Bidragsformat: Diskusjon

Integrating Student-Led Tutorials and Active-Learning in Large Basic-Knowledge Courses

Gilbert Bergna-Diaz[1], Frank Mauseth[1] and Reidar Lyng[2]

[1] Department of Electric Energy, NTNU, Norway
[2] SEED (Center for Science & Engineering Education Development), NTNU, Norway

Summary: This contribution summarizes the (re-)design of a relatively large (180 students) basic knowledge circuit course aiming for higher motivation and learning quality among students. The challenges inherent to the type and size of the course meant that we could not solely rely on project work with report writing to keep students motivated and engaged, as one could do in smaller-sized specialized courses. Therefore, we propose using two active-learning methods besides our lectures; namely Auditorium Workshops (AWs) and Student-led Tutorials (SLTs). In this configuration, students work and learn throughout the semester with more realistic, industrially relevant and motivating (exam-level) tasks from the beginning of the course. Given their complex nature, the teaching staff addresses any built-up frustration during the collaborative group work in the AWs, avoiding students getting stuck for too long. Moreover, the quality of learning is further increased by pairing the AWs with SLTs, as students not only need to have attempted to solve the tasks but be ready to explain and defend what they have done to other fellow students, taking their understanding to the next level. Preliminary reactions suggest that working towards reducing potential anxiety during the SLT presentations further improves the positive impact of this implementation.

Nøkkelord:
Student-led tutorials, auditorium workshops, large basic-knowledge course

1 Course Structure ELET1002

1.1 Course description

The first-year course «*ELET1002 – Electric Circuits: Modelling and Analysis*» was implemented for the first time in the spring semester of 2024. From a content perspective, the aim was to create a modernized version of the traditional circuit analysis course; including topics like AC circuit concepts, Laplace and frequency domain analysis, but with a control engineering and a multi-physics twist. It is a relatively large course consisting of 180 students and has a traditional 100% four-hour exam at the end, in addition to two mandatory physical laboratories and a mini project. Finally, the teaching staff is formed by two lecturers, one laboratory lecturer, one scientific assistant and twelve teaching assistants.

1.2 Motivation for new design

Our goal was to design the course such that it would increase students' motivation, engagement and learning quality, at least compared to its traditional lecture-centric implementation. This was not straightforward given 1) the relatively large number of students and 2) the basic-knowledge nature of the course. These two challenges appear as strong arguments against using a more motivating project-based implementation, paired with individual or group reports. The former would imply an excessively high grading effort of individual reports whereas the latter would not guarantee that each student has the necessary grasp on the basic knowledge required in subsequent courses. To overcome these challenges, we opted to design the course around industrially relevant and motivating tasks supported by Auditorium Workshops (AWs) and Student-led Tutorials (SLTs), according to the structure detailed below.

1.3 Structure description

The course was divided into six main (two-week) thematic blocks, as illustrated in Figure 1-a). In each block, the following learning activities are found:

- Live lectures
- One Block Challenge
- Two to three Auditorium Workshops
- One classroom TA session
- One Student-led Tutorial

The first week is reserved to the introduction to the course where the course structure and philosophy is explained to the students, in addition to a brief introduction to the MatLab software used throughout the course including the final exam.

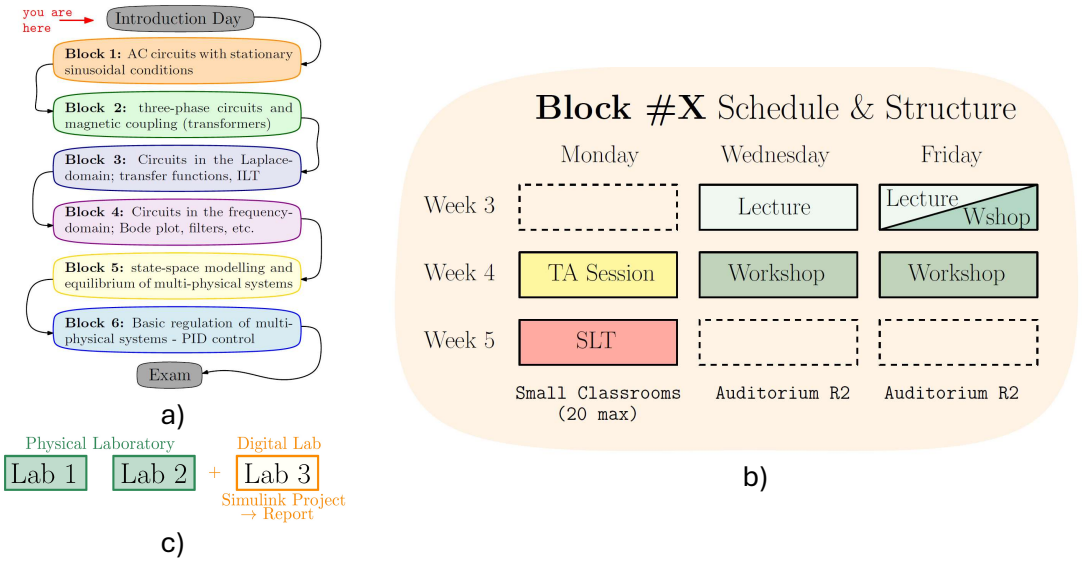

Figure 1- ELET1002 Structure. a) course divided into six thematic blocks. b) example of the structure within a block. c) additional mandatory activities.

The SLTs have a 70% mandatory requirement to gain access to the final exam in addition to participation in two labs and the Simulink project report, yet the students are strongly encouraged to attend all activities, described in the following lines.

1.3.1 Lectures + The Block Challenge

A block could end up looking like the one in Figure 1-b). Starting with a lecture summarizing the most essential topics. All other details are still covered in short plenaries during workshops, or in (*optional*) pre-recorded videos.
At the end of the lecture the Block Challenge is introduced consisting of six tasks. Students understand that these tasks are a very relevant training for the real exam, and thus do not feel like wasting their time by doing them. We aim to make the tasks industrially relevant and thus hopefully motivating.

1.3.2 Auditorium Workshops

Students are encouraged to attend “Auditorium Workshop Sessions” where they sit in self-enrolled groups of approx. 5-6 people working together solving the block challenges. They have access to approximately five TAs, the scientific assistant as well as the *two lecturers*, allowing the students to get immediate feedback on their performance. The only rule so far is that “only group questions are allowed”. It is worth mentioning that this configuration seems to allow to train more relevant “exam-level” tasks from very early in the semester as the risk of frustration from getting stuck in a seemingly hard tasks is significantly decreased by interacting with a member of the teaching staff. For the course, auditorium R2 at NTNU has been used that is well suited for group work with 28 group tables with individual screens and white boards in addition to a “raise hand” button students can press for help from the lecturers/teaching assistants.

1.3.3 TA sessions

The “TA session” (as well as the SLTs) are carried out in 10 small classrooms (max. 20 students), to which students have been randomly assigned—forming the SLT-group. This group carries on working with the Block Challenge for three hours, and is formed with students from different study programs, allowing for potential skillset exchange, and has access to one TA per classroom. Most importantly, it happens before the AWs allowing time for students to prepare their questions for the teaching staff later in the week.

1.3.4 Student-led Tutorials (SLTs)

As explained in Edström et al. (2017), SLTs are a peer learning strategy where students guide problem-solving tasks in a semi-structured activity. Students will get to attend a total of six SLTs, in ten different small classrooms. In preparation, students are handed a set of six tasks (i.e., “The Block Challenge”) and are required to seriously attempt to solve some of the tasks in advance by themselves and/or during workshops, and then present their efforts in finding the solution in the SLT classroom if the teaching assistant randomly selects them. Prior to the SLT session, students need to indicate which of the six tasks they are willing and are ready to present in the SLT classroom by «ticking» on the corresponding tasks numbers through a survey in Blackboard. The TA will only select students to present among those who have ticked on the relevant task. At the end of each session, students will have had a chance to discuss all exercises and collaboratively build the solutions. To gain access to the final exam, a student must have ticked minimum 70% of the tasks. Note that to have a valid «tick», the student is required to have made a serious attempt to solve the task at hand. This implies that the student should have arrived at a solution but will not be penalized if he or she did not find the right answer. They also need to be physically present for valid ticks. If it becomes obvious that the presenting student who has ticked on the tasks has not made any serious effort in solving the task, then the student loses all ticks for that session.

1.3.5 All-digital exam

The final grade is 100% based on a traditional end-examination. During the lectures, workshops and SLTs students have been introduced to and been using industry relevant software to solve the problems in the SLTs. These tools are also available for the students at the exam, so they get relevant training during SLTs that is used on the exam and in the industry. This makes the SLTs and exam more relevant and motivating for the students.

2 Background

Workshop Background: The initial motivation that led to the course structure came from wanting to replicate the seeming success of a different course (ELDI2002: Control for Electric Energy Systems) much smaller in size (approximately 30 students), and in a more specialized topic. This course was designed together with the help of Kristina

Edström (KTH) and was also divided into six two-week-long thematic blocks, with one (sometimes two) lecture(s) and a block challenge, where students were asked to apply the relevant control theory of the block to their electrical application in MatLab/Simulink, and write a 4-5 page report with the findings. Given the difficult (yet motivating and fulfilling) nature of the tasks, workshops became important to avoid frustration as there they counted with the help of the teaching staff. The quality of the six reports (70%) and performance in oral exam (30%) shaped the final grade of the course. The question was then twofold:

- *How can this type of structure scale, e.g.: from 30 to 180 students?*
- *Can it be used in a more basic knowledge problem-solving-based course?*

Indeed, it seemed rather impractical to continue to rely on bi-weekly individual reports as the basis of the grade for large courses and needed to shift towards a final exam, at least in the initial iterations. However, a (scalable) mandatory activity was still desired at the end of each block to keep the students engaged with the course. This is then where we opted for SLTs—again following advice from Kristna Edström (KTH)— to replace the reports in this larger course. They provide the scalability that was sought after and can be based on basic-course problem-solving tasks.

SLT Background: The first time we tried the SLTs was in the autumn semester of 2023 in a relatively large second-year course of 200 students called "TET4100 – Circuit Analysis." This course can be viewed as the more traditional version of ELET1002 and was given as a standard lecture-centric course. It was then the perfect candidate for trying out the SLTs on their own, i.e., before combining them with the AWs. For the implementation, we tried to mimic as much as possible the experience reported by *Serra et al. (2023)* where SLTs were tested in an electromagnetic course at Eindhoven University of Technology. This resulted in mostly positive results when applied to our TET4100 course, at least from the point of view of exam performance, in line with the results reported by *Serra et al. (2023)*. We believe that the reason behind the success is that asking the students to be prepared to explain what they have done takes their learning to a higher level, as suggested by Feisel-Smith technical taxonomy on quality of student learning, depicted in Figure 2. However, we also concluded after two implementations in TET4100 that the SLT implementation format should be better tailored to consider the cultural background of our students and the year of study—more on this in section 3.

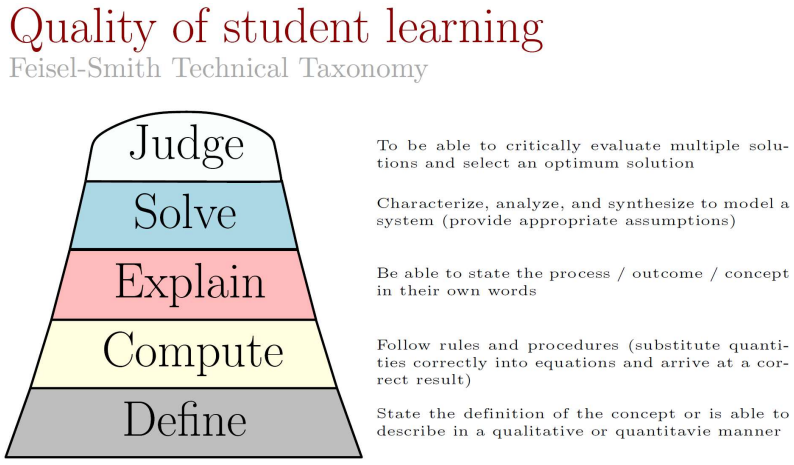

Figure 2 – Quality of student learning. Feisel-Smith Technical Taxonomy

3 Most recent experiences and updates

3.1 On fixing potential social discomfort caused by SLTs.

Perhaps the weakest point of implementing the SLTs in the first iterations within our course(s), was the high level of social anxiety and social discomfort that it caused in some students/SLT groups, often related with public speaking. This was of course the case for the presenter, but also for the rest of the classroom (audience) which did not dare to ask questions or engage in discussions. It has been well-established that social anxiety for students and teachers alike has a considerable impact on the learning dynamics in the classroom – see e.g. Aga (2024). This was viewed as a significant hindrance to learning since potential nervous presenters are not really listening much to who is currently presenting, but instead hoping that they will not be called up to the stage.

These initial iterations kept the benefit of having students that understood the task well enough for presenting them to others. Learning from these past experiences, the second implementation of the course (Spring 2025) then adopted the structure sketched on the right side of Figure 3. In this newer setting, the classroom has been divided into smaller subgroups with a size decided between the TAs and students—while respecting the minimum size of 4 members. The first implementation had six persons forming a subgroup (on average) leading to noisy classrooms given that there are multiple presenters talking at once. This in turn makes it easier for the rest of the students to engage in discussions and ask questions to the presenters. The most recent reference group meeting has indeed confirmed that there is very little to no anxiety caused by the SLTs and seem to be enjoying the rather social environment with a very active level of engagement from the participants. The TAs have also given very positive feedback, which they have summarized as "*It's working! Don't change anything!*".

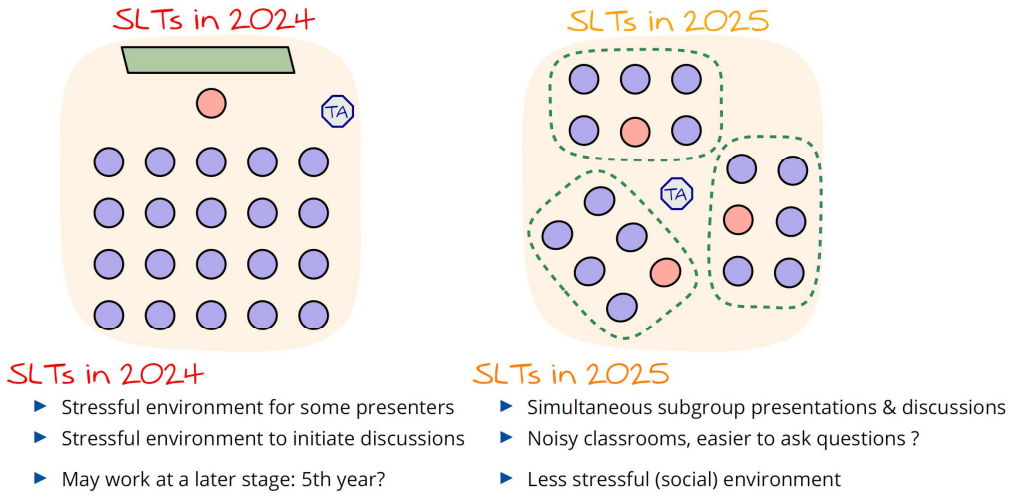

Figure 3. SLT implementation changes to reduce anxiety: 2024 vs 2025.

We have also encouraged the students and the TAs to make progressively larger groups as the semester advances with the idea to use progressive exposure to improve their public speaking professional skills. This is decided by the groups themselves, but only as long as it does not negatively affect their learning.

3.2 Workload for transition

The workload related to the transition from a lecture-centric course to this structure is arguably not too different from preparing a course for the first time, and quite possibly less. There is some time spent in preparing the SLT-tick submission system, structure of the course, and training the TAs for the SLTs, in addition to making sure we take the available infrastructure into consideration. However, given that the lecture time is reduced to around 50%, there is considerably less time spent on preparing for lectures, particularly if the course content had already been delivered as a lecture centric course in previous years. Perhaps the most important preparation time now is shifted to the design of the SLT Block Challenge. In our case, this translates into two or three short meetings with the scientific assistant per block to provide brainstorming for new/updated problems that guarantee that students will learn what we want them to learn, as well as ensuring a balanced and reasonable workload for the students.

References

K. Edström and P.-E. Hellström. Improving student learning in STEM education: Promoting a deep approach to problem-solving. 2017 [Online]. Available: https://kth.diva_portal.org/smash/record.jsf?pid=diva2%3A1154903&dswid=686

Serra, R., Martinez, C., Vertegaal, C., Sundaramoorthy, P., & Bentum, M. J. (2023). Using Student-Led Tutorials to Improve Student Performance in Challenging Courses. *IEEE Transactions on Education, 66(4), 339-349*. Article 10049399. https://doi.org/10.1109/TE.2023.3238175

Aga, K. (2024). Transitioning to Active Learning Spaces – Perspectives from teachers and students in mathematics and statistics. [Doctoral dissertation, NTNU]. NTNU Open.