Reflections on Teaching Electrical and Computer Engineering Courses at the Bachelor Level

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Abstract: This paper reflects on a number of observations the authors have made over many years of teaching courses in electrical and computer engineering bachelor programmes. We suggest various methods and tips for improving lectures, attendance, group work, and compulsory coursework, and discuss aspects of facilitating active learning, focussing on simple in-classroom activities and larger problem-based activities such as assignments, projects, and laboratory work. Moreover, we identify 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. Finally, we present and discuss some recent results from a student evaluation survey and draw some conclusions.

1 INTRODUCTION

In this paper we reflect on various aspects of teaching electrical and computer engineering courses based on our experiences from about 23 years of teaching combined (14 and 9 years for the first and second author, respectively) at the Norwegian University of Science and Technology (NTNU) (formerly Aalesund University College (AAUC) before 1 January 2016). We have taught courses both in the computer, 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 role that university colleges in Norway have traditionally played, our teaching have always had a practical approach, focussing on the application of a sound theoretical foundation to solve real-world problems that our graduates face as professionals.

In the following, we will reflect on our experiences from teaching, focussing mainly on undergraduate courses, and 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.

As such, we are perfectly aware that what we present in this paper does not generalise to all kinds of teachers, courses, and students. Still, 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 paper 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 a recent student evaluation survey that was undertaken in January 2017 by final semester engineering students enrolled in computer, automation, and power systems bachelor programmes at our institution. Finally, we make some concluding remarks (Section 5).

2 OBSERVATIONS AND REFLECTIONS

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. This of course demands that the classes we teach must be of sufficient quality and be attractive to students. One way of improving attendance is to facilitate learning activities that complement the traditional lectures and 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.

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. This practice has several benefits, for example, fewer students arrive late since they want to be present when their name is called, and also more students attend classes. The reason for this is likely because calling their names seems to make a social pressure to be present and probably also shows 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 send text messages to classmates for them to explain to the teacher their friend's absence. We interpret this as a willingness from the students to obey to a "rule" of attendance even if attendance is not mandatory.

We believe 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.

2.2 Lectures

There is a common notion that active learning activities such as solving problems and doing projects are favourable to the traditional lectures. We have done some simple tests of how much students remember directly after a lecture and admittedly been rather disappointed at 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 have often preferred to use the blackboard and write by hand. The 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.

Using slides, on the other hand, 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.

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 slides, 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, an approach is to ask the students to start working on a problem and give 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 approach the blackboard, 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 give the same effect.

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.

2.3 Student groups

Project-based learning (see Section 2.5) is an important pedagogic 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. Below we discuss our experiences on various aspects of constructing student groups for projects.

2.3.1 Size

How large a group should be depends of course on the estimated amount of work in the project (or assignments). For smaller assignments, groups of two are 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. 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.

2.3.2 Selection of Group Members

In general, we favour selecting random groups. 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 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.

We have often experienced some resistance from students when they are told they may not construct the groups themselves. This is to be expected, after all, 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.

Moreover, we can often 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.

In addition, 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.

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. We have found that students' performance improved about one grade on average after making the coursework compulsory in some courses.

At our institution we use an electronic learning management system for 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 programmes 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 programme 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.

When designing 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 seem more like tutorials. There is a lot to be learnt from a well-formed question and even good students will not find this approach boring. Making good assignments is of course a lot of work, but is probably even more important than making good lectures.

2.5 Project-based Learning

2.5.1 Project Selection and Ownership

We usually let students choose between a selection of assignments or projects, and sometimes even encourage them to participate in defining the problem, if possible. The reason for this is that the students seem to be willing to invest more time and effort into tasks to 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.

This willingness to invest more time and effort into activities the students feel ownership to may be a result of pride but may also be a result 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. 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.

2.5.2 Project Planning

Project planning is important in order to make the students aware of time expenditure versus progress. We prefer to let the students first make their plans themselves before having to submit their plans to the teacher for approval. The requirements for the plans are that they should show how the different activities are spaced out in time; the size of the tasks (duration); and the responsibility for the tasks. When approving their plans, we make sure their plans are sufficiently detailed and that they 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.

Throughout a project, 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.

2.6 Assessment

2.6.1 Oral and Written Exams

It is well known that many students dread oral exams out of (a sometimes unjustified) fear of performing worse than they think would have in a written exam. On the other hand, many students may 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 will be, or at least conceived to be, disadvantageous to some students and advantageous to others. Nevertheless, if limited to only these two means for evaluting students' performance, a good mix of oral and written exams can be considered fair to the students. Still, we would like to point out that 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.

2.6.2 Group Exams

One drawback with project assignments is that it is hard to give individual grades to the students. One approach to enable individual grades is to add an oral exam in addition to a written report. By using the report as a starting point, it is possible to at obtain some variation in grades within the group, if appropriate. This approach is probably not perfect but it will typically 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 individually. The students will sit in alphabetical order, they are given individual questions one at the time, and they may not speak out of order. An 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.

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 and they 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 because they are assessed individually and therefore will have the reward of a fair and better grade than fellow students who do not put in the same effort.

2.6.3 Exam Preparation

Nervousness, anxiety, or stress related to exams are quite common. 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. One way of helping students to get into this positive state of mind is to reduce uncertainty about the exam procedure and content, for example 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.

Moreover, we have had good experience with giving the students a long list of possible exam questions to study before the exam, often provided at 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.

Interestingly, we believe that having such a long list of questions is not of such big help to the students as they tend to believe it is. Rather, its main purpose it 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.

Finally, we often offer a course revision workshop at the end of the semester, where students can obtain answers to questions that may have accumulated during the semester and to topics they find difficult.

3 RELATION TO THEORY

In the following, we highlight some literature and pedagogical and didactical theory relevant to our observations and reflections above.

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., Gynnild, 2001; Marton, 1981). Many studies have tried to identify factors that promote deep learning (e.g., Baeten et al., 2010; Marton and Booth, 1997; Prosser and Trigwell, 1999), 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 (Marton, 1981). In between deep and surface learning, Case and Marshall (2004) also describe procedural deep 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 socalled strategic learning, where students aim for good grades with minimal effort, ignoring whether they achieve the intended learning outcomes or not (Entwistle and Ramsden, 1983, 2015).

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 (1979) and Marton et al. (1993), 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. (1999) 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 (2011), 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 (Felder and Brent, 2005). 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 the "elite" students have generally favoured the bigger universities in Norway.[1] 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 (Lan, 1996; Borkowski and Thorpe, 1994). 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 (Gynnild et al., 2008). Formative assessment and feedback are an important tool to help students become self-regulated learners (Nicol and Macfarlane-Dick, 2006). 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 per-

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

sonal trainer at the gym or a coach (Gynnild et al., 2007).

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 (2011), constructive alignment 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 (Prince, 2004). 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 (Biggs and Tang, 2011).

We have perhaps not adopted a very rigid scheme based on constructive alignment 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, 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 constructive alignment where too much simplification and generalisation can in fact counteract deep learning and creativity (Andersen, 2010).

3.3 Assessment

A very important aspect of teaching is the choice of assessment method. For example, in constructive alignment, 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 (Biggs and Tang, 2011). Therefore, in constructive aligment, 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 (2004) 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. (2007) found that active learning improve students' performance, as did Freeman et al. (2014).

Of particular importance are several studies on cooperative learning (e.g., Foldnes, 2016; Bowen, 2000; Johnson et al., 1998; Springer et al., 1999). 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 (2013) 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 (2007) 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 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 (2007) 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 (2007), 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 (Schaathun et al., 2015).

4 RESULTS FROM A STUDENT EVALUATION SURVEY

All students enrolled in their final sixth semester in January 2017 of the bachelor programmes in automation, power systems, and computer engineering were asked to complete an anonymous student evaluation survey online. Out of approximately 70 students, we received a total of 31 responses, from 16, 3, and 12 automation, power systems, and computer engineering students, respectively. The students were asked to indicate to which degree they agreed with the following statements, categorising whether they strongly or partly agreed or disagreed, or were indifferent:

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.*
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.*

In addition, they were given the opportunity to elaborate on the statement and any other issues they wished to raise.

In the following, we discuss answers relevant for the observations and reflections we have made above. The results are summarised in Table 1, where the number n of student responses and the corresponding percentage is given for each statement and response category.

4.1 Attendance

Only about 10% of the students strongly or partly agreed that calling the roll would make it more likely that they would turn up to class (statement 8), whilst about 20% were indifferent. On the contrary, about 19% partly disagreed and 52% strongly disagreed with this statement. This result conflicts 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. 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

Table 1: Results from student evaluation survey.

	strongly agree		partly agree		indifferent		partly disagree		strongly agree	
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%

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 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 across different semesters, and not the same cohort during a single semester. Moreover, we do not have accurate attendance numbers for all cohorts, thus our observations are more of a perceived kind than rigid studies. Finally, our impression that more students turn up to class when calling the roll can also be due to variation across different cohorts.

4.2 Lectures

Statements 1 and 2 relates to whether students want more passive learning activities such as traditional lectures and more teaching using the blackboard, respectively. It is clear from the responses that the students do not want want more traditional lectures, with nobody strongly agreeing with the statement, and only about 10% partly agreeing, 45% being indifferent, and about 45% partly og strongly disagreeing. With respect to teaching using blackboard, students are mainly indifferent (about 39%), or partly agreeing (23%) or disagreeing (29%), with a slight majority disagreeing overall.

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 through 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 facilitates active learning, for example, nobody disagrees (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). Regarding more flipped classroom and elearning/online learning (statement 4), only one student strongly disagree, whereas six students (about 19%), partly disagree. With respect to more active learning activities in general (statement 3), nobody strongly disagrees and only about 13% partly disagree. Hence, in agreement with our own views, it seems safe to conclude that most students want more active learning activities.

4.4 Mandatory Coursework

Students are mainly indifferent (about 32%) to whether we should employ more mandatory coursework (statement 9), with 26% partly agreeing and the same amount of students partly disagreeing. This result is as expected and matches the student feedback we have got over the years. 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.

4.5 Feedback to Students

An overwhelming majority of students (71% and 16% strongly or partly agree, respectively) wants more/better individual feedback during the semester (statement 10). This statement was perhaps badly phrased, as almost noone 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. Still, this result strongly indicates that students are not satisfied with the current state of affairs 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 students want a single final exam to be decisive for their grades (about 16% strongly agreed, 36% partly agreed, and 29% were indifferent). Interestingly, the majority of students also want their final grades to be composed of several parts (about 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).

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.

Regarding digital exams (statement 13) and home exams (statement 14), a large majority of students wants more digital exams (about 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.

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

Home exams have hardly ever been offered our courses, thus it is somewhat surprising to observe student 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.

5 CONCLUDING REMARKS

In this paper, 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 current students think about the learning activities that we provide, and how we examine students, through a final semester student evaluation survey. 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 survey indicates that our students tend to agree with this view.

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 constructive alignment, 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, only for a few of our courses. A large majority of 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 discrepancies between the survey results and the reflections on various teaching methods discussed in this paper. 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 (Bye, 2017).

Finally, we wish to underline that only a fraction of all the interesting aspects of teaching computer and electrical engineering courses at the undergraduate level have been covered in this paper, 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 we suggest in their own teaching.

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