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Improving university courses in mathematics with new lecturing technology: practical studies of classroom video recording and dissemination on the web

Introduction: a common problem in university mathematics courses

This article presents a new (although in some ways also traditional) method to improve the teaching of mathematics in university lectures. The method presented here has been shown to improve the understanding of the course contents among some students, and it never leads to a decrease in understanding. It is relatively easy to implement.

In mathematics lectures, students face the problem that mathematical content relies heavily on previously taught content. Examples are: logical deductions; use of definitions that were stated earlier; case distinctions, where the arguments used in one case are implicitly used in following cases; etc. Thus it is easily possible that students are "lost", i.e. unable to follow the lecture due to not being able to remember (or not having understood) previous parts of the course. This problem occurs even when the lecture itself is very clear, well structured, and charismatically presented.

This can be called a problem of "flow control": Individual students cannot control speed (and pauses) of the course easily, at least not in a sufficiently fine-grained manner. In comparison, when reading a book, the reader has such control. The video recording method presented in the following makes it possible for students to pause arbitrarily, to move backwards (and forward) through the lecture, and it allows the student to see parts repeatedly. The lecturer is not required to adapt their teaching style; in fact, the traditional chalk-on-blackboard style can be used without modification.

Using video recording to allow students to review course content

In the method analyzed here (which has been tried out by the author several times), the lecture takes place in its usual setting in a university classroom, where the students are present. Video cameras are present and record the lecture; more precisely, they record the recent writing on the blackboard plus the lecturer while talking and explaining. Suitable audio transmission technology is also used. After class, the video recordings are made available to the world (or optionally only to the students) on the web. There is no requirement for any particular software for the students; any web browser is sufficient to get the videos, and any video playback software will play

them. The students can use the recordings to review the lecture at home or at any other location and time of their choice.

Note that this approach, while using modern technology for recording and dissemination of content, is quite conservative as far as the actual teaching is concerned - after all, writing with chalk on a board is an ancient technique, but it is still highly popular with students. Clearly, much more modern methods of lecturing have been thought of, e.g. "inverted classroom" lecturing. The conservative approach discussed here will be easily adopted by all motivated lecturers, even those preferring traditional teaching.

How are mathematics courses special?

Mathematical language is particularly compressed, possessing a high density of content and ideas. Hence a slow writing method (chalk, handwriting) is popular with students. Many current video recording systems created for classroom use tend to focus on recording of presentation slides (with the image of the lecturer taking only a secondary role). Hence they assume that the lecture is held via computer and projector. This is generally not true in mathematics teaching. It is certainly not wise to require lecturers to adapt their teaching style to the recording technology available. Therefore I propose this maximally simple approach.

Results: How effective is this method in practice?

This method was tested in the following lectures at German universities:

- "Dynamische Systeme" (Dynamical Systems), 2010, University of Hamburg
- "Fachwissenschaftliche Grundlagen" (Introduction to Mathematics for MathEd majors), University of Koblenz-Landau
- "Differentialgeometrie" (Differential Geometry), 2012-2013, Technical University of Darmstadt

In the latter course, there were specially designed course evaluations to test the effectiveness of using this method to enhance teaching. Moreover, there were interviews with some of the students, asking them in detail about their use of the recordings. The evaluations and interviews showed:

- Students like the existence of video recordings profoundly, praising their existence frequently on the evaluation forms.
- There is a large fraction of students who use the video recordings regularly, in addition to attending the classroom lectures.

There is a small fraction of students who make hardly any use of the video recordings. This includes very good students (who presumably already understand the lecture in the classroom thoroughly). On the other hand, some students who had achieved top scores mentioned that they had spent particularly much time reviewing the recordings.

The evaluation questions asked in detail how the students watched the recordings, and what goals they had while doing so. The questions particularly asked how and why selected parts of the lectures were chosen by the students for review. The answers indicated that:

Primarily, students selectively review difficult parts of the lecture in order to understand them better. Sometimes, the recordings are also used to review the lectures in their entirety, e.g. for exam preparation. Students did not typically stay away from the classroom lecture to watch the recordings later. Instead, the recordings were used in addition to the classroom lecture.

Details of the required technology, and some practical suggestions

There are several big potential problems which must be avoided. They are mentioned here, as well as the required resources: people, equipment, and infrastructure. Equipment is most obvious: cameras, audio transmission systems, and video editing equipment. High definition cameras are required. (I suggest two of them; you will soon see why.) The resolution must be high so that handwriting is legible in the video later on; text must appear easily readable and crisp. Cameras should be mounted on large tripods with a special "head" which allows smooth horizontal swivel. Also needed is an audio transmission system with a microphone (e.g. worn around the neck or attached to the collar) to wirelessly transmit the words of the lecturer to the camera; this avoids recording small noises which might be present in the classroom near the camera's positions. These items are already all that is required in class (i.e., during the recording). Afterwards, a computer with video editing software is used to mark beginning and end of the recorded sequence, add a title page, and usually convert the recordings to a size suitable for internet transmission.

The expensive part is people. The cameras must necessarily have a person behind them, pointing them at the currently used part of the board, as well as the speaker, and zooming in on the current blackboard. This is important; it is usually not sufficient to just stationary cameras in the lecture room which always record all the blackboards at once, since that would make the writing on any one of them too small to read. In university

courses without people behind the cameras, the resulting recordings are often illegible. A web server is required for transmission; these are easily available at universities. The basic options are download server (which just offers the recordings as files) and streaming server which lets students watch recordings in their browser. Streaming can be achieved with entirely free and open-source software. It is possible to restrict downloading and viewing of the lectures to enrolled students; my personal recommendation, however, is to allow the whole world to see the lectures. Reliability: All technology can fail. The setup presented here is quite simple but obviously contains several components (batteries, storage media, etc.) whose failure will spoil the recording. If you want to be sure that your recordings cover every lecture of the course (e.g. if you are teaching a large class or want to tell students that they can rely on having video recordings), you need a redundant setup - two separate cameras and preferably two audio systems.

Do video recordings reduce classroom attendance?

A typical question (which the author gets asked again and again by other university teachers) is: "Do students still attend class if video recordings are available?" During my course on Dynamical Systems at the University of Hamburg, even though high-quality video recordings of the lectures existed (and were made available promptly after class), attendance in class was constantly almost 100%. This may well be due to the fact that I knew every student by name, and the class size was about 30. Presumably students could be less motivated in larger or more anonymous classes.

As a conclusion to draw from this, I suggest that a large amount of interaction between teacher and students is highly important and valuable. This also supports the view of the author that technology, such as the type suggested here, can noticeably enhance teaching, but it is certainly not a substitute for teaching. Hence video recording technology will not make classroom lectures obsolete.

References

Gunesch, R. (2012): Differential Geometry explained easily: A new teaching concept. In: Beiträge zum Mathematikuterricht. Münster: WTM, 321-324.

Handtke, J., Sperl, A. (2012): Das Inverted Classroom Model. München: Oldenbourg.

Fischer, M., Spannagel, C. (2012): Lernen mit Vorlesungsvideos in der umgedrehten Mathematikvorlesung. In: J. Desel, J. M. Haake & C. Spannagel (eds.): DeLFI 2012 – Die 10. e-Learning Fachtagung Informatik der Gesellschaft für Informatik e.V. Bonn: Köllen, 225-236.