Submitted to Journal of Materials Education (1998),
Proceedings of Symposium on Materials Education, MRS Fall Meeting, Boston, Dec. 1997

15-MINUTE "CLIPS" ON MATERIALS ENGINEERING

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ABSTRACT

This article describes a new way of structuring a course on atomic scale materials engineering. Each weekly 90-minute session is divided in six 15-minute blocks in the following order: 1) peer instruction on homework, 2) student presentation of homework exercises, 3) demonstration of equipment by instructor, 4) student presentation of a recent article, 5) explanation by instructor of new homework, and 6) news of the week. The students learn about techniques for thin film materials characterization, become acquainted with various applications of these techniques, and are able to situate them in the context of modern developments in materials science. In addition, a variety of presentation skills are addressed. Student evaluation of this new setup has been very positive. Although the number of students in the course was small (about 10 students), this course structure is suitable for larger groups and for other materials engineering courses as well.

Key words: pedagogy, teaching styles, course structure, presentation skills, peer instruction

INTRODUCTION

The attention span of present-day university students is short. During a lengthy lecture in front of a class student concentration often wavers. If our goal is to have students actually learn something for the full lecture period, it is essential that we change the format of the lecture at regular intervals. In this article I will present my experiences with an experiment I did with a group of third and fourth year students majoring in physics and materials science at the University of Utrecht in The Netherlands. Instead of the usual 90-minute weekly lectures, I divided this weekly session into six 15-minute blocks, each with a different topic. This new setup was termed "clips", inspired by MTV video clips in which presentations are short and rapidly changing.

The course I teach is on atomic scale materials engineering and characterization. My teaching goals for the students are that they learn:

1. to know and understand various techniques for thin film materials characterization;
2. to be familiar with the applications of these techniques;
3. to situate this knowledge in the context of modern developments in materials engineering;
4. to present scientific papers.

The course duration is fifteen weeks, with classes held once a week for 90 minutes. In the usual setup this 90-minute session consists of two 45-minute lectures, and includes a 15-minute break. The estimated recommended time to be spent on homework for this course is eight hours per week. In the following sections I will describe how the course was restructured into short clips, and how these weekly clips each address the above teaching goals.

LEARNING GOAL 1: TECHNIQUES FOR THIN FILM MATERIALS CHARACTERIZATION

The textbook I am currently using is *Fundamentals of Surface and Thin Film Analysis* by L.C. Feldman and J.W. Mayer.[1] This textbook describes the fundamentals of materials characterization that I want my students to know about. Each week I discuss one chapter for about 15 minutes. Of course this is very short, and only sufficient to highlight the most important issues dealt with in each chapter. In my weekly "clip" I give a short overview of the techniques and physical concepts addressed in the chapter, and project five to ten transparencies with the most important graphs presented in that chapter. I end this 15-minute clip by assigning my students this chapter as homework for the next week. As homework the students are also required to solve a set of exercises listed at the end of each chapter.

The following week I test students' knowledge of the chapter by using the transparent sheets of the week before. I select three to five students and ask them to lecture to their colleagues, using these transparent sheets. These homework presentations take about 15 minutes. I then ask a few students to stand in front of the class and present one of the exercises prepared as homework. I ask them to present this as if they are standing in front of an audience at a Materials Science Conference. I emphasize that their presentation should include what I consider to be four important aspects of any scientific presentation:

1. what kind of problem has been solved,
2. why it is an interesting problem,
3. how it has been solved, and
4. what was the result.

Each week we spend approximately 15 minutes on these presentations in class.

Both the homework presentation clip and the exercise presentation clip are ways of peer instruction. As has been shown by for example Mazur at Harvard University,[2] peer instruction is a learning and teaching method that can significantly increase the efficiency of physics course lectures. Mazur used peer instruction for elementary physics courses. Also in the present 15-minute lecture clip format it proves to be very effective. Moreover, the students always do their homework because they may be asked to stand in front of the class. They do not want to run the risk of not having anything to say. An additional advantage is that students often listen to each other better than to an instructor lecturing. Because they are actively involved in the class, they are motivated not only to understand formulas but also to be able to explain what these mean. And while learning about materials analysis they also learn a variety of presentation skills they will need later on in their career.

LEARNING GOAL 2: APPLICATIONS OF MATERIALS CHARACTERIZATION

Each week I spend about 15 minutes demonstrating materials analysis equipment. For example, I show a surface barrier detector for Rutherford backscattering spectrometry (RBS), a Cu x-ray source, Si wafers coated with a variety of thin films, solar cells, or I perform a computer simulation of ion ranges in solids, with input parameters suggested by the students.

In addition, two of the 15 weekly sessions are spent outside the classroom. One session is held in the RBS laboratory, where the students are presented with a sample box labeled "sample X" and are asked to find out the surface composition of the sample using RBS. The students divide the work among themselves, such as mounting samples, venting the vacuum system, starting the accelerator, setting up the detection electronics and collecting the data. After the RBS measurement has been made, they perform the data analysis using the theory they have learned the week before. After a few hours of team work the composition of sample X is determined. This is always a very satisfying and successful session for students.

The second outside session is an excursion to Philips Semiconductors, a silicon IC factory in Nijmegen, The Netherlands. Here the students can see how modern materials analysis techniques are being used in semiconductor processing, in device characterization and in failure testing. Visiting such a facility affords students with first-hand experience on the practical application possibilities of materials analysis equipment. Such up-to-date exposure on how techniques taught in the classroom are really being used in modern materials fabrication is a worthy addition to their textbook knowledge.

LEARNING GOAL 3: MODERN DEVELOPMENTS IN MATERIALS SCIENCE

To let students become acquainted with some of the more recent developments in materials science, each week I ask a student to give a presentation on a recent article that I have selected from Applied Physics Letters or Physical Review Letters. The student has to present the paper as if it were a conference presentation, within the typical 15-minute time limit, again addressing the four key aspects described earlier in the homework presentation section. These paper presentations have proven to be very instructive, both for the presentator and the audience.

A second way of communicating recent developments in materials research is that I end every weekly session with a "News of the Week" clip. In 15 minutes I discuss items such as a recent Nobel prize in physics, an interesting article in Nature, Science, Applied Physics Letters or Physical Review Letters, or a significant development in my own research group.[3]

LEARNING GOAL 4: PRESENTATION SKILLS

In many universities the materials curriculum does not include sufficient activities that allow students to develop their presentation skills. The opportunity to give a typical 15-minute lecture at a conference often only presents itself in later years, when students are well into their research programs. In order to further stimulate the development of presentation skills I plan one of the last sessions as a "Student symposium on atomic scale materials engineering". In this symposium, organized as a typical conference, each student presents a recent article which I have selected beforehand. Because all the articles are chosen so as to relate to a specific theme, for example "optical materials", an interesting and coherent symposium is guaranteed. The student presentations last 15 minutes each. In addition to my own students I also invite graduate students who are more experienced in their presentation skills. The graduates serve a two-fold purpose: not only do the students learn from their presentations, the symposium also gains in seriousness because of their presence as audience members.

CLASS SCHEDULE

In summary, the weekly 90-minute session is divided into six 15-minute blocks, as may be seen in Table I. The 15-week course schedule is shown in Table II: it includes 12 weekly lectures, two excursions, and the "Student symposium on atomic scale materials engineering". The last session is used to test student comprehension. In this session I ask each student to explain one or two aspects of the material covered during the course. In this final session the students also evaluate the course.

In this course, there is no final written exam. At the last session the students receive their final grade, which is the weighted average of two grades: the average of homework exercises (which they hand in weekly, and which I correct, rate and return the week after) and a rating of their in-class presentations (homework, papers, symposium).

Table I Weekly session: six 15-minute "clips"

Students:	homework chapter contents presentations
Students:	homework exercise presentations
Instructor:	equipment demonstration
- break -	
Students:	present a recent article
Instructor:	discusses next chapter and homework assignment
Instructor:	"News of the Week"

Table II 15-Week course schedule

1	Chapter 1
2	Chapter 2
3	Chapter 3
4	Chapter 4
5	Visit to RBS lab: students analyze sample X
6	Chapter 5
7	Chapter 6
8	Chapter 7
9	Chapter 8
10	Visit to a factory (e.g. Philips Semiconductors)
11	Chapter 9
12	Chapter 10
13	Chapter 11
14	Student Symposium on atomic scale materials engineering
15	Final test, students evaluation of course

ARE THE LEARNING GOALS ACHIEVED?

With the weekly division into 15-minute clips and the course schedule as shown in Tables I and II, all aspects of the four learning goals are addressed: the students learn and understand various techniques for thin film materials characterization, learn about applications of these techniques, and learn to situate them within the context of modern developments in materials science. In addition, a variety of presentation skills are addressed. Of course, an important criterion in measuring success is the student evaluation at the last class meeting. I have now given this course twice, in 1996 and 1997. Both times students were very enthusiastic about both the 15-minute clip setup and the course schedule as a whole. The average student's rating (on the Dutch scale of 1-10) for the course itself was between 8 and 9.

It is my conviction that this clip setup can be applied to other Materials Education courses as well. While my experience has thus far been limited to third and fourth years students, a similar setup can be used for first and second year students. Also, while my groups were limited to about ten students, this setup is feasible for larger groups, except perhaps for the weekly homework presentations, which is probably suited for groups to a maximum of about 20 students. However, the equipment demonstrations, students' paper presentations, and the "News of the Week" are all elements that can be included in courses with a large student enrollment.

ACKNOWLEDGEMENTS

The development of this teaching method is part of a program of Utrecht University, and of the Foundation for Fundamental Research on Matter (FOM), financed by the Dutch Organization for Scientific Research (NWO). I am grateful for the input from the students at Utrecht University for the development of this course.

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