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New Media in Teaching UML in the Large — an Experience Report

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Abstract: Huge classes (more than 800 students) pose a major challenge to lecturers as well as to students, especially when a practical part is included. In order to successfully master lectures of this size, novel kinds of teaching media provide a multitude of enhanced opportunities.

In this paper, we present our experiences with the application of new media in our undergraduate course Introduction to Object-Oriented Modeling (OOM). In this course, we teach approximately 800-1000 students per year the principles and techniques of UML 2.0. New media, i.e., technologies other than the traditional blackboard presentation like a document camera, web-based self assessments, or lecture recordings, are applied to support both, students and lecturers when learning and teaching, respectively. We empirically underline the acceptance of our concept with the feedback of our students concerning the newly used technologies gained through an extensive survey.

Keywords: Teaching Object-Oriented Modeling, Teaching UML, Basic Modeling Course

1 Introduction

Since computers have become a consumer product and the internet has become a mainstream medium, many tools and techniques supporting teaching electronically as well as learning have emerged. The rich variety poses a major challenge for teachers in order to effectively apply the new possibilities.

The application of new media in education has also always been an active research field. New technologies emerge bringing new ways for teaching and learning. Today, e-learning, d-learning[1] or m-learning[2] have become indispensable in education [GA03]. Also other digital media affect education. In the area of modeling, Qi et al. [CGH03] present the application of e-whiteboards, which serve perfectly for modeling in small teams. Another example is given by Zupancic et al. [ZH02]. They have recorded the whole lectures and have streamed them together with the notes of the lecturer. Mock et al. [Moc04] presented their experiences of using a tablet PC for teaching computer science courses.

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[1] Distance learning.
[2] Mobile learning.

In this paper we present our experiences with the selection of new media tools we used for our course Introduction to Object-Oriented Modeling (OOM), namely lecture recordings, a document camera, and self assessment tests. Those tools help us to teach a big number of students at the same time while still supporting the students as good as possible and offering them multiple learning channels.

At the end of summer term 2010, the students were asked to voluntarily take part in a survey covering the teaching methods of the lecture and about 180 of the all in all 500 students took part in the survey which results in a participation rate of 36%. The results of parts of this survey are presented within this paper.

The paper is structured as follows: In the next section, we introduce our course and teaching environment. In Section 3 we present the self assessments for students in our e-learning platform. In addition, the platform also provides lecture streams, which we present in Section 4. The application of our document camera is discussed in Section 5. Before we conclude in Section 7, we present our ongoing work in Section 6.

2 Background

Our course *Introduction to Object-Oriented Modeling* (OOM) is offered twice per year and attended by 800-1000 undergraduate students who study computer science or business informatics at the Vienna University of Technology. In OOM we teach modeling basics by introducing syntax and semantics of UML 2 models[3] [HKKR05, RQZ07]. Despite the huge number of students, we try to avoid mass processing, but we establish personal mentoring instead. Besides a traditional lecture where structural as well as behavioral modeling techniques are introduced, we organize the lab as exercise courses in smaller groups where the theoretical contents of the lecture are practiced. Furthermore we provide support via online forums on the e-learning platform TUWEL[4] (a Moodle adaptation of the Vienna University of Technology). A detailed description of the course is given in [BSW+08].

The *lecture* consists of six units covering the following UML 2 diagrams: class and object diagram, sequence diagram, state diagram, activity diagram, and use case diagram. Each lecture is given with powerpoint slides accompanied by small practical modeling examples and syntax illustrations which are developed live during the lecture.

For the *practical part* the students are divided into groups of about 50 persons. Each group meets six times during the semester for a so-called "lab session" in order to discuss the solution of exercise sheets for practicing modeling. For each exercise the assistant professor chooses one student who must present and explain his/her solution.

For *further support*, we provide various e-learning exercises including multiple-choice questions and practical modeling exercises. The students can voluntarily use the e-learning exercises to test their knowledge about the syntax and the theoretical background of the diagrams as well as the interpretation of given diagrams and they can gain some modeling practice.

In our course, we use different media to teach UML supporting the different learning methods and needs of our students. The students can choose between learning the UML diagrams with

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[3] http://www.uml.org/
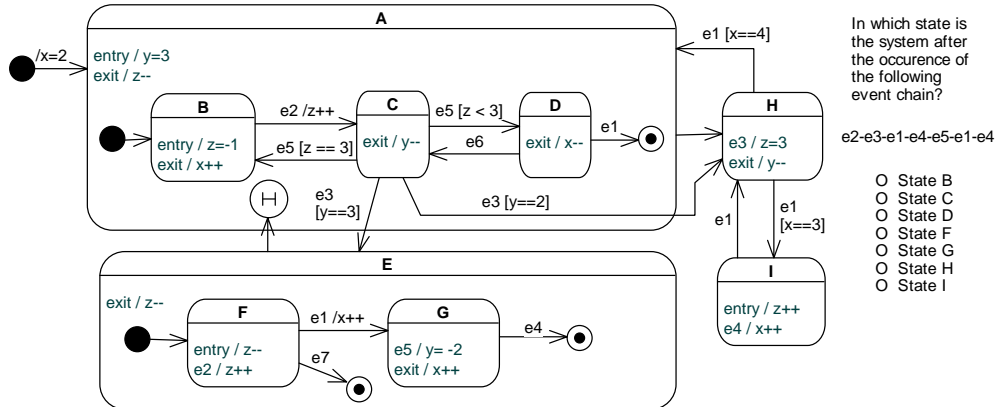
[4] http://tuwel.tuwien.ac.at

Figure 1: Self Assessment Example

the help of a book [HKKR05, RQZ07], attending the lecture, listening to the lecture at home or a combination of the three. The lab sessions are not simply used for assessing the students' knowledge, but also to answer questions and to examine each covered UML diagram from a more practical point of view — given that the students already have a basic knowledge of the syntax after the corresponding lecture as well as the preparation of the lab exercises have taken place. Three exams assess whether the students have reached the learning goals — if they understand the teaching material as well as if they are able to apply the taught concepts to small "real world problems".

To apply this teaching concept, we use traditional methods and material such as powerpoint or the blackboard as well as more recent methods such as lecture videos or e-learning. In this paper we concentrate on the more recent methods and technologies which assist us in teaching OOM.

3 Self Assessments

In OOM, the students have the possibility to practice all UML diagram types presented in the lecture with the help of our e-learning platform. In 2008, we started the first experiments on web-based self assessments for modeling [BSW+08], which we have extended providing now a higher amount of questions and more different types of questions presented in the following. As a whole, we distinguish between multiple choice and open questions with the overall goal that our students learn to understand both the syntax and semantics of UML by exercising on the basis of several examples on their own responsibility. Beside multiple choice questions checking the theory of object-oriented modeling, we mainly focus on multiple choice questions with practical background as depicted in Figure 1, where examples of UML diagrams are given and the students have to understand and interpret them. When exercising open questions where a textual description of a UML model is given, students have to develop the dedicated model from scratch.

All questions may be exercised during the whole term and may be repeated by the students as often as they like. Solving these exercises is not mandatory. Moreover, they are also a good starting point for fruitful discussions in our online forum, which is actively used by most students.
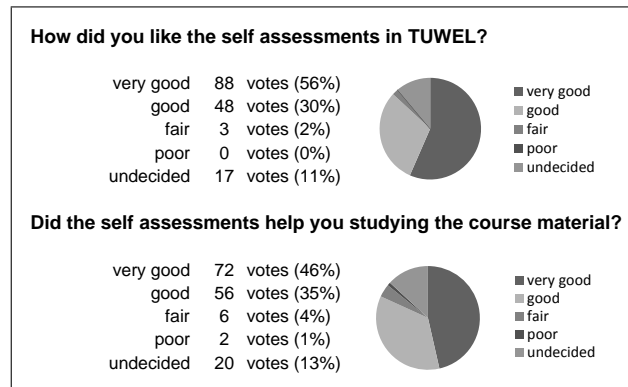
Figure 2: Survey results concerning the self assessments

Multiple choice questions are evaluated immediately and presented to the students, where wrong answers are marked. In contrast, open questions where students have to develop a model are not checked automatically by the system. However, the students may control their exercise by fading in the correct solution.

In summer term 2010, 73% of all students used the multiple choice questions for practising and approximately 50% of all students tried them two or more times, whereas 43% of all students worked through the open examples and only approximately 15% of all students repeated them. Of course, there is a huge increase of attempts a few days before the tests. Nearly 100% of all attempts happen during these days.

The self assessments support various types of learning (cf. [Kol04]) in the following sense:

- *Learning by doing.* In the lecture the students get a profound theoretical background of UML and in the lab they have to work out several exercises. Our students enhance their practical modeling skills with the help of the self assessments.

- *Learning by repeating.* Another major advantage of the self assessments is that students may exercise whenever and wherever they want. If a student has some problems with a specific topic, he/she may repeat the exercises as often he/she likes to consolidate the newly acquired knowledge.

- *Fast feedback for students.* By getting feedback immediately, students may quickly find out their strengths and weaknesses in the specific topics.

- *Qualified feedback.* If the students select a wrong answer to a multiple choice question, they get qualified feedback to know why this answer is wrong.

- *Self-evaluations during the learning process.* Another advantage for our students, which we have identified, are self-evaluations during the whole term. Students may check with the help of the assessments how far they are in studying.

According to the survey, 86% of our students appreciate the self assessments and 64% out of them even appreciate them very much as depicted in Figure 2. Furthermore, only 5% of the students stated the self assessments as not helpful for studying the UML diagrams.

In the following, students comments about the self assessments are summerized:

- The self assessments are a good method to learn UML.

- The slides are not enough to understand the principles and techniques of UML. The self assessments support the learning process very well.

- More exercises would be helpful.

- More qualified feedback (like mentioned above) would be supportive.

As mentioned above, only multiple choice questions can be evaluated automatically by our e-learning system. In future work, we want to develop an extension of the system to enable both, interactive modeling of the open questions and evaluation of the students' solutions. In a first step, we try to provide UML diagrams with missing model elements where students have to apply these missing elements.

4 Lecture Streams

One part of the course OOM are six lectures covering the theoretical background of the five taught UML diagrams (class and object diagram, sequence diagram, state diagram, activity diagram, and use case diagram). These lectures proceed in quite "traditional" ways, a professor or assistant professor is standing in a big lecture hall, presenting powerpoint slides and answering questions whenever they occur. The attendance of the lectures is not mandatory, nevertheless about 40% of the students visit the lectures.

In the long run, we plan to enhance all the lecture slides with spoken text thus producing lecture videos and exchanging the classical lecture with lectures that prepare the students for the lab sessions and focus more on the practical use of UML (for further information please refer to Section 6). Before actually combining our presentations with audio recordings we decided to do a test run with a less time-consuming method and therefore we simply recorded the actual lectures[5] to find out if the students like lecture videos and which features are important to them. With the kind help of the Teaching Support Center of the Vienna University of Technology we recorded the lectures and made them available through our e-learning platform TUWEL. The students had to be online and logged in to the platform to view the recordings. The videos were provided "just the way they were" with hardly no postprocessing at all. There was one file for each lecture which is played directly in TUWEL, allowing the student to pause the recording, control the volume and jump back or forward, but without any chapter structure, subtitles or similar mechanisms helpful for navigating through a video file. Simply recording the lecture and publishing it in TUWEL did not require a lot of additional work or knowledge, but pleased the students a lot. The greatest advantages of recording lectures in general and our method of doing it are the following:

- *Low effort, big effect.* The teachers' workload does not change when recording his/her lectures. He/she simply attaches the laptop to a lecture recorder which is then attached

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[5] http://www.big.tuwien.ac.at/external/OOM.html

to the LCD projector (instead of directly connecting the laptop to the LCD projector) and starts the recording.

- *Nearly time- and place-independent.* Students who are motivated to learn but cannot attend the lecture, can watch the video at home or some place else whenever they want. Especially in the field of computer science a lot of students are already working part time or full time during their study, recording lectures is one way of facilitating that.

- *High learning outcome.* In the lab sessions, we usually also explain the theoretical background and syntax of the UML model which is the topic of the session, because after the lecture about a specific diagram type most students still did not have enough background knowledge to fully understand and discuss all the lab exercises concerning that diagram type. In summer term 2010, we increased the focus on practical issues in the labs, for the students seemed to have gained much more knowledge out of the lectures — some students would maybe not have taken a look at the slides at all if it was not for the recordings, others attended the lecture and listened to parts of it which were still unclear to them again at home.

- *Student satisfaction.* Offering the students one more learning channel and giving them more flexibility than they are used to makes them happy — even the ones who did not watch the videos at all seemed to feel safer, because they "could watch them if they wanted".

When we decided to record the lectures, we were sure that the students would like it, but we did not expect that much acceptance. The students' comments on the newly used tool were not only good, they were almost enthusiastically encouraging us even more in our plans to produce lecture videos. An overview of the statements is given in the following:

- Students with previous knowledge of UML may decide only watching parts of the recordings.

- The students may choose time and place of watching the lecture by themselves, depending on when and where they can concentrate best.

- The students may take a break whenever they feel that their concentration is dropping.

- The students may watch parts they did not understand (either during the actual lecture or when watching the recording for the first time) again or they can watch the video again right before the test to refresh their memory about the materia.

- During the lecture, the students may concentrate on the speaker instead of taking notes, because they know that they may listen to the lecture again if they want.

According to the survey, students prefer lecture videos to traditional lectures held in a lecture hall, but even more students like a combination of both. Furthermore, for most of the students, completely disposing traditional lectures is not an option since they want the opportunity to ask questions personally and meet fellow students instead of sitting in front of their PC all the time

How did you like the lecture recordings?

very good	126	votes (80 %)
good	16	votes (80 %)
fair	1	votes (1 %)
poor	1	votes (1 %)
undecided	11	votes (7 %)

- very good
- good
- fair
- poor
- undecided

Do you prefer traditional lectures or lecture recordings?

Traditional Lecture	18	votes (11%)
Lecture Recordings	54	votes (34%)
Both	83	votes (53%)

- Traditional Lecture
- Lecture Recordings
- Both

Do you consider it a good idea to completely exchange the traditional lectures with online lecture videos?

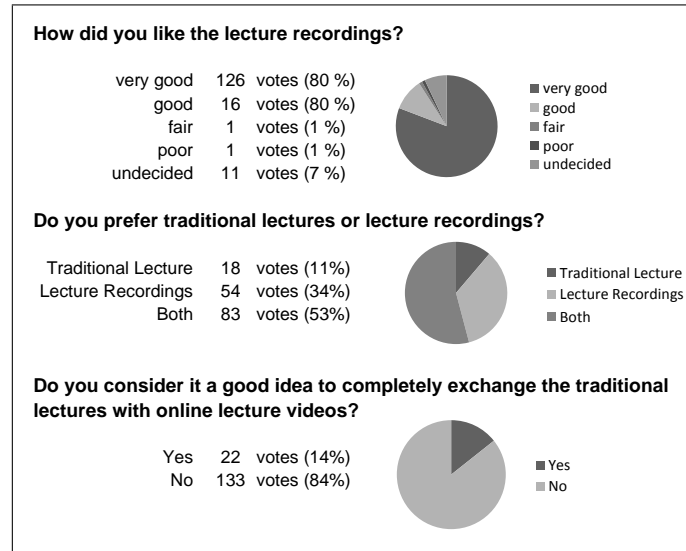| Yes | 22 | votes (14%) |
| No | 133 | votes (84%) |

- Yes
- No

Figure 3: Survey results concerning the lecture recordings

and only communicating via Skype and similar tools. For more detailed results about the survey questions concerning the lecture recordings, please refer to Figure 3.

We also asked the students what they would like to improve about the recordings, gathering valuable information for our future project. The desired features stated in the survey are as follows:

- Downloading the videos to view them offline on laptops and other mobile devices.

- Chapters or a structure of any kind to facilitate the navigation through the video.

- The option to search the video for certain words or phrases.

- A possibility to take notes comfortably while watching the video.

- Improved sound (due to some technical problems the sound of most lectures was only mono).

- The lecturer picture-in-picture with the video of the slides.

- Questions from the audience have to be repeated by the teacher to make sure they are recorded.

Most of the students' wishes can be fulfilled when enhancing the powerpoint slides with spoken text. During this summer, built-in lecture recorders are going to be installed in the first few lecture rooms of the Vienna University of Technology, eliminating the only hard factor, namely having to carry a lecture recorder with you for each lecture you wish to record. Due to the great success of the lecture recordings compared to the small extra effort, we think about using this technique in other lectures as well.

5 Document Camera

During our lectures, the lecturer often demonstrates how to model concrete scenarios with a UML diagram "on the fly" while the students are watching. Sometimes the teacher even develops small UML models together with the students. Before summer term 2010, a blackboard was used for that, but with the ambitions to record the lectures as described in Section 4, we had to find an alternative which allows us to record those demonstrations and to easily include them in the lecture recordings.

The solution was a document camera[6] in combination with a LCD projector. A document camera is basically a camera which is fixated on a holding. Connected to a LCD projector, it is possible to place paper documents or other objects under the camera and project them onto a screen. For demonstrations the lecturer formerly would have done at the blackboard, he/she now sits down next to the camera, places a sheet of paper under it and develops the UML model on the paper.

In our teaching environment, the document camera is the best solution for our needs. We can use the LCD projectors and the screens which are already installed in every lecture room, so we just have to take the document camera with us for each lecture — hopefully there will be built-in document cameras at least in the larger lecture rooms of the Vienna University of Technology soon. The document camera has many advantages for the students as well as for the teachers, the most important advantages we have identified during our lectures are listed below:

- *People are used to paper.* Teachers as well as students are used to model on paper and they usually prefer it to writing on a blackboard, tablet PC, or overhead projector. They usually also write or draw more readable on a piece of paper, clean neat writing on other material such as overhead sheets requires much more training.

- *Document cameras are easy to use.* Most document cameras are designed with only a small set of functions, enabling easy usage. The handling is very intuitively, basically it just has to be switched on and connected to a LCD projector.

- *Document cameras also work in very large lecture rooms.* The filmed image can also be projected on large screens in big lecture halls and the document camera can even zoom in on certain parts of a document. In contrast to blackboards, the teacher may write or draw as small as he/she likes and even the students in the last row can see the drawings.

- *Teacher stays turned to the students all the time.* The teacher does not have to turn around to look to the blackboard, he/she can stay focused on the students all the time.

- *Document cameras support vivid teaching.* Developing models on the fly makes lectures more interesting, the document camera is offering a simple possibility to not monotonously presenting the whole lecture with powerpoint slides but still being able to preserve the results and to provide them in TUWEL together with the lecture slides, videos etc.

Since the document camera proved its value in the lectures, we decided to use it in the lab sessions as well. In the past years, the students had to copy their solutions from their personal

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[6] http://www.big.tuwien.ac.at/external/OOM.html (In this video, the document camera is used, e.g. at minute 45)

sheets to an overhead sheet or the the blackboard before they could explain the UML model and discuss it with the teacher. Depending on the size of the model this could take very long time and the risk of a nervous student making copy-paste errors was very high. With the usage of the document camera, the student simply places his/her solution under the camera or — if developing the model together with the class and/or the one student is more appropriate for the given exercise — the student can sit down next to the camera and draw the model on paper instead of nervously scribbling on the blackboard. According to the survey, 82% of the students prefer the document camera to the blackboard or the overhead projector and they like the usage of it in the lab sessions and even more in the lectures — Figure 4 shows the results of this part of the survey. Among others, they stated the following advantages of the use of a document camera during the lab sessions:

- The students can present their own notes.

- Showing the results with the document camera instead of copying the solution to the blackboard saves time, especially with large diagrams. The teacher can use the extra time for giving more examples and explanations.

- The teacher does not have to clean the blackboard all the time.

- The students are less nervous because they can use a medium they are already used to (paper).

- The students can fully concentrate on explaining their model and answering questions instead of worrying about nice handwriting or copy-paste errors.

To sum up, the main advantage for the students seems to be the fact that they do not have to copy their solution to the blackboard before presenting it to the teacher, which seems to reduce their nervousness and the risk of making errors.

With the use of the document camera in the lectures, the fact that the whole lecture content can easily be preserved and that the lecture is more varied are the most important advantages from the students' point of view. Concretely, they stated the following advantages:

- Students which cannot attend the lecture for whatever reason get all lecture material instead of only the powerpoint slides.

- The students can also see details from behind rows.

- Demonstrations help the students understanding the teaching matter.

- The teacher does not talk to a blackboard while giving "live" examples.

This summer term, we used the document camera in our lecture for the first time and both, the students as well as us, first had to get used to the different technology. Most of the problems the students mentioned are linked to this lack of experience in the use of the document camera. The students specified the following drawbacks concerning the use in the lab sessions, some of them also apply to the lectures:

How did you like the use of the document camer in the lectures?

very good	120	votes	76	%
good	25	votes	16	%
fair	1	votes	1	%
poor	0	votes	0	%
undecided	11	votes	7	%

- very good
- good
- fair
- poor
- undecided

How did you like the use of the document camera in the lab sessions?

very good	95	votes	60	%
good	49	votes	31	%
fair	10	votes	6	%
poor	3	votes	2	%
undecided	0	votes	0	%

- very good
- good
- fair
- poor
- undecided

Which medium do you prefer for demonstrating your solutions in the lab sessions?

Blackboard	16	votes	10	%
Document Camera	129	votes	82	%
Overhead Projector	12	votes	8	%

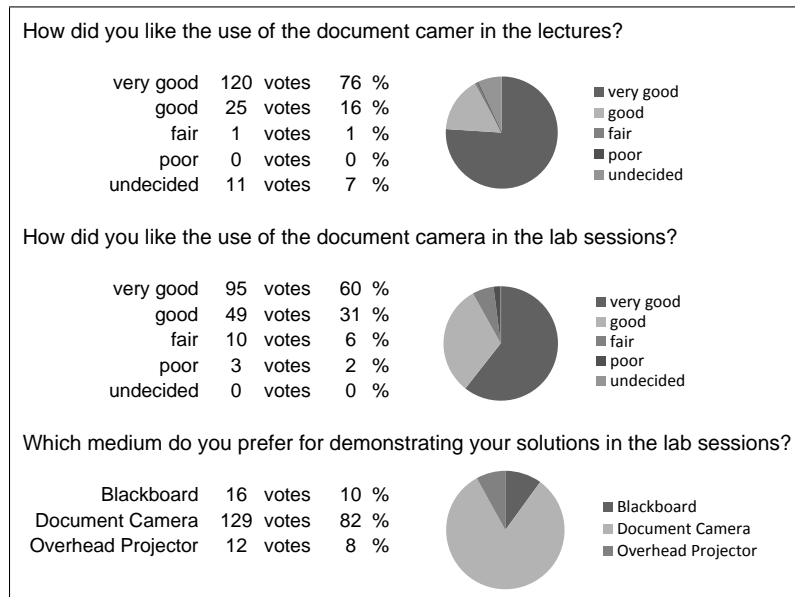- Blackboard
- Document Camera
- Overhead Projector

Figure 4: Survey results concerning the document camera

- The light in the lecture room is too bright to see the projection.

- Pencil-drawn models and models on squared paper are very difficult to see.

- Errors cannot be corrected as easily as with the use of a blackboard.

- There sometimes is a time interval between the students' actions on the paper and the display on the screen.

- In contrast to models on a blackboard, the paper sheets often "disappear" too quick, giving the students not enough time to take a detailed look at the model and take notes.

- The teachers should be trained in using the camera.

After this term's test run, keeping those things in mind, most of the mentioned downsides can be overcome and the document camera can also be of great use in our lab sessions. In the future, we will prepare both sides better — we will tell the students to properly prepare their solutions like modeling each diagram on a separate white sheet of paper and ask each teacher to train a little bit with the camera before using it in the course like watching their speed and the lighting conditions.

6 Ongoing Work

In summer 2010, we will start to enhance our lecture slides with voice recordings. First an appropriate tool for combining slides and audio has to be found. The software has to allow to combinine each slide (separately) with spoken text to be able to exchange single slides and their

audio later on. Then, we will prepare text for each of the slides and apply some minor changes to the slides themselves to prepare them to operation in a video. Finally, we ourselves will record the text passages and combine them with the powerpoint presentation, generating one video for each of the five taught UML diagrams. It is planned that the videos will provide a search function not only to search for text in the slides but also to search for parts of the spoken text as well as a navigation bar and a chapter structure to comfortably jump around in the video. Furthermore, possibilities to watch the videos online and to download them will be offered, video versions to watch it on a laptop or other mobile device such as a mobile phone will be provided.

We plan to have the first lectures combined with audio ready for use in the winter term of 2010. In our survey, we also asked the students if they would still need a tradtitional lecture given that lectures enhanced with spoken text are available. Most students stated that they would still want an additional traditional lecture — it should be noted that the quantity of students that want traditional lectures is significantly higher than the quantity of students that actually visited the traditional lectures. The following reasons for still additionally offering traditional lectures were named:

- They want to ask questions personally.

- The teacher listens and responds to the students, adapting the lecture to the student's needs and interests.

- Personal contact to teachers and fellow students is important.

- A fixed timetable is good for those who need to be forced a little bit.

- In a lecture room a higher level of concentration is possible than at home with lots of distractions.

We agree that personal contact and the possibility to ask questions are essential for each university course, thus we will not completely eliminate the lectures but exchange them with tutorials, preparing the students for the lab sessions and the test by modelling and discussing a lot of examples "live" together with the students. This offers the students an additional possiblity to gain more practical knowledge about UML diagrams.

We consider this approach very valuable, not at last because OOM is taught each semester and we would not be forced to explain the theoretical basics in traditional lectures each semester any more. The lecture videos sort of teach the students the theoretical background whereas we can concentrate on the practical aspects, questions and discussions.

7 Conclusion

In this paper, we have presented our experiences in our undergraduate course *Object-Oriented Modeling*. Due to the huge number of participants we apply alternative media like a document camera instead of the traditional blackboard on the one hand to support the learning process of our students and on the other hand to reduce time and effort for teaching. Furthermore, to improve the quality of our course we have introduced web-based self assessments, which

are used by our students to exercise UML modeling. Additionally, we recorded the lecture allowing the students to listen to it at any time. Especially when learning modeling, practical exercising (e.g., by self assessments) is of significant importance for students. Furthermore, developing small UML diagrams live in the lecture together with the students is more effective than just presenting Powerpoint slides. However, since the lecturers' knowledge is based on personal experiences (e.g., in modeling Use Case Diagrams), traditional face-to-face lectures are indispensable.

To evaluate our newly designed course, we have done an extensive survey, where we got responses of 180 students and beneficial feedback. To sum up shortly, our e-learning support providing self assessments and lecture streams, as well as the application of our document camera are considered very useful for studying. However, for our students it is of huge importance, despite the time of Web 2.0, to have personal contact to the teachers and to have, beside lecture streams, face-to-face lectures.

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