Impact of activating learning series on participation and student learning of Food Science Master students

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Abstract

Active learning is a student-centered teaching approach, which involves students through group discussions, problem solving, case studies, and summarizing concepts. My previous lectures were characterized by low level of student participation and a lack of feedback. It was the aim of this study to implement activating learning series in an already existing lecture to increase participation and learner autonomy of Food Science Master students. Student group and single activities alternating with 2-20 min long lectures by the tutor replaced the standard 45 min frontal lectures. At the end of the third lecture, a questionnaire was distributed to students to evaluate lecturer, exercises, motivation and learning autonomy. The lecturer filled a self-evaluation sheet after each lecture. The average score regarding the lecturer was 3.7 ±1.1 (median value: 4). The introduction of exercises was highly appreciated (4.2 ±0.9 (median value: 4). In regard to learner autonomy, the majority of students felt motivated, in control and confident after the lectures. Adjustments will be necessary to fit lecture content to the new lecture set-up (for e.g. overall number of slides) and to enhance the proportion of students showing learner autonomy, but in general, this study was a successful teaching experiment showing the benefits of introducing activating learning series for Food Science Master students, but also for the lecturer.

1 Introduction

1.1 What is active learning?

Active learning is an approach to teaching in which students engage in the material they study through peer discussion, reading, writing, listening, and reflecting (Felder & Brent 2016). Active learning is student-centered pedagogy in contrast to the traditional way of science instructions when a professor or tutor lectures a large audience frontally. In active learning, students have to take an active role. Teaching strategies that can be used to engage students include, among others, group discussions, problem solving, case studies, and summarizing concepts (Armbruster et al. 2009). Activities can be designed to engage higher level thinking but can also be lower level recall-based exercises (Gilboy et al. 2015). One way to introduce active learning is by using activating learning series where short (5-15 min) activities are dispersed throughout the class. It was shown before that replacing 50 min lectures by short lectures and activities led to increased average class scores and improved problem-solving skills (Reitmeier 2000).

1.2 What are the benefits of active learning?

The possible benefits to using student activities are many and include improved critical thinking skills, and increased retention and transfer of new information, which all contribute to student learning (El Shaer & Gaber 2014, Youngblood & Beitz 2001). As students might have to

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interact during group work, interpersonal and cooperative skills might also improve (Braeme & Biel 2015). Students might gain motivation, control and confidence and become experts in the future.
Meta-analysis indicated that active learning increased student performance, improved examination rates, and reduced class failure in STEM (science, technology, engineering, and mathematics) courses compared to traditional lecturing (Freeman et al. 2014). The introduction of active learning and student-centered pedagogy improved engagement, satisfaction and academic performance of undergraduate biology students (Armbruster et al. 2009). A study by Paxman et al. (2011) showed that nutrition and food science undergraduates had improved confidence, motivation and control at the end of an active learning module. Paxman defined confidence, motivation and control as the three major factors that contribute to learner autonomy. Learner autonomy was defined by Cotterall (1995) as 'the extent to which learners demonstrate the ability to use a set of tactics to take control of their learning'.

1.3 Relevance of this project

The course of interest was 'Functional Microorganisms in Foods.' It was an elective lecture of the Food Science Master program (semester 5) that has been usually attended by 50-65 students who gain 3 ECTS points for 2 hours in class per week. Performance assessment was a combination of and end-of-the-semester exam (open book, 60% of mark) and group project (40% of the mark, with an oral presentation and a written report each contributing 20% to the final mark). The first months (September-November) was plain lecturing by six different tutors, in December, groups of students (n=3) had to prepare a presentation and finally present in front of their peers. For this group project, a list of topics related to lecture content was provided by the lecturers. Each group chose a topic and was expected to summarize the topic background, to identify novelties, highlights and shortcomings, and to provide a group opinion.

I taught the first module 'Biopreservation' of the course was 'Functional Microorganisms in Foods' and followed and marked the group presentations. In previous years, I experienced a low response of students to questions during the lecture, it was difficult to initiate interaction. This was also reflected in student evaluations of the lecturer (for example mean 3.1, median 3.0 in 2016, highest score would be 5, see Figure 2). There were difficulties to initiate discussions after the group presentations. Due to this little interaction, it was difficult to judge whether and how students could follow the lecture, and the extent of student learning.

Nevertheless, there is a need for Master level Food Science students to become critically engaged with a topic and to gain learner autonomy to pass their degree but also for later work life. The majority of Master level Food Science students will move to industry and take leading positions, there might be the need to be able to initiate, defend and discuss projects. Active learning can be a way to increase critical thinking and self-confidence (El-Shaer & Gaber 2014, Youngblood & Beitz 2001). To enhance learning autonomy and critical engagement is also a personal motivation of the lecturer, to introduce them to scientific thinking.

1.4 Aim of this study

It was the aim of this study to implement active learning series in an already existing lecture to increase participation and learner autonomy for improved student learning of Food Science Master students. In addition, this teaching experiment aimed to further diversify the learning environment of the Food Science curriculum, and to make a little contribution to advance the education at ETH Zurich.

2 Teaching concept

2.1 Experimental approach

The traditional set-up of the lecture was a frontal teaching approach of the tutors followed by a block of student presentations. To increase engagement and participation of students already during the lecture, student group and single activities and 2-20 min lectures by the tutor replaced the standard 45 min lectures as shown in Figure 1.

To facilitate the implementation of activating learning series, the structure of the lectures was planned by the minute. In between the lecture blocks, activities were added. Activities included group and single work and lasted 5-15 min (summarized in Appendix 1). Activities were designed to train and emphasize the key concepts that had been introduced in the previous lecture block. Activating learning series asked students to explain, categorise, identify, apply, and to distinguish targeting different levels of the modified Bloom's taxonomy of cognitive learning (Anderson & Krathwohl 2001).

2.2 Evaluation of teaching study

Lecturer, student interaction and learner's autonomy were evaluated in two ways: A questionnaire was distributed to students at the end of the third lecture that followed the official ETH evaluation sheet for lectures (see Appendix 2). There were three main categories (Lecturer, Exercises, and Motivation & Learning) with sub-questions which evaluated students' response to the lecturer and his teaching style, to the support provided, to the exercises, and investigated the motivation of the students to attend the lecture and their impression about the skills they gained. There was also a question in regard to general satisfaction. Scores ranged from 1 (I do not agree) to 5 (I totally agree). Lecturer related scores were compared to the official evaluation of 2016.

The evaluation sheet contained three additional questions with descriptors to provide the students with terms to describe their motivation, control, and confidence in analogy to Paxman et al. (2011) to define the extent of learner autonomy. A questionnaire was chosen as evaluation method to collect opinions from the majority of students. A self-evaluation sheet for the lecturer was prepared to note down several aspects such as students' response to the activities and numbers of students participating after each lecture (see Appendix 2).

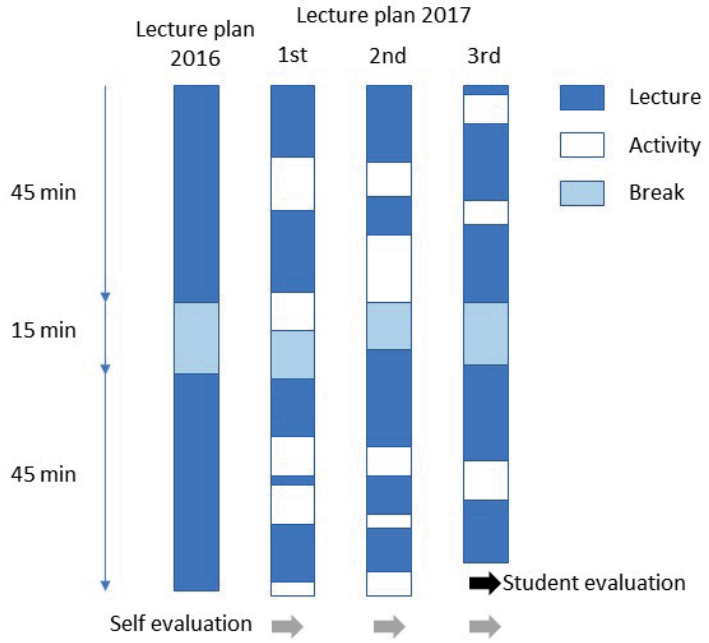

Figure 1: Lecture scheme 2017 in comparison to 2016. Indicated are the individual lecture outlines for the 1st, 2nd and 3rd lecture of the module 'Biopreservation' within the lecture 'Functional Microorganisms in Food'.

3 Analysis of student learning

3.1 Students' response to lecture style and introduction of activating learning series

The three lectures were attended by more than 55 students. Evaluation sheets were returned by 44 students. The majority of students (>50%) were enrolled in the Food Science Master program, but there were also attendants from Environmental Science, Health Science and Biology. Students were in generally satisfied with the lecturer's teaching style and the support provided (average scores in response to questions concerning the lecturer 3.4-3.9, Figure 2). The majority of students agreed (average score 3.8±1.1) that they felt motivated by the lecturer. The mean score of questions regarding the lecturer was 3.7±1.1 (median value: 4), which was similar to 2016 (average satisfactory: 3.8).

The major reason to attend the lecture was interest in the subject and not because it was compulsory or because of the lecturer (Figure 2).

In the first two lectures, 4-8 students actively participated with questions, comments and further inquiries, which might have been a bit more students than 2016, while in the third lecture, 9-12 students discussed and asked questions, indicating an increase in the number of students participating. Students responded fast to the start of the activities and demanded little further input which showed that the activities were introduced sufficiently. Intended time frames of some of the activities needed to be slightly adapted, sometimes extended, but sometimes also shortened.

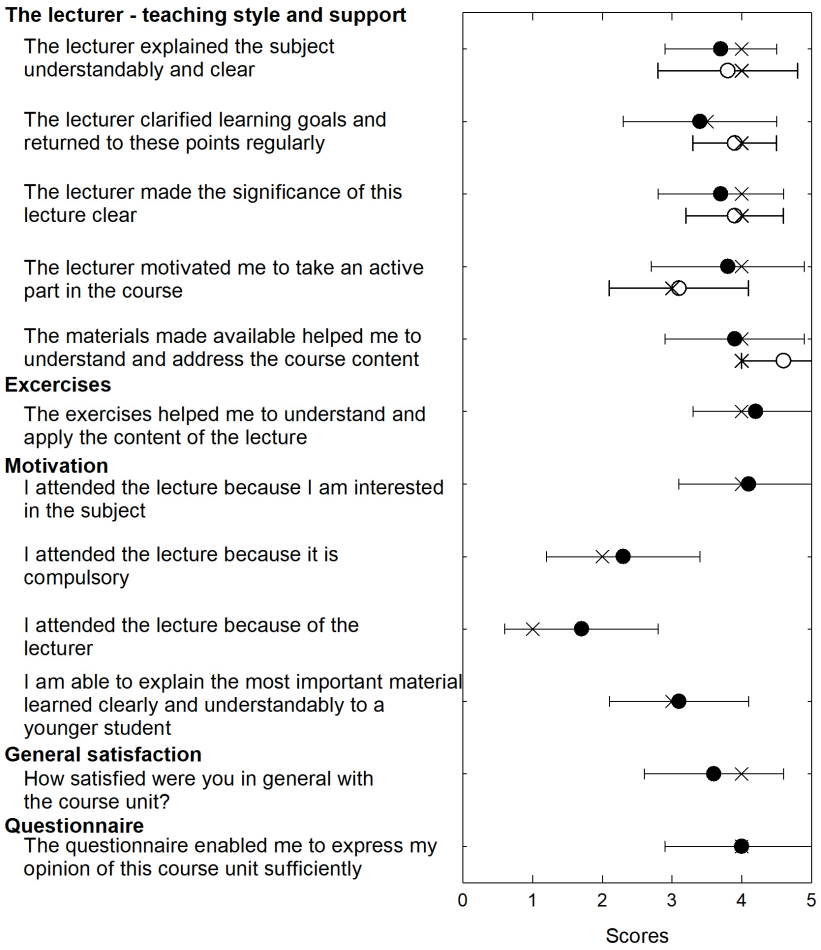

Figure 2: Summary of the students' evaluations. Scores ranged from 1 (I do not agree) to 5 (I totally agree). Shown are mean scores (closed circles) with standard deviation, and median scores (crosses). and lecturer specific scores from the class taught in 2016 (open circles). Scores from 2016 regarding Exercises, Motivations, General satisfaction and Questionnaire are not shown because they rated the entire course and not only the lectures taught by myself.

3.2 Response to the introduction of activities

One major aspect of this study was the introduction of exercises in a previously frontally taught class. The feedback on exercises was evaluated with one question in the final evaluation. More than 75% of the students agreed or totally agreed that the activities helped them to understand and apply the content of the lecture (score 4: 40.9%, score 5: 36.4%, average score 4.2, Figure 2). The introduction of activities was positively mentioned in the anecdotal comments made by students which appreciated the modified lecture style ('more lively') and the content ('keep track of important points').

• I really like the exercises, they helped focusing on important part and made the lecture more lively
• I think it is helpful to do these exercises in between
• interaction exercises are really helpful to keep track of the important points
• the short repetition at the beginning was useful as well as the questions in between
• exercises help to better understand the subject
• I think it is good that you put small exercises into the slides
• I would try to keep the exercises

Table 1: Representative student comments about in-class exercises

3.3 Response to lecture content and organization

The integration of activating learning series in an already existing lecture demanded modifications to the general lecture outline. While the introduction of activities was generally appreciated (see 3.2), other aspects affected by the change of lecture style were also criticized. Interestingly, in the evaluation, the question regarding learning goals was rated lower compared to 2016 (3.4±1.1 compared to 3.9±0.6, respectively) while scores on the material provided were similar (3.9±1.0 in 2017 and 4.1±0.6 in 2016) (Figure 2). Students additionally indicated that the lecture could be improved especially concerning the number of slides and slide content and suggested to more emphasize the key messages (Table 2, Table 3).

• it would be nice to have some more key words on the slides
• your slides were confusing. There are huge amounts of graphs and pictures, but never/hardly ever any bullet points, conclusions or summaries which I could follow
• There is absolutely no overview over the three lectures (except for starter/protective/antimicrobials) or I can't seem to understand the red line
• not clear what we have to know and what is side/extra information
• I would give an introduction and overview lesson in the first lecture to get everyone on the same page. Also explain what is expected.
• slides are unclear. Some sentences with important messages would be nice

Table 2: Representative comments made by students in regard lecture organization

• too many slides
• I would speak a bit slower and maybe decrease the amount of slides
• I prefer when there are less slides but then they are longer/better discussed
• not enough time per slide (too many slides)
• everything goes too fast

Table 3: Representative comments made by students in regard to lecture content

3.4 Impact on lecture re-organization on learner autonomy

Students were asked the following three questions and could select from a range of descriptors which were intended to rate learner autonomy after the lecture block.

The first question asked: (1) *How would you describe your motivation for preparing for a presentation on the topic of the past three learning sequences?*
The three most frequent answers were: interested (18 times), anxious (9 times), and focused (8 times). The majority of answers indicated that the students were motivated (71%) (enthusiastic, focused, excited, creative, inspired, interested), while 29% were not motivated (anxious, fearful, disinterested).

The second question investigated: (2) *How would you describe your control over succeeding on an exam on the topic of the past three learning sequences?*
The three most frequent answers were: equipped (17 times), informed (16 times), and prepared and unprepared (both 12 times). The majority of answers indicated control over succeeding on an exam (60%, prepared, equipped, I am on target, informed), while 40% was not feeling controlled (overwhelmed, disorganised, unprepared, lost, pressurized, clueless).

The third question inquired: (3) *How would you describe your confidence at this point in terms of feeling prepared for an exam on the topic of the past three learning sequences?*
The three most frequent answers were: optimistic (15 times), challenged (10 times), and in control/unprepared (both 9 times). The majority (63%) of the answers indicated confidence (well prepared, optimistic, supported, I will succeed, in control), while 37% felt less confident (challenged, pessimistic, unprepared).

4 Discussion

The aim of this study was to increase lecture participation and learner autonomy of Food Science Master students to overall improve overall quality of student learning. In general, evaluation results and student responses showed that changed lecture style was appreciated and encouraging, as the number of students participating increased during the run of the study indicating enhanced confidence.

One major change was the introduction of content related exercises. Most students responded positively to the activities as judged from scores on exercises, and motivation (average 3.8, mean 4.0), especially in comparison the evaluations of a previous lecture, in 2016. The introduction of active learning series was also appreciated in comments made by the students. However, there was also negative response by students to the modified teaching style and the introduction of activating learning series. In a previous study comparing a student activating learning environment with lecture style teaching, student activating teaching did not deepen learning (Struyven et al. 2006). In a feedback round, students suggested a higher proportion of lecture–directed activities to provide more structure and criticized workload and the lack of feedback (loc. cit.). The comments made in this study targeted similar issues. In preparation for the class in 2017, the lecture content (and number of slides) had been reduced in comparison to previous years to generate time slots for the activating learning. However, content might have to be further adjusted. Several students mentioned that the speed was too fast, and that there were too many slides.

Similar as previously observed by Struyven et al. (loc. cit.), not all the students responded positively to modified set-up. While some students for example felt that important facts were highlighted by the exercises, others criticized that key points were developed in class and not presented on the slides and suggested that slides should contain more bullet points. Others suggested that the learning goals should be emphasized more clearly. Indeed, in 2017, learning goals were only mentioned in the general introduction part of the lecture and not repeated thereafter as done in 2016. Based on these responses, and on previous studies which showed that presentation of learning goals received high scores on helpfulness for lecture content (Armbruster et al. 2009), learning goals will be again highlighted more strongly in future teaching.

Active learning has been related to increased learner autonomy, which has been linked to confidence, motivation and control (Paxman 2011). One aim of this study was to ensure and enhance learner autonomy. While a comparison to previous years is unfortunately not possible, results of this study indicate that the changed teaching style nevertheless promoted learner autonomy, and that especially high scores were obtained in regard to student motivation. However, there was also a proportion of students that felt low motivation, control and confidence, which might be related to comments made by the students indicating that learning goals and key messages were not made clear enough, and that there was overwhelming amount of information leading to a fearful feeling of being lost and unprepared. Further feedback rounds or additional, more targeted evaluation questions might help to investigate whether the reasons for these responses were due to the lecturer, lecture style, or related to lecture content, and how these students can be supported to increase learner autonomy.

Student learning is shared responsibility between students and teacher (Chew 2014). Indeed, the introduction of lectures containing activating learning series had to be prepared and asked for increased preparation time to design the activities and adjust the lecture plan. Nevertheless, the modified lecture style agreed with the expectations of the lecturer, who felt rather confident in all three lecturers possibly due to the extensive preparations done before class. It was pleasant to have talking breaks, and to hear novel, unexpectant aspects students brought up during group discussions.

A limitation of this study was the short frame it was set on. Activating learning series were only applied in the three first lectures of a course that lasted an entire semester and were not employed by the other lecturers. For improved evaluation of learners' autonomy and the quality of student learning, questions could have been asked at the beginning and the end of a semester long course to observe student development during the entire class. Nevertheless, already during this short period, an improvement in the number of students participating in discussions and contributing answers to the questions was observed.

5 Lessons learnt

Overall, the introduction of activating learning series was appreciated by the students and the lecturer. The introduction of activating learning series was appraised by more than 70% of students and exposed them to different activity scenarios which might benefit them in their future professional career.

The majority of students indicated learner autonomy after this lecture unit, which aids the process of student learning. The general lecture structure might still have to be improved, especially the number of slides might need to be further adapted or reduced, and the reasons of why a proportion of students did not feel motivated, in control and confident might have to be investigated and counteracted. Application of a student-centered teaching method for a longer time frame, and comparison between different years will show how the concept will be accepted and will show how the concept can be further developed in Food Science related courses. Adjustments will be necessary to fit lecture content to the new lecture set-up (for e.g. overall number of slides) and to enhance the proportion of students that showed enhanced learner autonomy, but in general, this study was a successful teaching experiment showing the benefits of introducing activating learning series for Food Science Master students, but also for the lecturer.

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Appendix 1

Rough outline of lecture 1 structure (first lecture of the semester):

Order	Content	Objective	Instructions/Materials	Time slot	Type
1.Welcome	introduce myself, my role at ETH and in this course.			1 min	Lecture
2.Intro	Present the lecturers/the lab			4 min (5)	Lecture
3.Organisatorial	Lecture set-up / topics/roles and expectations			10 min (15)	Lecture
4. Activity	Intro to biopreservation		• Pictures distributed to the table. Discuss in groups of four what is biopreserved (3 min). • Then add to the board here (3 min) • recapitulate (5 min)	11 min (26)	Activity team
5. Lecture	What is biopreservation	To describe (1) biopreservation		16 min (42)	Lecture
6. Lecture	Intro to protective cultures	To describe (1) protective cultures		1 min (43)	Lecture
7. Activity	Add protective culture	To associate (2) protective cultures to food products	• Place LAB/propionibacteria/fungi/yeast on wall to biopreserved food	5 min+3 min discussion (8 min) (51)	Activity teams of 4
Break				10 min (61)	
8. Lecture	Continue protective cultures	To describe (1) protective cultures		12 min (73)	Lecture
9. Activity	Add active compound		• Place main active compounds on the wall	5+3 min (81)	Activity teams of 4
10. Lecture	Targets protective cultures/critical foods	To differentiate (2) mode of action		2 min (83)	Lecture
11. Activity	What makes a food product a critical one?		Discuss 3 min with a neighbor parameters that help bacterial spoilage. Then we will collect in the plenum	3+5 min (91)	Activity neighbours
12. Lecture	Targets protective cultures	To differentiate mode of action		12 min (103)	Lecture
13. Text	Read text biofilm	To explain (4) shortcomings		3 min (106)	

Finished: 14:56

Structure lecture 2:

Prepare wall again with food products-protective cultures – what make a food product a critical one.

	Content	Objective	Instructions/Materials	Time slot	Method
1.Organisatorial				1 min	
2.What happened last week	Introduce fermentation chart – we developed ourselves!			5 min (6)	
3.Lecture	Summarize main metabolic pathways		Write main pathways on the board (single)	5 min (11)	Lecture
4. Lecture	Organic acids			5 min (16)	Lecture
5. activity	Questions	To analyse (4) activity	3 min to discuss 4 min to collect answer	7 m in (23)	Activity neighbour
6. Lecture	Organic acids application			8 min (31)	
	+Read and confirm statement			2 min (33)	
7.Activity			Calculate alone +results collected in class	1+7+2 min (43)	Activity alone
MODIFICATION			FINISHED AFTER 45 minutes, stopped for break at this point		
8. Lecture	From lab to industry			4 min (47)	
Break				10 min (57)	
9.Lecture	From lab to industry			13 min (70)	Lecture
10.Activity	Summarize antifungal compounds	To evaluate (7) effective compounds	To collect, which antifungal compounds did we talk about so far. Which were effective and which not, and why. 3 min 3 min 4 min	3 min (73)	Activity
11. Lecture	Antifungal compounds			8 min (81)	
12. Activity	Summarize antifungal compounds	To evaluate (7) effective compounds	Extend previous list	3 min (84)	
13. Lecture	Antifungal compounds summary		Summarize and wrap-up	5 min (89)	Lecture
14. Lecture	Reuterin			2 min (91)	
15. Activity	Acrolein – read and identify		Exogenous sources, endogenous sources, DNA and Protein interactions	3+2 (96)	

Finished 15 :00, stopped at point 13.

Structure lecture 3:

	Content	Objective	Instructions	Time slot	Method
1.Organisatorial				1 min	
2.What happened last week	Summarize			1 min (2)	
3.What happened last week			Which compounds would that be? How could they be produced List compounds and discuss with your neighbor possible production pathways	3 min+3 min collect (8)	
4.What happened last week	continue			4 min (12)	
5. Lecture	*Lactobacillus reuteri* and reuterin			12 (24)	
6. Activity	How to apply L. reuteri		Discuss 2 min with neighbor, then we collect suggestions	2+3 (29)	
7. Lecture	Application of reuterin		Who produces? Which substrate is necessary? Which organisms are targeted? Activity in food?	10 (39)	
11. Lecture	Reutericyclin			6 (45)	
12. break				10 (55)	
13	announcement		Distribute questionnaires	3 (58)	
12. lecture	Bacteriocins, intro			20 (78)	
13. Activity	Pro and Con		Discuss and collect 3 min with your neighbor, advantages and disadvantages Then we collect on black board	3+3 (84)	
14. Bacteriocins	Applications			12 (96)	
15. Open questions			Stopped at 14:55 to provide time	2 (98)	
Questionnaire			For questionnaire		

Appendix 2

Student evaluation sheet (adapted from the official ETH evaluation)

The lecturer

The lecturer explained the subject understandably and clear

Not true	○	○	○	○	○	Absolutely true	No answer	○

The lecturer clarified what I should be learning in this course unit (learning goals) and returned to this points regularly

Not true	○	○	○	○	○	Absolutely true	No answer	○

The lecturer made the significance of this lecture clear

Not true	○	○	○	○	○	Absolutely true	No answer	○

The lecturer motivated me to take an active part in the course

Not true	○	○	○	○	○	Absolutely true	No answer	○

The materials made available (e.g. lecture notes, textbook, handouts, etc.) helped me to understand and address the course content

Not true	○	○	○	○	○	Absolutely true	No answer	○

Exercises

The exercises helped me to understand and apply the content of the lecture

Not true	○	○	○	○	○	Absolutely true	No answer	○

Motivation and learning

I attended the lecture because I am interested in the subject

Not true	○	○	○	○	○	Absolutely true	No answer	○

I attended the lecture because it is compulsory

Not true	○	○	○	○	○	Absolutely true	No answer	○

I attended the lecture because of the lecturer

Not true	○	○	○	○	○	Absolutely true	No answer	○

I am able to explain the most important material learned in this course unit clearly and understandably to a younger student

Not true	○	○	○	○	○	Absolutely true	No answer	○

How would you describe your motivation for preparing for a presentation on the topic of the past three learning sequences?

I feel (several choices possible

anxious	○	focused	○	inspired	○	fearful	○
enthusiastic	○	excited	○	interested	○	competitive	○
disinterested	○	creative	○	Own choice	○		

How would you describe your control over succeeding on an exam on the topic of the past three learning sequences?
I feel (several choices possible)

prepared	○	overwhelmed	○	unprepared	○	lost	○
equipped	○	disorganised	○	informed	○	pressurized	○
I am on target	○	Own choice	○				

How would you describe your confidence at this point in terms of feeling prepared for an exam on the topic of the past three learning sequences?
I feel (several choices possible)

Well prepared	○	supported	○	challenged	○	pessimistic	○
optimistic	○	I will succeed	○	In control	○	unprepared	○
Own choice	○						

General satisfaction
How satisfied were you in general with the course unit?

Very unsatisfied	○	○	○	○	○	Satisfied	No answer ○

Questionnaire
The questionnaire enabled me to express my opinion of this course unit sufficiently

Not true	○	○	○	○	○	Absolutely true	No answer ○

Comments
Imagine that you are the lecturer teaching this course unit. What would you improve? What would you keep unchanged?
Note: Please refrain from leaving comments which insult the person or impinge on the honour of the lecturer or assistant

Self-Evaluation sheet (designed for this teaching experiment)

How many students participated in lecture 1

1-3	○	4-8	○	9-12	○	>12	○

How many students participated in lecture 2

1-3	○	4-8	○	9-12	○	>12	○

How many students participated in lecture 3

1-3	○	4-8	○	9-12	○	>12	○

How quick did they respond to start the activity?

Were the instructions clearly formulated, or did students hesitate and need additional input? If yes, what did they ask for?

Were the given the given time frames for activities suitable?

On a scale of 1-5, how confident did I feel in

Lecture 1

Not confident	○	○	○	○	○	Not confident	No answer	○

Lecture 2

Not confident	○	○	○	○	○	Not confident	No answer	○

Lecture 3

Not confident	○	○	○	○	○	Not confident	No answer	○

What did I like best about teaching in a combination of lecture style and active learning series?

What should be improved?

How did I observe the autonomy of the students following the key criteria of Paxman: Confidence, control and motivation?

How were the products the students developed during the active learning sequence in comparison to what I expected?