement of the course Principles of Transistors.

Integrating some courses into others: the courses Theoretical Mechanics, Electrodynamics, Statistical Physics, and Quantum Mechanics are to be integrated into a more compact course. Some materials such as fundamentals of quantum mechanics, which used to be for second year students, will be given in General Physics for first year students. This allows students in Microelectronics to learn more efficiently in the discipline context.

Adding new courses: we will add new courses that are necessary for students in Microelectronics: Analog Circuits, Digital Circuits (these two courses are essential for analysis and design of electrical circuits), and Analysis and Design of Integrated Circuits.

Renew laboratory manuals and experimental setups: in laboratory, students will be able to keep up with the pulse of development in Microelectronics.

Reconsidering teaching strategies

In this section, the author does not intend to cover every aspect of teaching, but focuses on the points that are considered more beneficial to student learning.

Teaching strategies

There is a variety of teaching strategies or methods, especially for teaching university students. In general, different lecturers may prefer different teaching methods; and different students prefer different approaches to learning. And more interestingly, a student may adopt different approaches to learning in different courses.

The students in Microelectronics are expected to gain a solid knowledge base and plenty of practical skills, consistent with the requirements of studying in this discipline. As well as many classroom lectures, many other forms of studying such as discussion, tutorials, laboratory work, practicum, program-participating activities, etc. should be considered.

The learning outcomes for students are usually either rote memorizing or productive; they depend mainly, but not completely, on learning approaches, course design, teaching ethos, and assessment. These are elements in teaching and learning. We must adopt appropriate teaching methods to allow students to gain better outcomes.

Students' previous experiences in learning form their schema deeply in their mind. Based on the awareness of students' schema, we have to make an adequate mixture, in a careful way, of the various elements in teaching and learning. Further, students may need a different mixture for a different course to account for the different characteristics of a subject. By doing so, we can modify the students' schema effectively, thus enhancing students' learning.

Suitability, feasibility and applicability

It is important that any improvements and adoptions of teaching strategies should be suitable, feasible, and practical. This involves the backgrounds in which current teaching is in practice. For example, the classroom may be redesigned to allow teaching by means of multimedia, simulation, demonstration, discussion, and teamwork. Another important point in teaching is to make incremental changes in teaching style, because the students may get well used to a specific teaching style.

Enhancing interactivity

The activities listed below are useful in enhancing interactivity. Some of these concern the interactivity between students and students; others concern the interactivity between students and lecturers.

Time for student discussion	*Questionnaires, surveys*
Arranging peer group activities	*Interview sessions*
Team work	*Tutorials*

A lot of literature has contributed to the above aspects of teaching; the author does not repeat them here.

Incorporating research into teaching

Programs for undergraduates: arrange some small projects or research programs for undergraduate students, specifically for the top rank students. These projects and programs mainly consist of scientific research or academic training. Thus, those participating in the programs or projects get training before they enter higher-level study or research.

Case study is an important means for students learning sciences. This is especially suitable for students in Microelectronics, because microelectronics is a cross-disciplinary subject; it involves materials sciences, chemistry, engineering, computing, etc. By means of case study, students can practice gathering a variety of information needed for problem solving, and develop skills of thinking, reasoning and analyzing.

Strengthening students' learning

Self study: lecturers are only the guides to student learning, while it is the responsibility of students to process, reorganize and digest the knowledge they receive. Self study involves interests, and teachers should take the advantages of the interests. For example, most of the students in Microelectronics like computing, and they elect to take Computational Physics; some of them even get better performance in examinations or programming than those taking this course formally. This is in turn a big help when they learn in later courses to model or simulate devices.

Problem based learning (PBL) encourages and challenges students to gain all-round development. For senior students, PBL is better because students are capable of solving real-scientific and problems of great significance.

Knowledge-frame setting-up: the subjects within Microelectronics have developed very fast in many directions; students are meant to learn much more than ever. On the other hand, if the workload is too much for students, they are likely to adopt a surface approach to learning. To help students overcome possible difficulties in learning, teachers should make efforts to set up a knowledge frame on the part of students.

Enhancing laboratory and tutorials: laboratory manuals and experimental setups will be modified and updated. Tutorials, which are not stressed in previous practice, will be put in the place of a previous 'answer-question' session to include weekly quiz.

Summary

Microelectronics as a discipline in university study needs changes in the course design, to introduce students to contemporary development. Some courses should be changed to being introductory, while others should be enhanced as intensive.

Teaching and learning in the discipline of Microelectronics requires an adequate combination of elements such as teaching strategies, learning approaches, course design, and assessment, to allow students to gain better learning outcomes. Laboratory work and tutorials should be strengthened from the current situation.

Teaching should be done for students at the beginning of their university study in a manner that lets them understand that science is powerful but NOT unreachable, provided they are enthusiastic in study and make appropriate efforts.

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