Departmental seminar series and journal club with enhanced learning outcomes

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Abstract
Listening to scientific presentations and reading scientific literature are core activities of any scientist, and frequent components of students' curricula. When employing these activities in teaching, finding the right balance between student instruction and autonomous learning is important for best learning outcomes and teachers' workload. We here present our course design for a coordinated lecture series and journal club, that finds this balance by leveraging modern learning concepts in a digital environment. Participating students were tasked to read a landmark scientific paper every week ahead of a lecture by a scientist with practical experience on the topic of that paper, often an author of that week's paper. Students then had to hand in written answers to three questions probing their understanding of the topic and the paper. In a subsequent seminar, activating questions were discussed by the students in break-out rooms and then answered by randomly chosen students in class, followed by a broad discussion that included the homework questions. Students gave weekly feedback on their learning progress and experience, and the course was then dynamically adapted accordingly. This yielded a course with largely increased course capacity, reduced teachers' workload, and substantially enhanced learning outcomes, qualitatively and quantitatively compared to previous implementations of the course.

1 Introduction

Scientific core activities include listening to presentations, discussions, literature research and writing, and critical appraisal of each of these [1]. While University level teaching generally considers these skills to be important, they are not taught comprehensively, with only few courses focussing on these skills specifically [2,3].
A contributing factor might be the high time consumption of scientific reading formats for both students and teachers. First contact with scientific communication needs a high degree of instruction and supervision. This is contrasted by tight teaching

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resources [4] and increasing numbers of student enrolments [5] that make it difficult to realise small scale formats like journal clubs or expert discussions.
Progressive teaching concepts like active learning and peer-teaching could overcome such limitations. Solutions could include topic rather than paper-specific journal clubs [6] or active teaching [7], peer-mentored learning [8], which proved to increase student engagement and learning outcomes; this could potentially be further enhanced by restructuring a course into problem-solving and instruction phases [9].
Furthermore, science-related classes feature a huge variety of topics, which creates challenges and chances alike. Being confronted with expert-level knowledge from different fields can be overwhelming and discouraging, however it can also be utilised to make students profit even more. Studies showed that interleaving different topics enhanced memory and problem-solving ability [10] and that translation between different research fields greatly improved metacognition, which consequently increased active learning success [11]. Another point to consider when covering different topics in an iterative manner is the frequency of testing or feedback on learning status. Meta-analysis showed no significant correlation between test frequency and academic achievement but also suggested that topic associated, frequent assessment outperforms centralised assessments (e.g. midterm or final exams) regarding learning outcomes [12,13].
Our previous “student peer teaching” concept [14] for the presented course included many of these considerations already. Each week, a student presented a scientific paper and its associated topic to the class in a full lecture, supported by us in the preparation and during Q&As. This, however, limited the number of attendees to the number of weeks and students complained that only the topic they themselves presented was really mastered.
We here present a course and its first test that builds on these considerations to enhance learning outcomes in an open participant number format. We combined a departmental lecture series of expert talks with an active learning journal club in a digital environment. Initially introducing topics by experts from the field sparks interest, translates the research into different contexts and defines objectives (educational trajectory phase) [15] for the subsequent active learning & problem-solving phase, which is rounded by a seminar including peer-teaching and teacher instruction phases.

2 Methods

2.1 The current course concept was created in a three stage process. The first stage consisted of conception sessions of a professor and two teaching PhD students similar to the curricular spider web [16] following the rationale of increasing the participant number, whilst decreasing teacher time expense and most importantly enhancing the learning outcome for students. This step included reviewing the structured student feedback and teacher notes from running the previous course format for seven years, followed by literature research on formats like lecture series and journal clubs and concepts like active learning [7], peer-teaching [8,14] and problem-solving [9]. The resultant plan of the course was further refined in the following two ways:

2.2 The second stage included the acquisition of speakers for broadly predefined topics in the area of modern biological mass spectrometry, based on the content of the previous iterations of the course. The scientific publication to focus on was suggested by us and in some cases adjusted based on feedback from the speaker. External speakers were all chosen from the list of authors of the scientific papers we wanted to cover and approached proactively. In our experience, scientists have a general interest in propagating their field specific knowledge and techniques, especially to students. Besides altruistic reasons, the aspect of recruiting potential new master or PhD students can be compelling and is far from being a one-way road, as this also offers the students career options.

2.3 The third stage took place whilst running the course and based on student participation. We collected feedback and ideas for improvement at the end of every week, screened that immediately and categorised it into: unfeasible (ideas/wishes restricted due to e.g. limited expert availability, university regulations, time etc.), potential long term goals (ideas for next year's course) and potential immediate implementations (ideas that seem short term viable and potentially add value). Third category ideas were implemented and followed by feedback at the end of that week, so that we could decide if changes would be solidified or dropped again.

It took about six weeks into the course to find the right balance between student instruction and autonomous learning. The resulting final course concept is presented in the following section.

3 Results

3.1 Goals

When planning the course, we defined three main goals, elaborated in the following passages. To facilitate critical reading of scientific literature, we followed an active learning strategy. We used paper examples and tasks to emphasise certain caveats and foci when reading a scientific publication.

A second aim was to enhance general paper reading skills. Next to the natural progression by regular reading and discussing, two weeks into the course (after students read the first couple of papers) we discuss with the students how to approach a paper and mutually developed a reading strategy. This strategy suggested getting an initial overview of the papers' main points by perceiving the graphical content first, then understanding the abstract and figures, and finally reading the paper with a focus on the critical parts [17].

Thirdly, at the end of the course we want the students to be equipped with a large toolbox full of bioanalytical methods, problem-solving skills and an individual compartment for their own ideas, including the courage to think big. By giving them the opportunity to pre-familiarise themselves with these topics in a flexible environment, bringing them into contact with experts from these fields and finally encouraging them to apply the gained knowledge into new contexts every week, we expand their long-term skill set and strengthen their confidence in applying these.

3.2 Implementation

To achieve these goals, we developed a weekly schedule (summarised in **Supplement Figure 1)**, which is further explained in the next paragraphs.

The weekly paper and corresponding homework questions were uploaded on the universities' moodle based platform each Friday morning of the preceding week. To profit most from the expert session on Monday, students read the paper beforehand.

The expert's session consisted of a 45-min talk and a subsequent 15-min discussion with the students via Zoom. The talks included an introduction into the technology, examples of its application, personal side notes from the expert scientist and an inaugural part on the week's paper. The latter was especially important as it helped students to understand the paper's premise and set the objective (educational trajectory phase[15]) for the subsequent active learning phase. Students liked to hear these personal side notes and hands-on experiences, as it makes technical content more approachable and imaginable.

Students were then asked to re-read the paper and answer three questions regarding the paper until Wednesday night. Answering the following topic-related questions, across all twelve topics, made up 72% of the final mark.

1. "What is the core idea of the technology and how is it applied in the paper?"
2. "What application of the technology intrigued/inspired you and why?"
3. Examples for *general or topic-specific* third questions:
   "Explain the principle of the technology and what it is used for in easy words (like for a 12-year-old) preferably supported by metaphors or picturesque explanations". (*general*)
   "It is 2030, how did the technology used in the paper develop? How does it influence science and maybe even society? Write a brief future scenario!" (*general*)
   "What are differences between protein and mRNA coexpression data?" (*specific*)

The first two questions stayed the same, whereas the third question varied across each week and was more translational. According to student feedback, this seemed to give the right balance between consistent expectation and motivating variety.

Each week was finalised with a seminar (**Supplement Figure 2**) that started with an anonymously answered multiple choice activation question, usually a seemingly basic question on the paper's fundamentals. However, the polls consistently showed ambiguous outcomes, with substantial proportions voting for the wrong answers. We find this especially noteworthy, as even after reading the paper, listening to an expert on it, being able to ask questions and then having to provide written answers, these students frequently did not get the underlying core concepts. The results were shared uncommented with the students, which were then sent into 30-min breakout sessions with five to six students. They were instructed to discuss the activation question (peer teaching) and the answers to their homework questions. Back in the plenum, the activation question was then polled again. Interestingly, the vast majority now answered correctly! Subsequently, the pre-discussed homework questions were

shortly presented by randomly chosen students, complemented voluntarily in a discussion and rounded through additions by teaching staff. This further deepened the understanding of the core concepts. Student feedback steered the course towards more time within the breakout sessions and a concise plenum afterwards. So also the students became clear about the value of peer interaction.
Seminar participation was marked following a “points remain unless you abstain” system, meaning everyone gets full points from the start, only being lost when a participant is chosen by a randomizer tool and does not answer at all (most basic answers were accepted and used as discussion starters). This being communicated clearly at the course’s start created a seminar discussion environment without competition for speaking times (when participation would equal points), hence less overlapping content. This also encouraged preparation, and appearance of each student, and allowed the discussion to evolve more naturally and autonomously.

3.3 Feedback

Finally, students were asked to give their weekly feedback on the course structure, and the content and to evaluate their knowledge of the topic before and after the topic’s week. Students also commented on implementation of their suggestions.
Students viewed time requirements as demanding, but very fair. The course required regular time investment throughout the week, however the consistent structure with flexibility in-between helped to learn efficiently and plan their weeks in advance. The weekly time needed to access a paper fully and to answer the homework questions was very individual to each student, ranging mainly between 2-8 hours (**Figure 1**); however, oral feedback indicated that the time expense declined throughout the course progression due to improved paper reading skills.

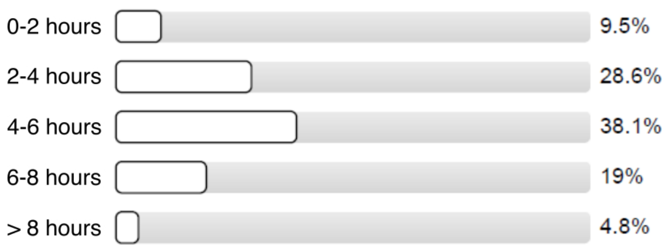

Figure 1: *Weekly time investment for students (acquired by the systematic university’s evaluation system at the end of the semester)*

This also applied for the teacher’s time investment; with growing experience, especially marking the homework questions became more efficient. One major workload on the teacher's side was the course preparation; guest speakers needed to be acquired, fitted into a suitable schedule, briefed on the concept and a suitable paper had to be proposed and/or mutually agreed on. Including the usual tasks like online course setup and material collection, one to two full-time weeks should be considered as preparatory work (however this should decrease on reiterations with the same guest speakers). Weekly time investment was necessary for the course

maintenance including paper reading and content generation (~1-2 h), moderation of the talk (1 h) and the seminar (2 h), feedback assessment and organisational matters (~1 h), and examination of the homework questions (~4-6 h) adding up to a weekly time expense of around 9-12 h. With 45 students in the course, this equated to ~15 min/student per week, with an improved learning outcome and student satisfaction compared to the previous concepts (~1 h/student per week).
We assessed student progress across all topics through weekly evaluation shown in **Figure 2**. We could observe a substantial increase of self-assessed knowledge levels from prior to afterwards across all topics. The ratings (x-axis) span from 0 (absolutely no knowledge) to 10 (expert knowledge).

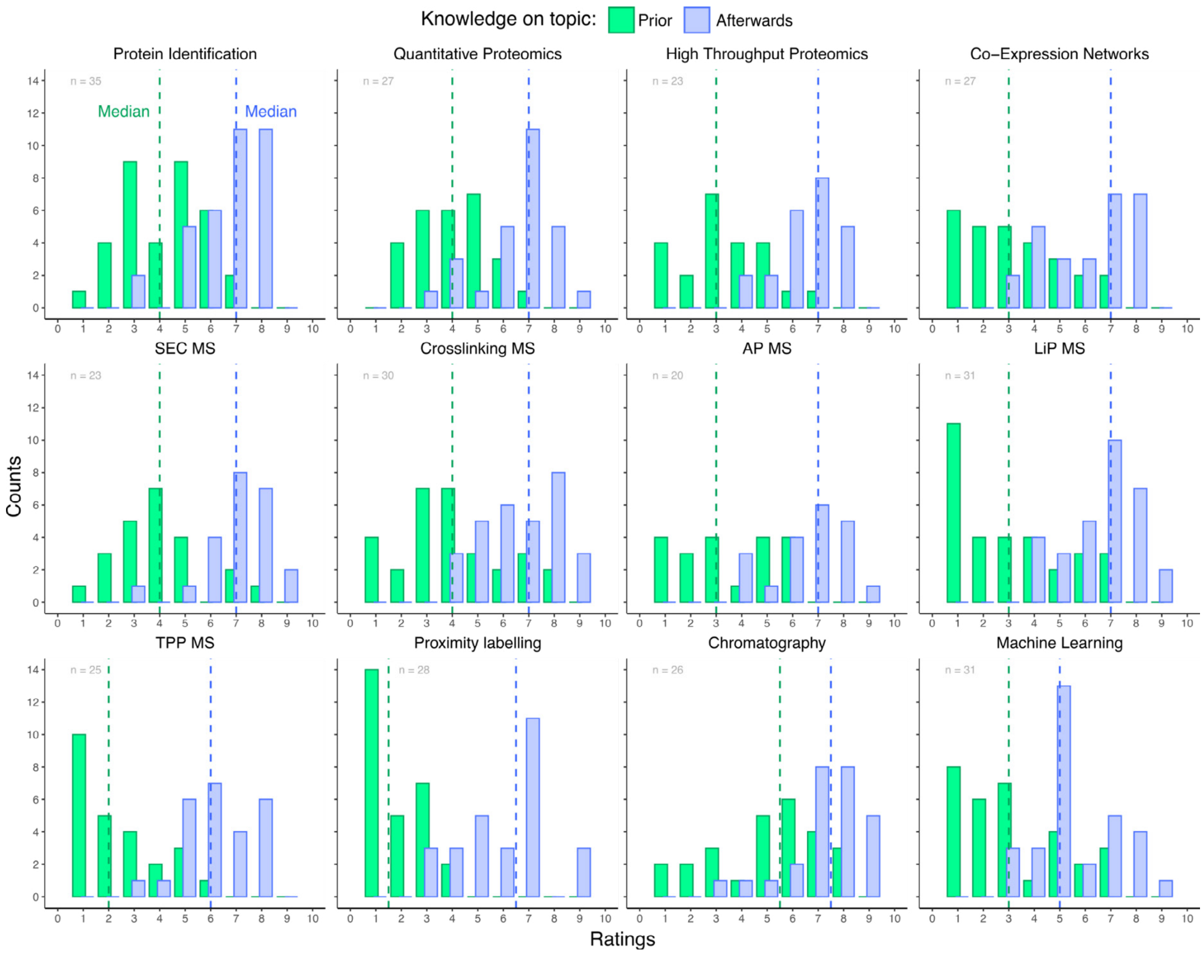

Figure 2: *Self-assessed knowledge level of students prior to (green) and after (blue) a topic-specific week, with medians given as dotted lines*

For the majority of topics, we observe an increase by 3 or 4 of the median knowledge level (dotted line) from 3-4 (prior) to 7 (afterwards). This is a marked improvement over the previous years, when students consistently complained about achieving limited progress. We also noticed increased precision and depth of answers given in homework and seminars as the course progressed. The average mark improved from 1.7 (WiSe 20/21, n = 12, old format) to 1.3 (WiSe 21/22, n = 45, new format) (*1.0* being the best and *5.0* being the worst possible). Overall, this data supports the assumption to have enhanced the students' learning outcomes and skill set sustainably across all topics.

This assumption is further supported by the university's systematic final evaluation system, marking the course quality on average with *1.1* . Providing the course content in the format of a lecture series in combination with a journal club seemed very useful for students' learning success (*1.2*) and gave them confidence in having understood these (*1.6*), even though the overall content was perceived as more complicated than in other courses (**Figure 3**).

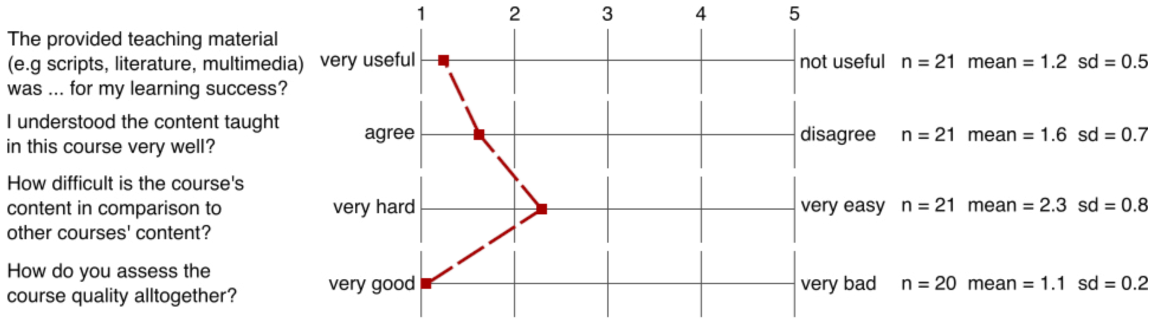

Figure 3: *Overall course feedback at the end of the semester (acquired by the systematic university's evaluation system)*

Lastly, it is also the students' qualitative feedback that shapes the course evaluation and its further development. Feedback like *"Thank you for all the Input! I learned a lot and will definitely recommend this course.", "This course is pretty much the first in which the possibilities of e-learning have been properly exploited"* or *"One of the most interesting and informative courses I have ever had"* encouraged us to consolidate this concept and to make it available for others through publication.

To outline some of the most frequent feedback we got (supported by frequency analysis [**Supplementary figure 3**]), most students were pointing out their interest and content ("interesting topic/discussion", "everything …[fine, good, great etc.]") and they were positive about the variety of content and formats ("new things/information", "good way", "different aspects", "third question"). Additionally, the majority affirmed adequate course pace or time expense ("enough time") and in the beginning, many pointed out a wish for smaller discussion groups ("many people", "smaller group"), which was complied by refining the seminar structure ("break out session", "small group discussion").

4 Discussion

The entirety of collected feedback suggests us having enhanced the learning outcomes across all topics considerably by remodelling the course into a departmental seminar series and journal club. We here rely on an extensive collection and interpretation of regular student feedback and the experience of our teaching perspective. However, we are aware that our study lacks a long-term comparison and a standardised learning outcome assessment. Such measures are currently being developed.

Furthermore, it has to be considered that the remodelling from a topic-centric "student peer teaching" concept towards a lecture series and journal club shifts the focus of trained soft skills from presentation towards paper reading, critical assessment and discussion. All of these are essential skills for scientists, though, our experience and received feedback indicate that we could achieve greater improvement within the literacy skill set, than previously in presentation skills. Note that the latter is being trained from elementary school on, whereas for most students, scientific reading and assessing is only a part of writing up their theses. We see a great necessity to help students approach scientific literature confidently. Many of them, even when close to finishing their studies, still feel demotivated or overwhelmed when researching literature [6].

Apparent improvements we could work out already refer mainly to the need of weekly summaries. The in-depth discussions and topical excursion in the seminar made it hard for some students to remain focused on the essentials, so that they asked for more frequent summaries. This could be achieved by ending a seminar by collectively defining e.g. the three most important points about the technology or answering the same summary questions for each topic. This would refocus the natural flow of the discussion into a digestible take-home message. From the teaching side, we identified as the main caveat the time needed for marking the homework questions. In the next course iteration, we will experiment with students having increased responsibility, to answer non-assessed topical questions and use the seminar discussion to evolve their answers. We will then use part assessments (e.g. every 3 papers) consisting of a mixture of multiple choice (similar to the activation questions) and partly free text questions (as described in 3.2).

In conclusion, the revised course achieved the defined goals. The now scalable, more student-autonomous concept enabled us to lift the participant restriction whilst showing substantially improved learning outcomes across the range of very specialised content. Instructors' absolute time investment decreased only slightly, however with student numbers quadrupled and learning outcomes increased, we consider this a great success.

5 Recommendation

Our course concept might serve as a blueprint for a departmental lecture series in combination with a journal club. We see this concept as being highly transferable, as the structure evolves around weekly building blocks that could be filled with any topic and corresponding speaker and literature. We happily encourage any educational team or lecturer to adopt the here presented concept and would in such a case just ask to reference us and, more importantly, to give feedback to us on its performance and potential improvements.

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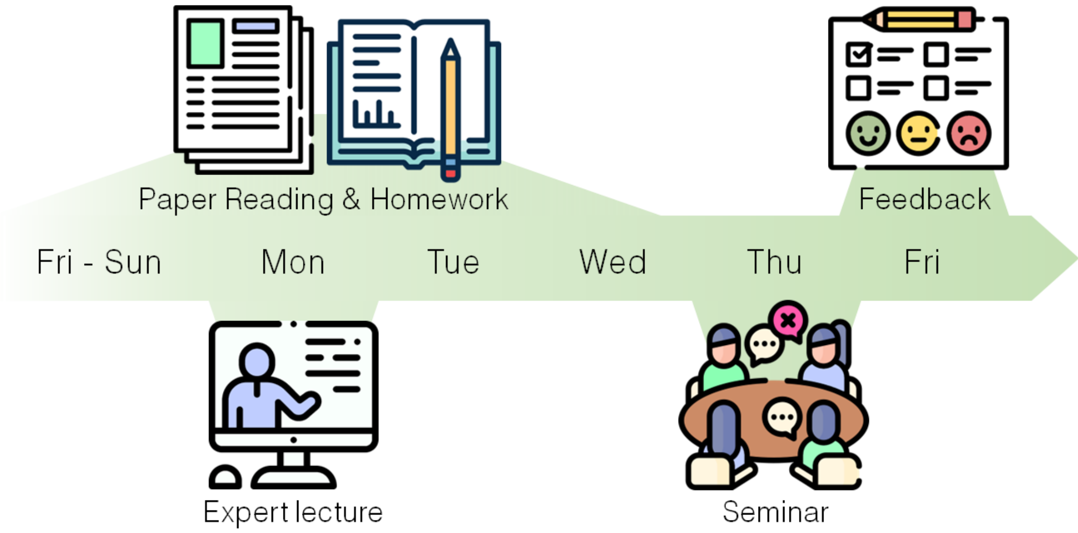
Graphical sources

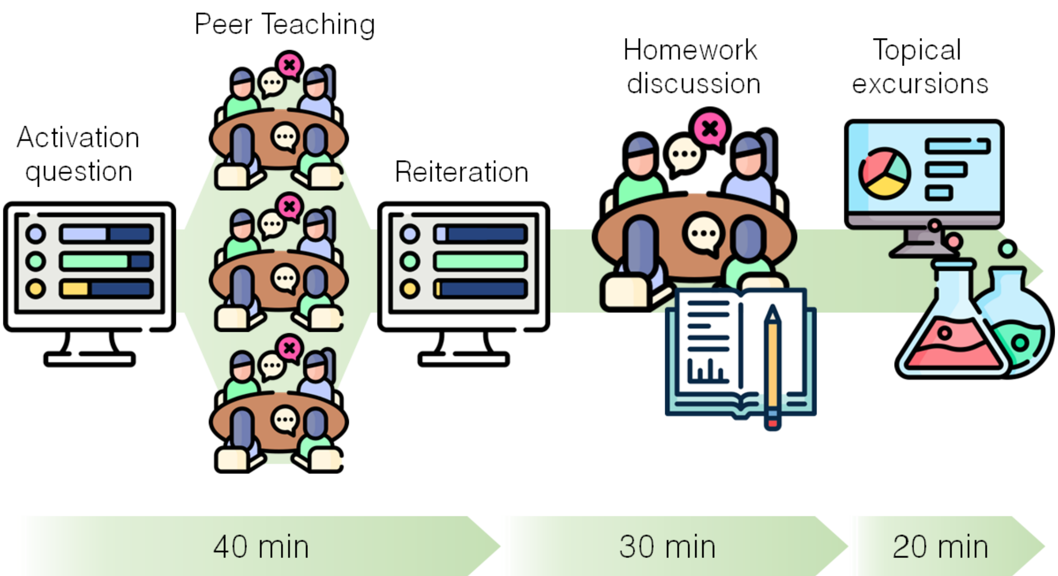
Icons used in Supplement figures 1 and 2 were downloaded from https://www.flaticon.com/

Word cloud in Supplement figure 3 made at https://monkeylearn.com/word-cloud

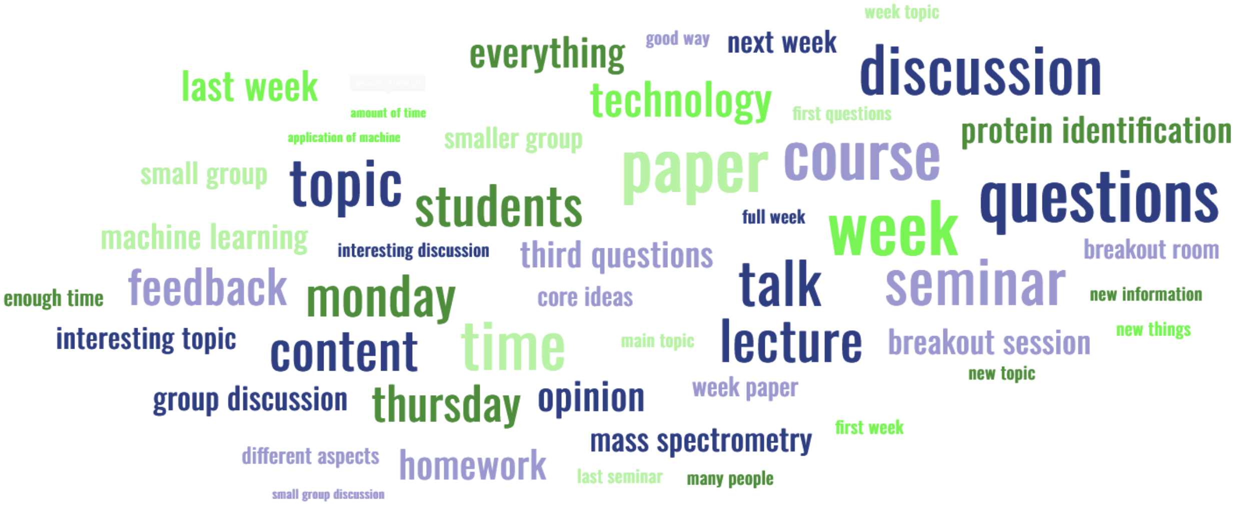
Supplement:



Supplement figure 1: *Weekly plan of the departmental lecture series, consisting of reading a paper, listening to an expert's talk, answering homework questions, discussing these in a seminar and finally giving feedback*



Supplement Figure 2: *Seminar structure, consisting of a paper related activation question, peer-teaching breakout sessions, re-iteration of the paper related activation question, discussion of the homework and excursions on related topics*



Supplement figure 3: *Word cloud of 50 most relevant word (groups) within a total of ~380 written weekly feedback on “Do you have general feedback and/or comments on the course?”; created with [Free Word Cloud Generator – MonkeyLearn]*