Observations and Reflections on Teaching Electrical and Computer Engineering Courses

Ottar L. Osen* and Robin T. Bye

Software and Intelligent Control Engineering Laboratory
Department of ICT and Natural Sciences
Faculty of Information Technology and Electrical Engineering
NTNU — Norwegian University of Science and Technology
Postboks 1517, NO-6025 Ålesund, Norway
Email: {ottar.osen, robin.t.bye}@ntnu.no
Website: http://softicelab.wordpress.com

Abstract. In this article, the authors make a number of observations and reflections based their experiences over many years of teaching courses in electrical and computer engineering bachelor programmes. We present important aspects of attendance, lectures, group work, and compulsory coursework, and how these can be addressed to improve student learning. Moreover, we discuss how to facilitate active learning activities, focussing on simple in-classroom activities and larger problem-based activities such as assignments, projects, and laboratory work, and highlight solving real-world problems by means of practical application of relevant theory as key to achieving intended learning outcomes. Our observations and reflections are then put into a theoretical context, including students' approaches of learning, constructive alignment, active learning, and problem-based versus problem-solving learning. Next, we present and discuss the results from two recent student evaluation surveys, one for senior (final-year) students and one for junior (first- and second-year students), and draw some conclusions. Finally, we add some remarks regarding our findings and point to future work.

Keywords: Active Learning; Problem-Solving Learning; Assessment; Engineering Pedagogy and Didactics.

1 Introduction

In this article, we make a number of observations and reflections based on our experiences from about 23 years of teaching combined (14 and 9 years for the first and second author, respectively) at NTNU — the Norwegian University of Science and Technology in Ålesund (formerly Aalesund University College (AAUC) before 1 January 2016). We have taught courses both in the computer,

---

* Corresponding author. This article is an extended and revised version of a paper presented at the 9th International Conference on Computer Supported Education (CSEDU '17) in Porto, Portugal, April 2017 [34].

automation, and power systems bachelor programmes that we offer as well as in our master programmes in simulation and visualization and product and system design. The courses we have taught involve linear control theory and cybernetics; industrial control systems, microcontrollers, and instrumentation; artificial intelligence and intelligent systems; functional programming; and computer graphics, with aspects of modelling and simulation embedded in most of our courses. In line with the traditional role of university colleges in Norway, our teaching has always had a practical approach, focussing on the application of a sound theoretical foundation to solve real-world problems that face our students when they graduate and enter the work force. Hence, our department has always ensured that teaching and research activities are closely linked to local industrial partners.

When we present our observations and reflections below, we kindly ask the reader to please keep in mind the following:

– These are our subjective experiences, based on years of teaching activities, discussions among the faculty, and student feedback.
– Our experiences are naturally greatly influenced by factors such as personalities, education and work experience, authority, and likability (or lack of these).
– Our students are mostly young men in their early twenties from the town of Ålesund and the surrounding region.
– About 50% of our students have background from vocational school, thus with a tendency to be more practically than theoretically inclined.
– Our classes have usually had about 20–40 students, some as little as 8–12, which is quite different from larger classes of 100 or more students.

Whereas we are perfectly aware that what we present in this article does not generalise to all kinds of teachers, courses, and students, we hope that interested readers will be able to extract and adopt several of our ideas and approaches in their own teaching.

1.1 Outline

The remainder of this article consists of three main parts. In the first part (Section 2), we summarise a number of observations from our teaching experiences and reflect on these. In the second part (Section 3), we discuss our findings in relation to relevant pedagogical literature and theory. In the third part (Section 4), we include results from two recent student evaluation surveys. One survey was undertaken in January 2017 by final semester engineering students enrolled in computer, automation, and power systems bachelor programmes and the second was undertaken in June 2017 amongst the first and second year students from the same programmes at our institution. Finally, we summarise with some concluding remarks (Section 5).

2 Observations and Reflections

From working with students we have commonly observed that fairness is very important. Students react very negatively on anything that seems to be unfair or discriminating, that is, treating students differently. The studies are naturally the most important part of the students lives and the importance of a level playing field must not be underestimated. On the other hand, we have found that students easily adopt to rules and requirements set down for them as long as they make sense and are the same for everyone. Such rules and requirements can be related to achieving learning goals but also fair treatment.

We also believe that in an increasingly free society full of choices and distractions it may be beneficial for the students to have a highly structured learning environment. Many of the observations and pedagogical methods we present in this article may appear more appropriate for kids in school than students at the university level. However, we find that young adults, or most adults for that matter, share much of the same basic traits deep down. For example, whilst it is well known that kids love competitions and games, we also observe a positive change of atmosphere among students if we introduce a competition in the classroom, even if there is no reward.

In the following, we highlight some aspects of our teaching that we consider particularly important for our degree programmes, namely *attendance*, *lectures*, *group work*, *compulsory coursework*, *project-based learning*, *the bachelor thesis*, and *assessment*.

2.1 Attendance

Although our study programmes do not enforce *mandatory attendance*, we believe that in order to become a good engineer it is generally important to attend classes as much as possible, especially since many of the learning outcomes are related to practical skills (hands-on/laboratory work) and interpersonal skills. These skills are not learned in solitude at home or in a library. This of course demands that the classes we teach must be of sufficient quality and be perceived as useful and/or attractive to students.

Several studies suggest that there exists an inverse relationship between absenteeism (not attending classes) and learning [e.g., 12, 26, 38]. Moreover, enforcing a mandatory attendance policy can significantly reduce absenteeism and improve exam performance [27]. In addition to mandatory attendance, one way of improving attendance is to facilitate learning activities that complement the traditional lectures or that are sometimes missing or have limitations in courses offered online or at more traditional universities with larger classes and more theory-heavy degree programmes. Such learning activities may include good individual tutoring and feedback to each and every student, lectures on topics not covered in textbooks, laboratory work, group assignments and projects, all within an active learning environment. We observe that active learning gives us the opportunity to provide students with "*added value*" that can motivate the students to attend, and to attend in an active and constructive way.

Even though attendance is not mandatory we have often practised *calling the roll* before the class starts. Calling students' names can be done quite quickly and does not shorten the time available by any substantial amount, at least not for classes of up to 30–40 students, say. There are several benefits to this practice, for example, fewer students arrive late since they want to be present when their name is called, and also more students attend classes. We believe the reason for this because the act of calling students' names seems to create social pressure to be present, whilst at the same time displays to students that the teacher care about whether they are present or not. Indeed, we have experienced students that have happened to be away from class due to a doctor's appointment or for other valid reasons send text messages to classmates for them to explain to the teacher their friend's absence. This can interpreted as a willingness from the students to obey to a social "rule" of attendance even if attendance is not mandatory.

It is our belief that this kind of *social contracts* between the teacher and the students and between students themselves can be a useful tool and may be further developed, since unspoken rules or norms are less subject to negative pressure or resistance when they are not formalised (mandatory) and therefore are acted upon on more of a subconscious level.

To summarise, we can improve attendance by using both carrot (added value) and stick (social contracts).

2.2 Lectures

Higher education is dominated by the *transmission method* of teaching, which can be popularly rephrased as *teaching by telling* [e.g., 42]. There is a common notion that active learning activities such as solving problems and working on projects are favourable to the *traditional lectures*. For example, according to Bligh [5], traditional lectures are not very effective for personal development, including skills or values, and deep learning, all of which are natural learning goals in higher education.

We have done some simple tests of how much students remember directly after a traditional lecture and admittedly been rather disappointed by the results. We believe the inactive and passive role of the students during a lecture is the reason for this and we welcome methods of activating the students in the classroom for example by means of "clickers," quizzes, competitions, discussions, and so on. However, there are situations when traditional lectures must be given, for example when the material is not covered by textbooks or online video lectures. In these situations, we often prefer *using the blackboard* and *writing by hand*. An advantage of this is that it encourages the students to be active and to take down the notes themselves simultaneously, since the students know they have ample time to write down whatever is being written on the blackboard. If the students also take notes by hand, which they commonly do in engineering courses since the material often covers mathematics and diagrams, the act of handwriting will trigger the brain to be more receptive to learning than from passive listening or writing on a computer [32].

In addition, the teacher will tend to be quite selective in what is being written and not overloading students with information. In order to move new information from a working memory with very limited capacity into long-term memory, deep cognitive processing is required [2]. This process is referred to as *cognitive load theory* [11] and represents a bottleneck in learning when too complex problems and information must be processed in too short a time.

Moreover, by using the blackboard, the teacher can display the thought process interactively, address questions with live written illustrations or examples, and easily improvise on the fly. Using slides, on the other hand, can often lead to a rigid display of a pre-made manuscript with little room for straying off the normal path, especially if the blackboard is hidden behind a projector screen, thus disallowing parallel use of the blackboard.

Lectures with slideshows often have the effect that students generally become passive listeners; they see no point in taking notes since the slides will usually be available electronically, and often there will not be enough time to copy down everything. To illustrate this point, we recap an experiment once done in class: After showing a slide with three main bullet points, each with three sub-bullet points (a fairly standard slide), the bullet points were read out loud and the students were given plenty of time to read the slide. Thereafter, the presentation was muted by showing the students a black slide and then they were asked to recreate the previous slide. In a class of about 30 students, nobody was able to do so.

Traditional lectures with computer-projected material do have their purpose though. Before teaching a new topic it can be useful to paint a backdrop for the students and put the topic into perspective. This usually requires textual information, pictures, videos, internet resources, or figures, diagrams or charts. However, the content that is presented simply serves as an introductory preparation for the students for storing the knowledge that will be presented to them afterwards in much more detail. The idea is that such a short keynote talk will give the students some mental hooks they can use for storing the details that follow. We have also found that students are more motivated and attentive if the lecture is closely connected to a problem to be solved in an assignment or an exercise.

As a precursor to giving a lecture, a useful approach is that of *delayed instruction*, where the teacher asks the students to start working on a problem and gives some individual assistance until at some stage most of the students realise that they need more knowledge to solve the problem. When the teacher then gives a lecture tailored to the problem at hand, the students will be attentive and motivated for learning the theory required for solving the problem. In contrast, starting a lecture by saying that the students will need this or that for their assignment does not yield the same effect. Delaying instruction has been found to be advantageous in a study where students outperformed their control group when they had first interacted in a collaborative problem-solving phase at the beginning of the learning process, with content-related instruction delayed until a subsequent phase [44].

Finally, we have found that it is a good idea to keep lectures short, or at least break up lectures regularly with active learning activities (variation) and breaks (time to digest).

2.3 Group Work

Project-based learning (see Section 2.5) is an important pedagogical tool that usually requires placing students together in suitable groups. Experience tells us that *group dynamics* can both bring the best or worst out of a group [see 17, for primer]. Below we discuss our experiences on various aspects of constructing student groups for projects.

Size How large a group should be depends of course on the estimated amount of work in the project (or assignments). According to the literature review of Pfaff and Huddleston [35], there is no clear evidence of an optimal group size for teamwork, with studies suggesting that either three, four, or five group members is the ideal. Larger groups tend to be less efficient, and thus emulate the Ringelmann effect.[1]

In our case, for smaller assignments, groups of two can be sufficient, but normally we will aim for groups of four, and try to avoid groups with odd numbers. The reasoning behind this is that students working on a task in pairs are able to communicate efficiently and require both participants in the pair to be active. In groups of three, we have often observed that one member is less active than the other two and in the worst case, the third member becomes a mere observer, involuntarily or on purpose as a "free-rider."

Since oral communication only allows for the ideas of one participant to be shared, at any time a group of two is the most effective. However, a big drawback with groups of only two students is their limited capacity if the assignment is big and/or requires competence that may not be held among the group members. Hence, we generally favour groups of four. Finally, with four participants it is possible to make two subgroups that support each other and may re-arrange themselves depending on the tasks at hand and the competence within the group.

Selection of Group Members In general, we favour *selecting groups randomly*. There are several reasons for this. If students are allowed to make groups by their own choice they will often assemble groups that follow existing social structures. As a result, the groups will often become rather homogeneous and strengthen these existing social bonds. The upside is that many of these *homogeneous groups* will have little internal friction and will not require time to socialise, since the students already know each other. The downside is that such homogeneous groups may lack the necessary diversity in competence to solve the problems they are facing. Furthermore, forming student groups at random

[1] A group effort in a rope-pulling task is inferior to the sum of individual performances; the discrepancy between potential and actual effort increases with size of group.

results in more *heterogeneous groups* and can help the teaching environment by widening the social networks in the class. It forces students to get to know each other when working on a common challenge and they therefore become less reluctant to ask questions in class and to interact. On the other hand, heterogenous groups can take longer to perceive and develop cooperative norms early in the groups' formation than more homogeneous groups [10].

We often experience some resistance from students when they are told they may not construct the groups themselves. This is not surprsing, given that most people are resistant to changes and will feel more comfortable with people they know. Nevertheless, challenging this resistance is important in order to get optimal results.

We can attempt to improve the heterogeneity in the groups by not selecting the students 100% randomly, but instead also take into account their sex and background. For example, since we usually have very few female students, we generally prefer to make sure they are distributed evenly amongst the groups, unless there are good reasons not to. In a similar vein, the vast majority of students are native Norwegians, therefore, we try to distribute the non-natives evenly among the groups in order to improve integration. Finally, we often take into consideration that about half of our students have experience from vocational school. These students often have hands-on practical experience that can be very valuable in assignments with a large practical component.

By making sure there is a good mix in the groups, students with a more theoretical/academic background learn practical skills from their fellow students with a vocational background. Likewise the students with vocational background improve their methodological skills by learning from the more theoretical students. This way of grouping students may seem to require much work from the lecturer, however, by repeatedly pulling two names randomly from each of two lists of students (one for those who have vocational training and one for those without), we quickly get a set of possible groups, which then can be rearranged somewhat in order to get a better distribution of females and non-native Norwegians.

When presenting the groups to the students we do not mention such fine-tuning and instead emphasise that the groups have been put together randomly. We also remind them that working together in groups set down by others is something they must expect to do when they start working professionally and that cooperation skills will be beneficial for them in their future work. Finally, we randomly pick a group member to be the *leader of the group*. This person's responsibility is to make sure the group meets sufficiently often, that everyone contributes, and to report group malfunctioning to the teacher.

There are of course many social challenges that can arise in a class of students. We meet students that range from the extremely extrovert to the extremely introvert in addition to students that suffer from mental illnesses of various severity. Semi-random groups put down by the tutor can actively take these issues into consideration. Self-organised groups will on the other hand will often make these challenges greater since socially challenged students will be left out. Although our primary goal is to educate the students in their area of study it falls within our contract with society to also develop the students' personalities in a direction that favours the community. Hence, we should help introverts to be more open and find ways to develop their interpersonal skills. Likewise it is also important to teach extroverts that a solution to a challenge may be found with an introvert that is reluctant to speak out in a group. Since universities commonly have health services that also cover mental health, we as teachers should not try to fill their place. Still, our support for students with mental health challenges is essential, but then as only a part of the total support programme.

2.4 Compulsory Coursework

From our experience with various approaches, we believe that *compulsory coursework* is very often required in order to make the students work steadily throughout the semester. Although our students are adults and should be able to take responsibility for their own learning, students, like the rest of us, are subject to conflicting interest and need to prioritise their time. Even with the best intentions in mind it is easy to push forward activities that have no deadline. Hence, compulsory coursework with hard deadlines help students prioritise. It should be kept in mind, however, that courses that do not have compulsory coursework quickly may be given lower priority by the students. We have found that students' performance improved about one grade on average after making the coursework compulsory in some courses.

The electronic learning management system Blackboard[2] is used at our institution most teaching tasks, including handing in assignments, however, we have found it very effective to also ask the students to show the teacher their work in person, especially on more practical topics, for example where the students are required to write computer programs or otherwise use computers for their solutions. Much too often we have found that students split the work unequally to such an extent that some students have never had the actual computer program or design running on their own computers. By doing such quick *spot checks* we force the students to familiarise themselves with the problem and have an individually working solution they can understand and explain even if they have had a lot of help from fellow students. We have also noticed that the requirement of showing the coursework in person, even only a spot check, improves the quality of the work. It is probably easier to hand in a mediocre result in an electronic system than face to face with the teacher. This is probably especially true in cases such as ours, where coursework generally is not part of the final grading but only a prerequisite that must be passed to enter the exam.

When we design coursework, we believe it is good practice to start with simple questions and subproblems and proceed in a stepwise manner in order to guide the students' progress, in other words, making the assignments resemble step-by-step tutorials. There is a lot to be learnt from a well-formed question and even good students will not find this approach boring, they will just "climb the steps" faster. However, engineering problems in the real world do not come

[2] http://www.blackboard.com

with detailed step-by-step instructions such as those describe above. Therefore, more research-based or investigative problems should not be completely avoided but build on and be carefully aligned with the less investigative problems. One approach that is quite investigative in nature is project-based learning, which we discuss below. Naturally, making good assignments is a lot of work but is probably even more important than making good lectures, since assignments may be re-used and consumed at any time, and especially as final preparations before final exam.

2.5 Project-Based Learning

A popular approach at all levels of schooling, including universities, is that of *project-based learning*, and a key ingredient in active learning. Below, we highlight two factors we have identified as important for success when adopting project-based learning, namely *project selection and ownership*, and *project planning*. Theory related to project-based learning is postponed to Section 3.

Project Selection and Ownership In our courses, students usually get to choose between a *selection of assignments or projects*, and sometimes we even encourage them to participate in defining the problem, if possible. The goal of this approach is make students invest more time and effort into tasks of which they have *ownership*; they seem more reluctant to "lower the bar" if they have first put it high themselves. In other words, they are willing to suffer more from "self-inflicted pain" than from "pain" given to them by the teacher. Another important aspect is the fact that groups with different projects cannot easily copy material from each other and the uniqueness also strengthens the feeling of ownership.

Although this willingness to invest more time and effort into activities the students feel ownership to may be a result of pride, it may also be the result of a kind of "self-love." We believe people in general are less likely to blame themselves than others since blaming oneself is very tiresome in the long run and it is therefore easier to forgive oneselves. Hence, it is beneficial to avoid giving students opportunity to blame the teacher's poor assignment for their own lack of progress or success. Giving students ownership to the activity and giving a clear framework for execution helps in putting the responsibility for success firmly on the shoulders of the students themselves. With no scapegoat in sight the students will prefer to walk the extra mile rather than blame themselves and accept defeat.

We have seen many projects where the students have put the bar too high but instead of intervening, we have just anticipated that the students eventually will face the hard obstacles and lower the bar. To our surprise, quite often the students are able to deliver as they had planned in the beginning through massive team effort. As a teacher this may pose a dilemma since the students are putting more effort into the project than planned, and other teaching activities may suffer from it. In interviews after project hand-ins we have asked students whether we should have intervened, and the students seem to agree that although the load was heavy they felt they learnt so much from it and that they were able to prove to themselves that they are able to solve difficult tasks. Hopefully this self-confidence will help them in their studies. However, there is of course a significant possibility of failure if projects are allowed to become to ambitious, which can give negative effects on learning and self confidence. Hence, it is crucial to have close monitoring and follow-up of these projects in order to be able to intervene in time to secure "a soft landing" of the project. This can be done by the means of the teacher intervening and redefining the project goals into what we see as achievable for the group. The next section describes in more detail how the projects may be monitored in order to secure progress and awareness.

Project Planning The process of *project planning* is important in order to make the students aware of time expenditure versus progress. Therefore, we prefer to let the students first make their *project plans* themselves before having to submit their plans to the teacher for approval. Students are faced with three requirements for their project plans: are that they should clearly present

- how different activities are relatively spaced out in time
- the size (duration and manhours) of each task and subtasks
- who is responsible for the tasks

Before approving the project plans, we make sure the plans are sufficiently detailed and that the students have taken into consideration constraints in both time and resources. Asking the students to make plans forces them to apply a common engineering approach of breaking the work down into manageable tasks, which is also important in order for them to understand the scope of the work ahead. Moreover, we insist on the *responsibility* for each task to be assigned to a single student. In addition, we usually recommend that one other student is assigned as a task assistant. This way, there is no doubt who is responsible for a particular task, while at the same time, the responsible student has another student to help out. This will prevent the many discussions and possible sources for misunderstandings that can arise when tasks are not completed on time. It also discourages "free-riders" by increasing each individual's *accountability* [24].

As the projects progress, we regularly ask the students to update their plans with task completeness given as a percentage. As a result, the students will immediately detect any lack of progress and see the need to take appropriate measures at a time when it is still possible to influence the result. In short, we want the students to panic well ahead of delivery date!

Further down the road, it is usually not necessary for the teacher to comment much on students' plan updates. Quite often the students will be behind schedule but it will be visible in their plans and the need to improve progress will be self-evident. Occasionally, we ask the students to present the updated plan to the teacher in person in order to "increase the pressure" and to verify their understanding of the project status.

Today, a wide range of planning and collaboration tools are available, many of them for free. We encourage the students to find one they prefer and in this way they also get useful insight into what kind of tools they may use in the future, both during study and in their professional life.

Finally, the teacher may use the project plan status as an important metric for follow-up of the students. As mentioned in the previous section this is crucial in order to make sure that the group learn as much as possible from the project, and that the difficulty level is adequate.

2.6 The Bachelor Thesis

At our university, bachelor students deliver a *bachelor thesis*, usually as a group, during their final semester. The workload is 20 ECST, where one full semester corresponds to 30 ECST. Hence, the students only have one 10 ECTS topic to study in parallel with the work on the thesis.

The bachelor thesis projects are often provided by the local industry and seen as being very positive by both the university and the students. The projects maintain the important cooperation between the university and the industry and the students appreciate the opportunity to get in touch with possible future employers. One of the key benefits from this arrangement is a two-way flow of information between the industry and the university. The university learns about the challenges the industry is facing, the industry learn about progress in science that are of relevance to them, and students get relevant and up to date challenges, thus representing a win-win situation for all involved.

Project planning and monitoring in bachelor thesis projects are mostly done as described before for smaller projects but it is important to emphasise the need of getting the projects on-track with milestones and deliveries from the very start. Otherwise, we have observed that students tend to believe they have a lot of time available and therefore will relax in the beginning of the project. We find it crucial that the students learn that projects depend on a constant effort and in this way differs from the typical home assignments and smaller projects they have delivered so many of before, with much of the work often performed very close to the deadline.

For the selection of group members for the bachelor thesis we allow the students to form groups themselves indirectly in a process where each student applies for the different projects they are interested in. Students will therefore often coordinate their order of preference of available projects. However, if two small groups favour the same project we might suggest merging the groups into one bigger group but out of respect for the fact that bachelor thesis is the students' most important work we are reluctant to enforce group memberships except making sure the groups are not too large.

As for defining the scope of the project the situation is often the same as for the smaller projects. The students may often influence the scope significantly since the problem definitions and assignments are usually rather open.

When we are to grade the bachelor theses we often find it hard to use the full span of grades as we usually do. It seems to us as the students put more effort into their bachelor theses that anything else. Hence, the quality of the theses as a whole is usually much higher than could be expected when we compare to other courses.

2.7 Assessment

Below, we reflect on various aspects of *oral and written exams*, *group exams*, and *exam preparation*.

Oral and Written Exams A common perception among ourselves and our colleagues is that many students seem to dread *oral exams* out of (a sometimes unjustified) fear of performing worse than they think would have in *written exams*. On the contrary, however, many students may actually fare better at oral exams, for example if they have dyslexia or for other reasons struggle with written communication, or if the written exam is designed in a poor manner that prevents students from displaying their true knowledge, competence, and skills. Hence, both written and oral exams can be, or conceived to be, disadvantageous to some students and advantageous to others due to individual differences. Consequently, if limited to only these two means for evaluating students' performance, we believe a good mix of oral and written exams can be considered fair to the students. Still, a particular advantage of oral exams over written exams is that it is possible for the examiner to adjust the exam questions ad hoc, for example if a student is nervous. Therefore, a good oral examiner will be able to both uncover lack of knowledge and skill as well as providing an opportunity for students to show the opposite.

Group Exams A drawback with project assignments is that it is difficult or impossible to grade the students individually based on a common written report. One approach to enable *individual grades* in *group exams* is to add an oral exam in addition to the report. By using the report as a starting point, it is possible to at obtain some variation in grades within the group, if appropriate. Whereas this approach is not perfect, at least it provides an opportunity to give a fairer reflection of the differences in skills and knowledge within the group.

We have also experimented with giving oral exams with the whole group present instead of each student individually. The students will typically sit in alphabetical order, be given individual questions one at the time, and may not speak out of order. A practical advantage of this approach is that the total examination time can be reduced compared with individual oral exams, since unanswered questions in a given context can immediately be passed on to the next student without repeating it and less time is used for bringing students in and out of the examination room.

In addition, another important advantage is that the examiner can more easily compare the students with each other, whilst at the same time, the students can observe for themselves who is able to provide the best answers. Students will therefore have a better understanding of why they deserve the grade they get. We suspect this has the effect that individual students work harder (in group projects where they are assessed individually) because they will have the reward of a fair and better grade than fellow students who do not put in the same effort. Finally the teacher has the ability to ask questions about the project work in a way that will disclose students that have been passive during the semester. Different levels of commitment for the project is often observed by the teacher and the oral exam gives an opportunity to document this to the students and to the exam evaluator (usually an external examiner who has the final word on the grade) in a transparent way.

Exam Preparation Common symptoms among students before exams include nervousness, anxiety, and stress. If students feel secure and good about themselves and have a feeling of being in control, they will likely be more prone to deeper learning and typically perform better at exam. To help students get into this positive state of mind, we attempt to *reduce uncertainty* about the exam procedure and content beforehand, typically by providing a well-defined curriculum for the course, run mock exams or practice presentation skills in class, and provide practical information about the exam.

We also have had good experience with giving the students a long *list of possible exam questions* to study before the exam, and try to provide the list as early as possible in the start of the semester. By making the list long and the questions rather open we can ensure that if the students are able to answer most of the questions adequately they will also have good coverage of the curriculum and achieved most of the intended learning outcomes and hence will have better chances of obtaining a good grade.

Notably, having such a long list of questions is probably not of such big help to the students as they tend to believe it is. Rather, its main purpose it simply to help the students getting into a positive state of mind before the exam. Indeed, with a well-defined curriculum and list of intended learning outcomes and good supporting material such as a course textbook, students should be able to make such a list themselves, however, getting the list from the lecturer removes a lot of uncertainty and stress from the students. Feedback from our students have been unanimously positive and we have observed anxiety levels in the classroom go from high to low when the students learn that they will be provided a list of possible exam questions. Finally, we often offer a course revision workshop at the end of the semester, where students can obtain answers to questions that they may have accumulated during the semester and to topics they find difficult.

3 Relation to Theory

In the sections below, we highlight some pedagogical and didactical theory found the literature that is relevant to the observations and reflections we have made so far.

3.1 Students' Approaches to Learning

It is well documented that *students' approaches to learning* has a significant effect on achieving learning outcomes [e.g., 19, 29]. Many studies have tried to identify factors that promote *deep learning* [e.g., 3, 30, 37], that is, learning associated with understanding, in contrast to *surface learning*, which is learning associated with the memorisation of facts and procedures, and with little or no understanding as a result [29]. In between deep and surface learning, Case and Marshall [9] also describe *procedural deep learning* and *procedural surface learning* as two learning approaches for student learning in engineering contexts. In addition to these learning approaches along an axis of deep and surface learning, a commonly observed third category of learning is so-called *strategic learning*, where students aim for good grades with minimal effort, ignoring whether they achieve the intended learning outcomes or not [13, 14].

Students tend to have different conceptions of what learning means, and these conceptions can generally be categorised hierarchically along an axis from surface learning to deep learning. For example, according to Saeljo [39] and Marton et al. [31], students conceive learning as

1. increasing one's knowledge
2. memorising and reproducing
3. applying
4. understanding
5. seeing something in a different way
6. changing as a person

Similarly, and specific to engineering students, Marshall et al. [28] suggest the following categories of how students conceive learning:

1. memorising definitions, equations and procedures
2. applying equations and procedures
3. making sense of physical concepts and procedures
4. seeing phenomena in the world in a new way
5. changing as a person

Higher education institutions obviously have a duty to graduate highly qualified candidates and avoiding surface learning is a means towards this goal. However, according to Biggs and Tang [4], there has been a dramatic change in higher education worldwide, maybe due to the workplace increasingly requiring higher education degrees to qualify for jobs, with many more people enrolling at universities than before, from a wider diversity of background. This has resulted in a shift from perhaps more academically inclined students previously to students who may have a poorer background both academically, socioeconomically and perhaps also motivation-wise, where higher education studies are perhaps conceived more as a "necessary evil" in order to simply qualify for a job.

The big variation among students with respect to background leads to great differences in learning strategies and approaches to learning and has necessarily had an impact on how higher education is being taught [15]. At our institution, this change in students that we enrol has perhaps been less radical, since we have mainly been concerned with bachelor engineering programmes and "elite" students have generally favoured the bigger universities in Norway.[3] Therefore, we are perhaps better equipped with suitable actions to accommodate this new generation of students. Indeed, despite the fact that we also have some very talented students every year who approach their studies with learning strategies that favour deep learning, we believe many of the methods we have described previously are very useful for counteracting students with lesser motivation and weaker academic backgrounds.

Moreover, it is well known that lack of *self-monitoring* and *self-regulation* will lead to poor academic results [6, 25]. One must therefore acknowledge the fact that the learning environment itself is not sufficient to achieve intended learning outcomes but is also dependent on the students' individual skill in selecting and structuring the material to be learnt [21]. *Formative assessment* and *feedback* are an important tool to help students become self-regulated learners [33]. Also, the teacher must facilitate learning strategies that favour deep learning. One method for doing so consists of the teacher adopting a role as a *facilitator for learning*, adopting a role similar to a personal trainer at the gym or a coach [8, 20].

In Section 2.5, we describe various aspects of project-based learning and how the teacher can use several means to facilitate deeper learning. We try to make the students adopt project ownership, whereby they become more willing to invest more time and effort on the tasks they must accomplish. This can help reducing a strategic learning strategy where students are not only doing the work to get a desired grade but because their pride is at stake, they actually want the project solution to become as good as possible. Likewise, for project planning, we require the students to presents plans that breaks down the work and include time, size, and responsibility for tasks. By doing so, the student are effectively self-monitoring and self-regulating themselves.

3.2 Constructive Alignment

According to Biggs and Tang [4], *constructive alignment* (CA) is a teaching strategy where components such as the teacher, the students, teaching context, learning activities, and learning outcomes must be aligned while maintaining the *constructivist view* that students learn by doing, commonly know as active learning, that is, any learning activity that actively involves the students in the learning process [36]. Specifically, when designing a particular course, one adopt a backward scheme, starting with the intended learning outcomes (what competence, skills, and experience students should have upon completion of the course), then define assessment tasks that closely relates to the intended learning outcomes, and then proceed to choosing teaching methods and learning activities aligned with the intended learning outcomes and assessment tasks [4].

[3] AAUC was a small university college before merging with NTNU to become Norway's biggest university.

We have perhaps not adopted a very rigid scheme based on CA for our teaching but it is clear that we emphasise active learning and constructivism and we are very careful in our choice of assignments and projects to ensure that a successful completion will lead to intended learning outcomes being achieved. For example, most of our courses involve compulsory coursework that is closely aligned with intended learning outcomes. By being compulsory and usually with a pass requirement for access to the final exam, students are forced to complete the assignments in a satisfactory manner and will achieve some intended learning outcomes while doing so. Also, in contrast with more rigid assignments where there often is only one correct answer to each problem, our projects are often open-ended, where many different approaches can lead to successful completion. This is in line with *research-based* or *problem-based teaching* and can be effective against too rigid implementations of CA where too much simplification and generalisation can in fact counteract deep learning and creativity [1].

3.3 Assessment

A very important aspect of teaching is the choice of *assessment* method. For example, according to proponents of CA, many students are mainly concerned with achieving grades, not learning. These students have a surface approach to learning, typically aiming for memorising and reproducing course curriculum, and essentially, the exam can be said to *define* the curriculum [4]. Therefore, in CA, one must align the exam, or rather, the set of components that make up a grade, such as laboratory exercises, assignments, projects, and oral and written exams, must all be designed in a manner that ensures that satisfactory completion also means that intended learning outcomes are achieved. It makes obvious sense to accept this premise at least to some extent, after all, who would want to be a passenger of an airplane where the pilot had only passed a big written exam, and not a variety of practical flight tests?

In our own teaching we have adopted similar means in a lighter manner, where components such as lab or project activities perhaps have not affected the the final grade directly but at least usually required students both to show up and to complete the tasks at a pass grade level before being granted admission to a final exam.

3.4 Active Learning

As should be clear from our observations and reflections of teaching activities, we are proponents of *active learning*. There are several metastudies that show that active learning in science, technology, engineering, and mathematics (STEM) indeed has several advantages. Prince [36] found comprehensive support for core elements of active learning, for example that students being active during a lecture improve their ability to reproduce the material later and that they become more motivated and engaged. Likewise, Schroeder et al. [41] found that active learning improve students' performance, as did Freeman et al. [18].

Of particular importance are several studies on *cooperative learning* [e.g., 7, 16, 23, 43]. These studies show that particularly cooperative learning strategies are effective for deep learning. In our own teaching, cooperative learning is a core element, where students often work in groups not only on projects and large assignments but sometimes also in smaller exercises or quizzes that with great effect can be introduced to break up long lectures.

3.5 Problem-Based Versus Problem-Solving Learning

Summarising the results of 800 meta-analyses, Hattie and Goveia [22] points out the incredible fact that problem-based learning does not have a positive effect on achieving intended learning outcomes! Why is this so? Sotto [42] suggests that there is a dinstinction between *problem-based* and *problem-solving* learning. Specifically, Sotto argues that for learning to be successful, one must employ well-designed case studies and avoid problem-based and too student-centred learning. Specifically, a pitfall in problem-based learning activities is that the problem at hand is large (which is not by itself the problem) and there is no clear guidance towards how to solve it. Students end up spending too much time on searching the Internet or studying textbooks even for solving just small parts of the problem. Instead, Sotto [42] argues that the assignments given must be carefully designed in order for the students to quickly be able to practice the core knowledge and skillset selected by the teacher.

In our own teaching, we have at least tried to adhere to some of the suggestions of Sotto [42], for example by first providing an open-ended problem using a top-down approach but instead of leaving the students alone for an eternal chase of information, we usually interrupt with more information on the blackboard after some time and guide them towards a solution. Also, we sometimes use case studies where students work through detailed *step-by-step exercises*, carefully avoiding the risk of students spending too much time on any one step. Finally, we would like to emphasise the importance of *immediate feedback*, often easily achieved in lab work and programming assignments, as found in a pedagogical study on one of our courses [40].

4 Student Evaluation Surveys

In January 2017, all third-year students enrolled in their final sixth semester of the bachelor programmes in automation, power systems, and computer engineering were asked to complete an anonymous student evaluation survey online. Subsequently, in June 2017, the remaining cohorts of first- and second-year students who had just completed their second and fourth semester, respectively, were asked to complete the same survey. For simplicity in the following, we label the third-year students as *seniors*, and the first-year and second-year students as *juniors*. It should be noted that seniors at the time of their survey had completed all coursework of their degrees (except for a single 10 ECTS course), thus focusing most of their time in the final semester on their bachelor thesis (20 ECTS).

In contrast, juniors, especially first-years, had experienced a lot less courses at the time of their survey.

Out of approximately 70 seniors, we received a total of 31 responses, from 16, 3, and 12 automation, power systems, and computer engineering students, respectively. From the approximately 170 juniors (approximately 90 first-year and 80 second-year students), we received a total of 46 responses, from 28, 7, and 11 automation, power systems, and computer engineering students, respectively.

In both surveys, the students were asked to indicate to which degree they agreed with the statements in Table 1, categorising whether they strongly or partly agreed or disagreed, or were indifferent: In addition, they were given the opportunity to elaborate on the statements and any other issues they wished to raise.

Table 1. Statements for student evaluation surveys.

#	statement
1	*I want more traditional lectures*
2	*I want more teaching using the blackboard*
3	*I want more active learning activities (exercises, quizzes, discussion, competitions, etc.)*
4	*I want more flipped classroom and elearning/online learning activities*
5	*I want more focus on practical application than theory*
6	*I want more problem-solving learning activities*
7	*I want more laboratory learning activities*
8	*Calling the roll makes it more likely that I will turn up in class*
9	*I want more mandatory coursework*
10	*I want more/better feedback on my work during the semester*
11	*I want my final grades to be fully decided by oral or written final exams*
12	*I want my final grades to be composed of several parts (e.g., lab, assignments, project, midsemester test, final exam)*
13	*I want more digital exams*
14	*I want more home exams*

The results are summarised in Table 2, where the number n of student responses and the corresponding percentage is given for each statement and response category. Below, we discuss answers relevant for the observations and reflections we have made above. Please not that all percentages without decimals have been rounded to the nearest integer.

4.1 Attendance

Only 10% of the seniors strongly or partly agreed that calling the roll would make it more likely that they would turn up to class (statement 8), whilst 20% were indifferent. On the contrary, 19% partly disagreed and 52% strongly disagreed with this statement. Among the juniors, 13% strongly or partly agreed, 33% were indifferent, and 22% and 33% partly or strongly disagreed, respectively.

Table 2. Student evaluation surveys for seniors[4] and juniors.

seniors	strongly agree		partly agree		indifferent		partly disagree		strongly disagree	
statement #	n	%	n	%	n	%	n	%	n	%
1	0	0.0%	3	9.7%	14	45.2%	10	32.3%	4	12.9%
2	1	3.2%	7	22.6%	12	38.7%	9	29.0%	2	6.5%
3	10	32.3%	12	38.7%	5	16.1%	4	12.9%	0	0.0%
4	6	19.4%	9	29.0%	9	29.0%	6	19.4%	1	3.2%
5	13	41.9%	14	45.2%	4	12.9%	0	0.0%	0	0.0%
6	12	38.7%	13	41.9%	6	19.4%	0	0.0%	0	0.0%
7	8	26.7%	14	46.7%	8	26.7%	0	0.0%	0	0.0%
8	2	6.5%	1	3.2%	6	19.4%	6	19.4%	16	51.6%
9	2	6.5%	8	25.8%	10	32.3%	8	25.8%	3	9.7%
10	22	71.0%	5	16.1%	2	6.5%	2	6.5%	0	0.0%
11	5	16.1%	11	35.5%	9	29.0%	5	16.1%	1	3.2%
12	7	22.6%	5	16.1%	8	25.8%	9	29.0%	2	6.5%
13	15	48.4%	9	29.0%	5	16.1%	2	6.5%	0	0.0%
14	2	6.5%	4	12.9%	15	48.4%	3	9.7%	7	22.6%

juniors	strongly agree		partly agree		indifferent		partly disagree		strongly disagree	
statement #	n	%	n	%	n	%	n	%	n	%
1	1	2.2%	8	17.4%	23	50.0%	11	23.9%	3	6.5%
2	2	4.3%	10	21.7%	22	47.8%	8	17.4%	4	8.7%
3	12	26.1%	16	34.8%	13	28.3%	4	8.7%	1	2.2%
4	5	10.9%	14	30.4%	15	32.6%	8	17.4%	4	8.7%
5	19	41.3%	18	39.1%	7	15.2%	1	2.2%	1	2.2%
6	18	39.1%	21	45.7%	6	13.0%	0	0.0%	1	2.2%
7	9	19.6%	20	43.5%	13	28.3%	3	6.5%	1	2.2%
8	4	8.7%	2	4.3%	15	32.6%	10	21.7%	15	32.6%
9	0	0.0%	10	21.7%	22	47.8%	6	13.0%	8	17.4%
10	21	45.7%	13	28.3%	12	26.1%	0	0.0%	0	0.0%
11	10	21.7%	14	30.4%	8	17.4%	9	19.6%	5	10.9%
12	10	21.7%	13	28.3%	8	17.4%	9	19.6%	6	13.0%
13	20	43.5%	15	32.6%	9	19.6%	0	0.0%	2	4.3%
14	6	13.0%	10	21.7%	19	41.3%	4	8.7%	7	15.2%

These results conflict with our observations that indeed more students do show up to class if the roll is called, despite attendance not being mandatory. We speculate that students in their responses may have wished to emphasise their own free will and autonomy in choosing whether to turn up to class, and

[4] Adapted from Osen and Bye [34].

from the results, this appears to be especially true for the seniors. In Section 2.1, we discuss how social contracts and unspoken rules and norms can emerge in the relation between teacher and students and among the students themselves, however, these mechanisms are acted upon more at a subconscious level than mandatory rules, and this may explain why the students fail to agree with the statement, as they may simply not be sufficiently self-aware to know whether they actually will yield to social pressure for turning up or not.

Another possible reason for this result is that the effect of calling the roll may not be as strong as we think it is. After all, we have only observed the effect across different cohorts, and not for the same cohort during a single semester. Thus, our impression that more students turn up to class when calling the roll may be due to variation across different cohorts. Moreover, we do not have accurate attendance numbers for all cohorts, thus our observations are more of a perceived kind than rigid studies.

4.2 Lectures

Statements 1 and 2 relates to whether students want more passive learning activities such as traditional lectures and using the blackboard, respectively. It is clear from the responses that seniors do not want want more traditional lectures, with nobody strongly agreeing with statement 1, and only 10% partly agreeing, 45% being indifferent, and 33% and 13% partly og strongly disagreeing, respectively.

The juniors are more positive towards more traditional lectures than the seniors, although the average still wants less. Among the 46 juniors, only one student strongly agreed (2%), whereas about 17% partly agreed, 50% were indifferent, and about 24% and 7% partly or strongly disagreeing, respectively.

With respect to teaching using the blackboard (statement 2), seniors were mainly indifferent (39%), or partly agreed (23%) or disagreed (29%), whereas 3% strongly agreed, and 7% strongly disagree.

Juniors were even more indifferent (48%), and an equal number of students (12, or 26%) strongly or partly agreeing/disagreeing (although twice as many strongly disagreed rather than strongly agreed (8.7% vs 4.3%).

The results are in correspondence with our observation and reflections in Section 2.2. As teachers, we wish to emphasise active learning activities, yet, sometimes lectures or blackboard teaching are necessary. The students seem to think that we and the rest of our colleagues in the three study programmes employ about the right amount of blackboard teaching but should reduce the amount of traditional lectures.

4.3 Active Learning

Statements 3–7 relates to active learning activities and practical application versus theory. It is very clear from the responses that the students want more activities that facilitate active learning. For example, among seniors, nobody disagreed (partly or strongly) that they want more focus on practical application than theory (statement 5), more problem-solving (statement 6), or more lab work (statement 7). For juniors, only a single student (2%) strongly disagreed with each of statements 5–7, whilst only one (2%), zero (0%), and three (7%) students partly disagreed, respectively. On the contrary, a vast majority of both seniors and juniors strongly or partly agreed with statements 5–7.

Regarding more flipped classroom and elearning/online learning (statement 4), only one senior strongly disagreed, whereas six seniors (19%), partly disagreed. Among juniors, 9% strongly disagreed and 17% partly disagreed. Of the seniors, 19% strongly agreed and 11% of the juniors, whereas 30% of both the seniors and juniors partly agreed.

With respect to more active learning activities in general (statement 3), no seniors strongly disagreed and only 13% partly disagreed, whereas one junior strongly disagreed (2%) and 9% partly disagreed. Hence, in agreement with our own views, it seems very safe to conclude that most students want more active learning activities as described by statements 3–7, with a slightly smaller preference for flipped classroom (statement 4) when compared to statements 5–7 and active learning in general (statement 3).

4.4 Mandatory Coursework

Seniors were mainly indifferent (32%), or split between 26% partly agreeing/disagreeing, and 7% strongly agreeing and 10% strongly disagreeing to whether we should employ more mandatory coursework (statement 9). Juniors were even more indifferent (48%), although 17% strongly disagreed and 13% partly disagreed, whereas no junior strongly agreed with the statement, and 22% partly agreed. Hence, when contrasting seniors and juniors, the seniors were slightly opposed to having more mandatory coursework, whereas juniors were much more against the statement.

The result of the seniors is as expected and matches the student feedback we have got over the years, especially among the final-semester students. Many students know that they do not have the necessary motivation and willpower to do the necessary work unless they have mandatory coursework, whereas others, and often academically more skilled students would like more freedom in their studies. The result of the juniors, however, is more skewed towards less use of mandatory coursework. We speculate that the reason for this is that it is easier to appreciate the hard work required for mandatory coursework in retrospect than being in the midst of it. At the time of the surveys, the seniors had only a single course left and were focusing on their bachelor theses, whilst the juniors were having three courses run in parallel and often several compulsory assignments within a short period of time.

4.5 Feedback to Students

An overwhelming majority of seniors (71% and 16% strongly or partly agred, respectively; 7% were indifferent or partly disagreed; and noone strongly disagreed) wants more/better individual feedback during the semester (statement

10). Of the juniors, 46% or 28% strongly or partly agreed, respectively, and the remaining 26% were all indifferent.

This statement was perhaps badly phrased, as almost nobody would ever say no to more of a given good, e.g., money. A better question would be whether students were *satisfied* with the amount and quality of individual feedback they have received during their studies, not if they wanted more feedback. In addition, students answers to the statement act as an average of all the courses they have participated in. Hence, and as noted in the student comments, there may well be courses with sufficient levels of student feedback whilst other courses give far less feedback. Nevertheless, the result indicates that students are not satisfied with the current state of individual feedback provided in the courses we offer and our department will need to investigate this issue further.

That students are concerned with not getting enough individual feedback may also be an indicator of lack of self-monitoring and self-regulation skills, which to some extent can be mitigated by facilitating learning activities where students adopt ownership, such as projects or lab work.

4.6 Grades and Exams

Statements 11 and 12 relates to whether the final grade of a course should be fully decided by a single oral or written exam (statement 11) or be composed of several parts, such as lab work, assignments, projects, midsemester tests, and final exams (statement 12). The majority of seniors want a single final exam to be decisive for their grades (16% strongly agreed, 36% partly agreed, and 29% were indifferent). Interestingly, the majority of seniores also want their final grades to be composed of several parts (23% strongly agreed, 16% partly agreed, and 26% were indifferent) but with more disagreement (29% partly disagreed and 7% strongly disagreed) than for statement 11 (16% partly disagreed and 3% strongly disagreed).

For juniors, opinions appear to be more polarised, and fewer students were indifferent when compared with seniors. With respect to having a single final exam deciding the grade (statement 11), 17% were indifferent; 30% partly agreed and 20% partly disagreed; and 22% strongly agreed and 11% disagreed. Regarding composite grades (statement 12), the figures were approximately the same (17% were indifferent; 28% partly agreed and 20% partly disagreed; and 22% strongly agreed and 13% disagreed).

Hence, amongst both seniors and juniors, 50% either strongly or partly agreed with both statement 11 and statement 12, which are in conflict with each other.

Historically and currently, we almost exclusively use a single final exam to determine grades but in many courses we have mandatory coursework that must be passed for access to the exam. The results suggest students want both grading approaches and consequently, we should probably increase the number of courses where the final grade is composed of several parts to have a suitable mix.

Regarding digital exams (statement 13), a large majority of seniors wants more digital exams (48% strongly agreed, 29% partly agreed, 16% were indifferent, 7% partly disagreed, and nobody strongly disagreed), whereas the majority are indifferent (48%) or partly (10%) or strongly disagreed (23%) with wanting to have more home exams. Juniors are slightly less enthusiastic but still a large majority want more digital exams (44% strongly agreed, 33% partly agreed, 20% were indifferent; nobody partly disagreed, and 4% strongly disagreed).

Digital exams have just recently started to take places but only in a few of our courses. Its usage will likely increase in the future, partly because of administrative pressure towards cost-saving measures and societal trends but also because of various advantages, especially in some courses where this examination kind is suitable, such as programming-related courses.

With respect to more home exams (statement 14), many seniors were indifferent (48%) but 23% and 10% strongly or partly disagreed, respectively, whereas 7% strongly agreed, and 13% partly agreed. In contrast with seniors, juniors are more positive than negative towards adopting more home exams. 13% strongly agreed and 22% partly agreed; 41% were indifferent; and 9% and 15% partly or strongly disagreed, respectively.

Home exams have hardly ever been offered our courses, thus it is somewhat surprising to observe the seniors' resistance against a kind of examination that they have never experienced (at least not during their studies). There is currently no plan to begin to offer home exams in our courses as far as we know.

4.7 Summary and Conclusions

The views expressed by the students in the evaluation surveys can be summarized as follows:

- Students, especially seniors, are quite opposed to the idea that *calling the roll* (statement 8) will increase attendance. This finding is in contradiction with our own observations.
- Likewise, students are indifferent or opposed to having more *traditional lectures* (they want less on average), whilst they are indifferent and on average want neither less nor more teaching *using the blackboard*.
- Students clearly wants more *active learning activities*, especially more focus on practical application than theory, more problem-solving, and more lab work. They also want more flipped classroom, although to a smaller extent than for the abovementioned activities.
- Seniors are indifferent or slightly against more *mandatory coursework*, whereas juniors want less on average. We hypothesize that students are more appreciative of mandatory coursework and see its benefit when they are able to critically view back in retrospect in their final semester.
- Students, especially seniors, want more *individual feedback* during the semester. A possible reason may be that seniors have developed better skills for critical thinking than juniors and therefore have higher expectations regarding feedback from teachers.
- Students are split between having a *single final exam* (oral or written) deciding grades versus *composite grades*. They are positive to more *digital exams* but split towards *home exams* (juniors want more, seniors less).

If we as teachers were to act on the advice from students in our degree programmes, which is not necessarily obvious, since students do not have the same academic nor pedagogical insight as teachers, we should

- reduce the amount of traditional lectures (statement 1);
- continue using the blackboard as before (statement 2);
- use more active learning activities (statements 3–7);
- not call the roll (statement 8);
- keep the same amount of mandatory coursework (statement 9);
- strongly improve individual student feedback (statement 10);
- have a good mix of single final exams and composite grades (statements 11-12);
- use more digital exams (statement 13); and
- slowly introduce home exams and evaluate its effect (statement 14).

Notably, however, apart from calling the roll, student views are in accord with our own observations and reflections presented previously.

5 Final Remarks

In this article, we have summarised some of the observations and reflections we have made after many years of teaching courses in computer and electrical engineering bachelor programmes. We have put the observations and reflections into theoretical context, and finally, we have provided some insight into what the students think about the learning environment that we provide, and how we examine students, through one student evaluation survey for our first- and second-year students, and one for our final-year students. In line with the most up-to-date literature, we emphasise that higher education of today is still in need of a shift away from passive learning activities such as traditional lectures towards active learning activities in the classroom, with more problem-solving and laboratory work, whilst focussing on practical real-world application with a sound theoretical foundation. The surveys indicates that our students tend to agree with this view and that there seem to be little difference of opinion between the junior and the senior students.

Whilst many students want a single final exam grade, many students also want their grades to be composed of several parts. The latter is a viewpoint that we share and it is also a key component of CA, keeping in mind that many students are more concerned with exam grades than with what they actually learn.

We have just recently begun to use digital exams but only for a few of our courses. Many of the students appreciate this new trend and want more digital exams, a change that is likely to happen the next few years.

Regarding future work, we would like to do some more rigid studies on the various teaching methods discussed in this article. Such studies should try to establish more firmly whether the perceived effects of the proposed methods are real and advantageous. We also need to collect more and better student evaluation data, as well as continue to improve and facilitate an active learning environment. Moreover, we would like to formalise our teaching methods slightly, and possibly adopt flipped classroom in several of our bachelor courses similarly to what we have done for a master's course on artificial intelligence [8].

Finally, we wish to underline that obviously not all the interesting aspects of teaching computer and electrical engineering courses at the undergraduate level have been covered in this article, and that our observations and reflections are necessarily subjective in nature. Nevertheless, we hope that the interested reader is able to make valuable use of at least some of the methods and findings we present in their own teaching.

Acknowledgements

The Software and Intelligent Control (SoftICE) Laboratory is grateful for the financial support given by the Study Committee at NTNU in Ålesund through the educational research project *Research-Based and Innovation-Driven Learning (FILA)*, grant no. 70440500.

Bibliography

1. Andersen, H.L.: "Constructive alignment" og risikoen for en forsimplende universitetspædagogik. Dansk Universitetspædagogisk Tidsskrift 5(9) (2010)
2. Anderson, J.R.: Cognitive Psychology and Its Implications. Worth Publishers, 8th edn. (2015)
3. Baeten, M., Kyndt, E., Struyven, K., Dochy, F.: Using student-centred learning environments to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness. Educational Research Review 5(3), 243–260 (2010)
4. Biggs, J., Tang, C.: Teaching for Quality Learning at University. McGraw Hill/Open University Press, 4th edn. (2011)
5. Bligh, D.A.: What's the Use of Lectures? Intellect Books (1998)
6. Borkowski, J., Thorpe, P.: Self-regulation and motivation: A life-span perspective on under- achievement. In: Schunk, D., Zimmermann, B. (eds.) Self-regulation of learning and performance: Issues of educational applications, pp. 44–73. Hillsdale, NJ: Erlbaum (1994)
7. Bowen, C.W.: A quantitative literature review of cooperative learning effects on high school and college chemistry achievement. Journal of Chemical Education 77(1), 116 (2000)
8. Bye, R.T.: The Teacher as a Facilitator for Learning: Flipped Classroom in a Master's Course on Artificial Intelligence. In: Proceedings of the 9th International Conference on Computer Supported Education — Volume 1: CSEDU). pp. 184–195. INSTICC, SCITEPRESS (2017)
9. Case, J., Marshall, D.: Between deep and surface: procedural approaches to learning in engineering education contexts. Studies in Higher Education 29(5), 605–615 (2004)
10. Chatman, J.A., Flynn, F.J.: The influence of demographic heterogeneity on the emergence and consequences of cooperative norms in work teams. Academy of Management Journal 44(5), 956–974 (2001)
11. Clark, R.C., Nguyen, F., Sweller, J.: Efficiency in learning: Evidence-based guidelines to manage cognitive load. John Wiley & Sons (2011)
12. Durden, G.C., Ellis, L.V.: The effects of attendance on student learning in principles of economics. The American Economic Review 85(2), 343–346 (1995)
13. Entwistle, N., Ramsden, P.: Understanding student learning. Beckenham: Croom Helm (1983)
14. Entwistle, N., Ramsden, P.: Understanding Student Learning (Routledge Revivals). Routledge (2015)
15. Felder, R.M., Brent, R.: Understanding student differences. Journal of Engineering Education 94(1), 57–72 (2005)
16. Foldnes, N.: The flipped classroom and cooperative learning: Evidence from a randomised experiment. Active Learning in Higher Education 17(1), 39–49 (2016)
17. Forsyth, D.R.: Group dynamics. Cengage Learning (2009)
18. Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., Wenderoth, M.P.: Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences 111(23), 8410–8415 (2014)
19. Gynnild, V.: Læringsorientert eller eksamensfokusert? Nærstudier av pedagogisk utviklingsarbeid i sivilingeniørstudiet. Ph.D. thesis, NTNU (2001)

20. Gynnild, V., Holstad, A., Myrhaug, D.: Teaching as coaching: A case study of awareness and learning in engineering education. International Journal of Science Education 29(1), 1–17 (2007)
21. Gynnild, V., Holstad, A., Myrhaug, D.: Identifying and promoting self-regulated learning in higher education: roles and responsibilities of student tutors. Mentoring & Tutoring: Partnership in Learning 16(2), 147–161 (2008)
22. Hattie, J., Goveia, I.C.: Synlig læring: et sammendrag av mer enn 800 metaanalyser av skoleprestasjoner. Cappelen Damm akademisk (2013)
23. Johnson, D., R., J., Smith, K.: Active Learning: Cooperation in the College Classroom. Interaction Book Co., Edina, MN, 2nd ed. edn. (1998)
24. Joyce, W.B.: On the free-rider problem in cooperative learning. Journal of Education for Business 74(5), 271–274 (1999)
25. Lan, W.: The effects of self-monitoring on students' course performance, use of learning strategies, attitude, self-judgment ability, and knowledge representation. Journal of Experimental Education 64(2), 101–116 (1996)
26. Marburger, D.R.: Absenteeism and undergraduate exam performance. The Journal of Economic Education 32(2), 99–109 (2001)
27. Marburger, D.R.: Does mandatory attendance improve student performance? The Journal of Economic Education 37(2), 148–155 (2006)
28. Marshall, D., Summers, M., Woolnough, B.: Students' conceptions of learning in an engineering context. Higher Education 38(3), 291–309 (1999)
29. Marton, F.: Phenomenography — Describing conceptions of the world around us. Instructional Science 10, 177–200 (1981)
30. Marton, F., Booth, S.: Learning and Awareness. Mahwaw, NJ: Lawrence Erlbaum (1997)
31. Marton, F., Dall'Alba, G., Beaty, E.: Conceptions of learning. International Journal of Science Education 16(4), 457–474 (1993)
32. van der Meer, A.L., van der Weel, F.R.: Only three fingers write, but the whole brain works: A high-density eeg study showing advantages of drawing over typing for learning. Frontiers in psychology 8 (2017)
33. Nicol, D.J., Macfarlane-Dick, D.: Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. Studies in higher education 31(2), 199–218 (2006)
34. Osen, O.L., Bye, R.T.: Reflections on teaching electrical and computer engineering courses at the bachelor level. In: Proceedings of the 9th International Conference on Computer Supported Education — Volume 2: CSEDU (CSEDU '17). pp. 57–68. INSTICC, SCITEPRESS (Apr 2017), selected for extended publication in Springer book series Communications in Computer and Information Science (CCIS)
35. Pfaff, E., Huddleston, P.: Does it matter if i hate teamwork? what impacts student attitudes toward teamwork. Journal of Marketing Education 25(1), 37–45 (2003)
36. Prince, M.J.: Does active learning work? a review of the research. Journal of Engineering Education 93(3), 223–231 (2004)
37. Prosser, M., Trigwell, K.: Understanding learning and teaching: The experience in higher education. Buckingham: Society for Research in Higher Education and/Open University Press (1999)
38. Romer, D.: Do students go to class? should they? The Journal of Economic Perspectives 7(3), 167–174 (1993)
39. Saeljo, R.: Learning in the Learner's Perspective 1. Some Commonsense Conceptions. Report no 76, Institute of Education, University of Gothenburg (1979)

40. Schaathun, W.A., Schaathun, H.G., Bye, R.T.: Aktiv læring i mikrokontrollarar. Uniped 38(4), 381–389 (2015), special issue following *MNT-konferansen*, Bergen, Norway 18-19 March 2015
41. Schroeder, C., Scott, T.P., Tolson, H., Huang, T.Y., Lee, Y.H.: A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the united states. Journal of Research in Science Teaching 44(10), 1436–1460 (2007)
42. Sotto, E.: When teaching becomes learning: A theory and practice of teaching. Bloomsbury Publishing (2007)
43. Springer, L., Stanne, M., Donovan, S.: Effects of small- group learning on undergraduates in science, mathematics, engineer- ing and technology: A meta-analysis. Review of Educational Research 69(1), 21–52 (1999)
44. Westermann, K., Rummel, N.: Delaying instruction: evidence from a study in a university relearning setting. Instructional Science 40(4), 673–689 (2012)