IMPROVING WRITTEN COMMUNICATION – IMPLEMENTATION AT INDUSTRIAL DESIGN ENGINEERING

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ABSTRACT

The purpose of the paper is to present how we have improved the quality of technical writing for students in Industrial Design Engineering at Luleå University of Technology. To achieve this, we have identified a number of courses focusing on verbal and written communication, one course – Product and production design focus on documenting and reporting a technical development work to a client. During the last seven years, the course has continuously been improved, and this paper contains an in-depth review of the course performed during spring 2018. The review was done by discussions in the teaching team, interviews, workshops, analysis of course documentation (course-reviews, course-pm, assessment-scheme etc.). The evolution of the course and how different support systems have been implemented such as peer-reviews, templates, formative feedback and self-assessment has been developed is described in detail. The current course is designed as a stage gate process with four design reviews, in which the student present and receive critique. At each design review, each team produces a short process memo (PM) that is peer-reviewed. Each student conducted three individual peer reviews, as well as group review. With 56 students in the class (spring 2018) over 180 completed peer reviews are performed by the students themselves before they receive formative feedback from the teachers. Self-assessment is also used, first by the team on their own final documentation. Finally, all student perform a personal self-assessment with feedback from their team members. The final assessment of the student is performed by the teachers and the result is similar to the students' self-assessment.

KEYWORDS

Technical writing, design-implement experiences, peer-review, assessment, continuous improvement, Standards: 1, 2, 3, 5, 7, 8, 11.

BACKGROUND

This paper describes an implementation of CDIO at Industrial Design Engineering (IDE) at Luleå University of Technology, Sweden. The focus is on improving written communication. In Sweden the Higher Education Ordinance (Appendix 2, Chapter 4.) describes the learning objectives for each higher education degree and written communication is described in the learning outcome 5 *"…the student must demonstrate the ability, in both national and*

international contexts, to explain and discuss in a written and written manner in dialogue with different groups their conclusions and the knowledge and arguments that underlie them."

The learning objectives are both general (are applied to all engineering master programs) and quite formal and described in a way that they are difficult to interpret and implement in teaching. To simplify the assessment of learning objectives of IDE students, a specific competence profile has been developed (Wikberg Nilsson & Törlind, 2016) that will support the students' understanding of overall goals and what they aim for. The competence profile is inspired, among other things, by the Vitae Research Development Framework (Bray & Boon, 2011) and other similar frameworks. The competence profile is designed to support the students' individual development and supports that students themselves can map their knowledge, skills, experiences and qualities. The competence profile should at the same time provide support for teacher feedback and assessment. In the course, the competence profile is used for goal formulations and also by the students for self-evaluation.

Course placement in the program

The course Product and production design was created in 2012 in connection with an audit of the education program in technical design, when there was a need for an integration course between product design and production technology (the two specialisations in the program. The course is today the third design-implement experiences (Crawley et al. 2007), see Figure 1) located in spring term the third year. A more detailed overview of the program is described in Wikström-Nilsson et al. (2017).

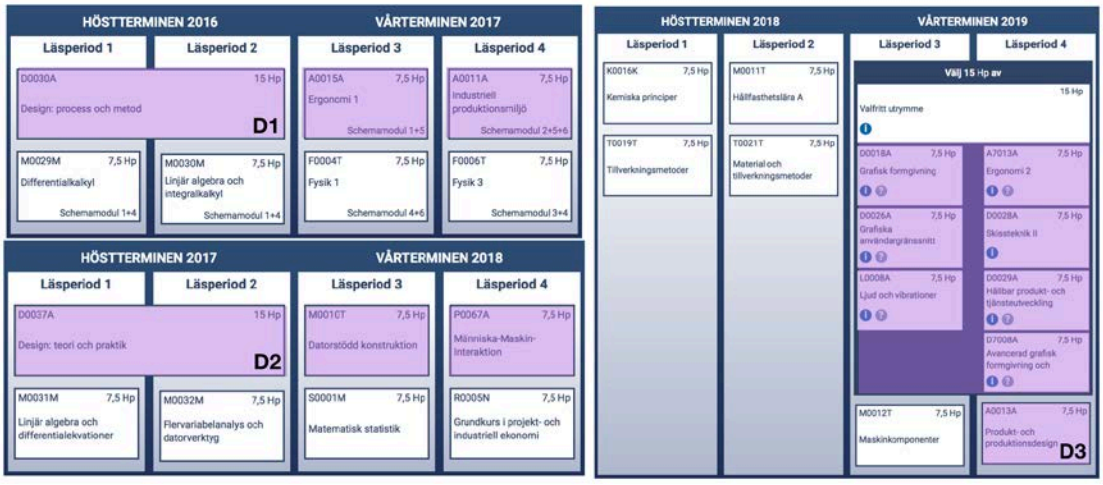

Figure 1 Course placement (D3) in the IDE programme. Shaded areas are design courses.

Students have already been introduced to design-implement experiences in the introduction course D1 (first course year one), and D2 (first course second year) these courses contain a mix of theory, methodology and more practical design-implement experiences.
The Product and Production design course is the first Design-Implement Experiences where no new theory is presented, and the aim is to integrate knowledge and skills acquired previously in the program and also focus on improving their teamwork and interpersonal skills in a product design project. The course was inspired primarily by courses at Stanford University such as d.school (Brown 2008) and ME310 course (Carleton, & Leifer 2009), that teaches a way of working based on design thinking that combines creative and analytical methods and

requires collaboration across disciplines. A more advanced design-implement experience (D5) is also performed in the fifth year.

Course aims:

- Acquire theoretical and practical knowledge of the interaction between product and production design.
- Under real-life forms, gain an understanding of how design and choice of materials affect production.
- Apply theory, knowledge and methods from previous courses.

In the course students work in small teams, each team consist of 4 students, that go through a traditional design process with five phases (see Figure 2). Students know when and what they should deliver at each stage gate, then it's up to the students to decide which methods are suitable for performing the design.

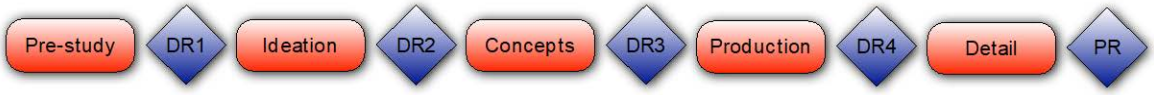

Figure 2 Phases in the course (red), design reviews and the final presentation (blue).

After each phase, students present their progress and receive critique at four design reviews (DR), they also produce a 4-page written Process Memo (PM). The course ends with a presentation and documentation of the final concept.
The written communication implemented in the program IDE follows a progression path over the years, where the students learn to create different types of written communication in different courses. For an overview see Table 1.

Table 1 Progression in written communication in IDE.

YEAR	Design	ID	ECTS	NAME	TYPE OF WRITING
1	**D1**	D0030A	15	Design: process and method	Presentation-Poster-Posters-Presentation (group) Workbook v,1, v.2 (individual)
1		A0014A	7,5	Ergonomics 1	Theory presentation (individual), Project report (group)
1		A0011A	7,5	Industrial production environment	Investigation report (group)
2	**D2**	D0037A	15	Design: theory and practice	Workbook x 2 (individual)
3	**D3**	**A0013A**	**7,5**	**Product and production design**	**PM x 4 (individual) + technical documentation (group)**
4	**D4**	D7007A	7,5	Form giving	Workbook (individual)
3-4		D7011A	7,5	Product visualization	Process poster **(**individual**)** Workbook (individual)
4		D7015A	7,5	Interaction design	Workbook (individual)
4*		A7004A	7,5	Research project	Academic paper in English
5*		D7017A	7,5	Advanced prototyping	Storybook (group)
5	**D5**	D7006A	15	Advanced product design	Project plan, presentation x 4 (group) Workbook v.1, v.2 (individual)
5		D7018A	7,5	Design science	Academic report in English
5		D7014A	30	Master thesis	Thesis in English
* Elective course					

METHOD

The course product and production have continuously been improved since the course started, through review by the teaching team, course evaluations (one more informal performed after 5 weeks into the course and a formal at the end of the course each year). The latest improvement cycle was performed in the spring of 2018 where a more systematic analysis, evaluation and improvement was performed. The analysis was performed in nine steps, see Figure 3 for an overview and the details below.

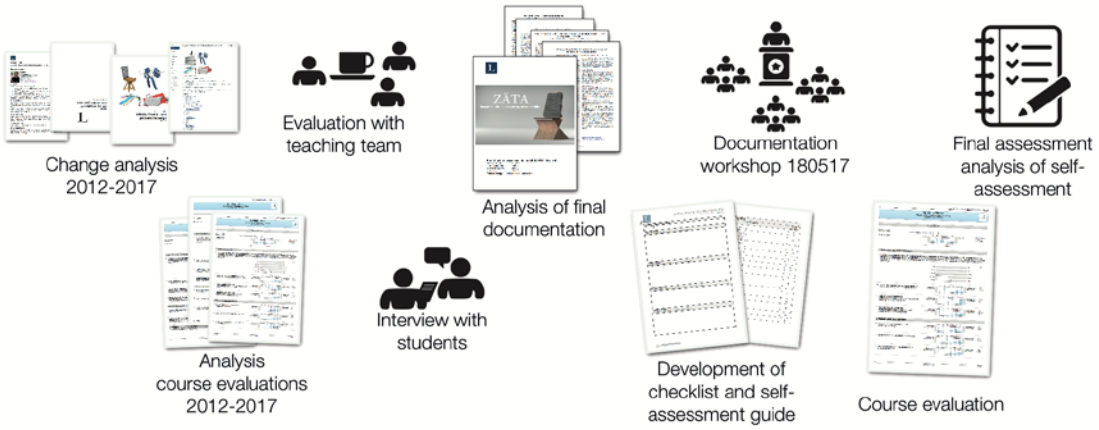

Figure 3 The systematic analysis and improvement performed during spring 2018.

1. *Change analysis* first, a review was performed of the changes that have been implemented since 2012-2017 by going through the course memo and introduction lecture material.
2. *Analysis of course evaluations 2012-2017*, mainly focusing on issues regarding the written report and peer-review. Open comments were compiled in an Excel document and coded according to 'final documentation', 'PM', 'peer-review', 'DR'.
3. *Evaluation with the teacher team*, written documentation has been evaluated with some of the teachers who have been involved in recent years and weak areas identified.
4. *Interviews with students*, short informal interviews have been conducted with three students who attended the course in 2016. The focus was on what was good with the written moments and how they could be improved.
5. *Analysis of submissions* has been reviewed by selecting final documentation from the years 2012-2017. Documentation from 2016-2017 was mainly used because all teachers' comments are still available in Canvas, the Learning Management System (LMS) used at LTU. It was not possible to see the previous comments from 2012-2015 (because they were made in Fronter, an older LMS system).
6. *Development of checklist and a self-assessment,* to support the final phase, developed a checklist and template for self-assessment. This was done by searching for 'checklist' and 'self-assessment / self-evaluation' on Google Scholar.
7. *Development of the documentation workshop*, in order to support the students' writing of the final documentation, an interactive documentation workshop was performed where 98% of the students participated. During the workshop, Mentimeter (mentimeter.com) was used to receive feedback.
8. *Course evaluation*, since we wanted to get the self-evaluation and their experiences of the report writing, the course evaluation was done after they submitted the report and self-evaluation (usually this is done after the final presentation), unfortunately using this approach we only got 16 answers (28% response rate).

9. *Analysis of the final documentation*, when the final documentation was submitted, the results of the self-evaluation and self-assessment was compared with the final assessment of the teachers. Figure 4 shows an example of the compilation of the self-evaluation and the report for all students. We also see an example (right sheet) of the students' self-assessment of the final documentation and the teacher's assessment.

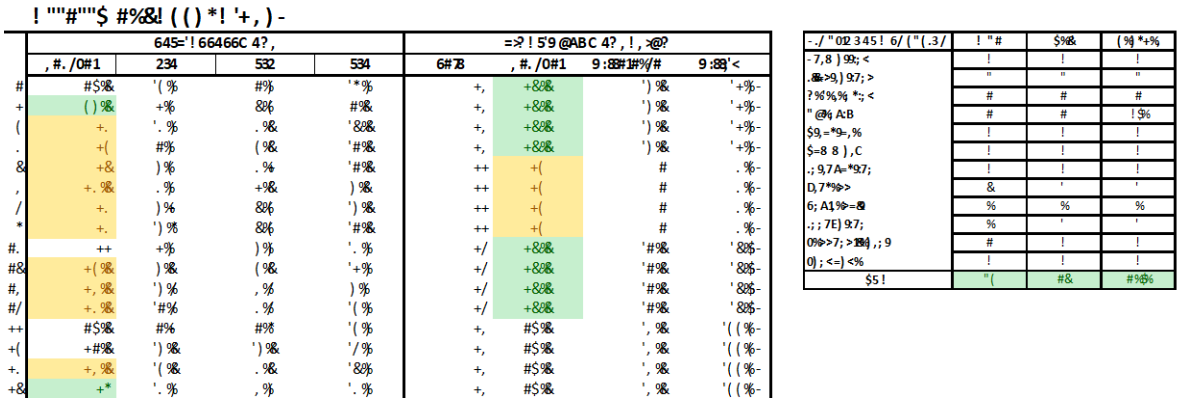

Figure 4 Part of the evaluation sheets used.

RESULTS – THE EVOLUTION OF THE COURSE

One of the crucial parts of CDIO is the evaluation of the programme and individual courses to enable continuous improvement. Since the start of the course, it has constantly changed and improved based on the students' feedback. Each introductory lecture has gone through important feedback from the previous year and the changes that have been implemented.

Below, the main changes are briefly presented, see also the summarised in Table 2.

- HT2012, the course is implemented for the first time
- HT2013, removed a submission on production technology after feedback from students. Scheduled coaching meetings were introduced (previously, the students had to book coaching meetings with the teachers, but many did not use this). Clearer expectations for the various DRs and PMs with assessment templates. Document templates were introduced for both PM and final documentation.
- HT2014, clarified study guide, introduced feedback templates for written PM (used only by teachers).
- Spring2015, the course moved to the spring term and a facilitated peer review was introduced for each PM (4 times) and a lecture and coach session was performed before the final presentation.
- VT2016, introduced Canvas LMS system and then moved the course Memo to Canvas (instead of a pdf document) to get a more uniform structure and to make it easier to find and hyperlink to different types of information. Self-evaluation with student feedback with the help of competence profile was introduced (Wikberg Nilsson & Törlind, 2016).
- VT2017 introduced an agile template and SCRUM methods to facilitate the planning of the project. Facilitated peer review was performed two times, then the peer-review was done by a team, and the last peer-review was done individually by each student.

Table 2 Summary of improvements in the course

	Course memo [nr words]	Number of students	Course evaluation (1-6)	Templates						Assessment, ECTS Points					
				PM	Assessment	Feedback on PM (lärare)	Peer review	Self assessment competence profile	Self-assesment of final documentation Slutdokumentation	PM	Final presentation	Final documentation	Process	Self-assessment	Other
HT2012	2551	48	4,6							2	1	3			1,5
HT2013	4513	56	4,3	x	x					4	1,5	2			
HT2014	4599	50	4,9	x	x	x				4	1,5	2			
VT2015	4535	15*	5,1	x	x	x	x				1,5	2,25	2,25		1,5
VT2016	canvas	68	4,9	x	x	x	x	x			1	3		3,5	
VT2017	canvas	61	5,0	x	x	x	x	x			1	3		3,5	
VT2018	canvas	56	?	x	x	x	x	x	x		1	3		3,5	
*Only bachelor students															

From 2015 (after the CDIO implementation started at LTU) the assessment change quite a bit. In 2012-2014, PM1-4 were also assessed. From 2015, PM1-4 was used only to provide formative feedback, and the examination was done only on the final documentation. From 2016, a self-assessment was also used where students assess their contribution in the course towards the course objectives.

CURRENT IMPLEMENTATION

McHugh, Engström and Tinto (1997) showed that students are more likely to continue and develop their skills in a learning environment that provides frequent feedback on their abilities. Formative feedback also offers students an opportunity to improve their performance and supports better students' motivation and their willingness to work more constructively towards specific goals (Biggs and Tang, 2011). To implement this type of continuous feedback an iterative approach is used with four design reviews where students presented current status results and receive critique. At each occasion, the students also write a short 4-page PM and at the end of the course, they submit a project report, see Figure 5.

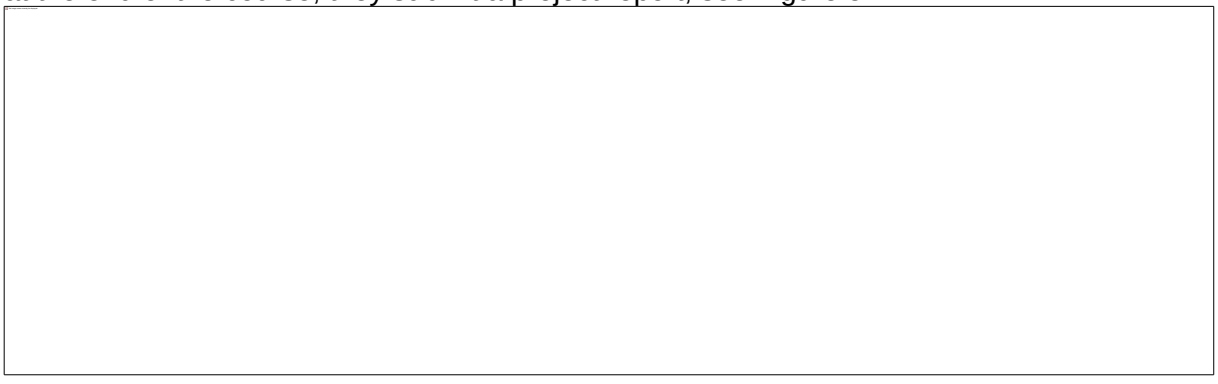

Figure 5 Submissions of four PM and a final report.

Peer review

After each submission, students receive feedback through a peer review process, as well as formative feedback from the teacher, see Figure 6.

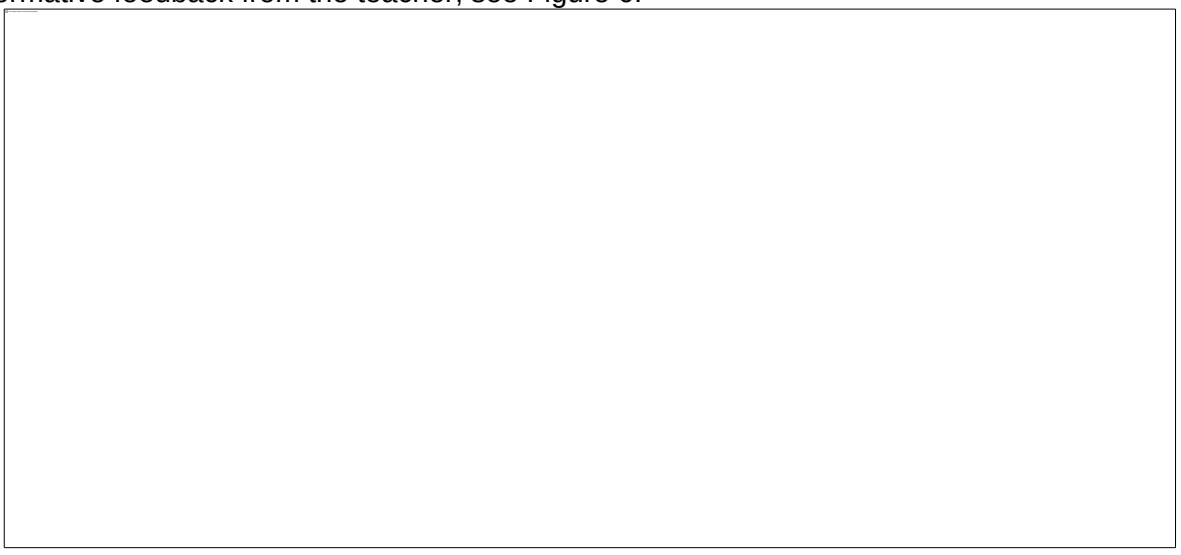

Figure 6 Feedback via peer review and formative feedback from the teacher team.

In order for students to learn to give feedback, feedback templates are used and in the first two peer reviews, the teacher facilitates the feedback process (what the students should think about, how to give critique, etc). The students also have the opportunity to discuss their feedback and how they individually have assessed the PM in smaller groups. Using this peer review the students receive feedback from four different people on three occasions and one group feedback, they also receive formative feedback four times from teachers. They also have to update and improve each PM two times.
Overall, in the course 2018, each student conducted three individual peer reviews, as well as a peer review group, with 56 students this represents over 180 completed peer reviews where the teachers are not involved. This means that the students will be well acquainted with what is expected, and they become accustomed giving feedback and that they actually spend time reading and assessing others' work, learning how to judge what is good and bad (Gibbs 1999) this type of active learning and time on task are two principles for learning (Chickering and Gamson, 1987). The peer-review is supplemented with the teachers' written formative feedback four times per team. The final assessment is seen as quality control (Gibbs 1999) and is only done on the final documentation.

From the course evaluations, we can see that most students appreciate the peer review sessions, and they believe that it has improved the quality of the written documentation. Also, students think that by reading others documentation they have improved their documentation. The formative feedback given throughout the course is supplemented by a self-evaluation that the students perform at the end of the course.

Final documentation

When performing the analysis of the final documentation from 2012-17 it was obvious that the final documentation more or less was a compilation of the four PM, and from the student feedback, they thought it was unnecessary work to rewrite the four PM into a new document, and that they did not really improve the documentation. From 2018 the final documentation is

similar to a compilation thesis and consists of the main part that presents the overall process and the final product, the four previous PMs are attached as appendices to provide the understanding of the process of the early stages and argumentations for the design rationale. From 2018 also a checklist /self-assessment was also appended, see Figure 7.

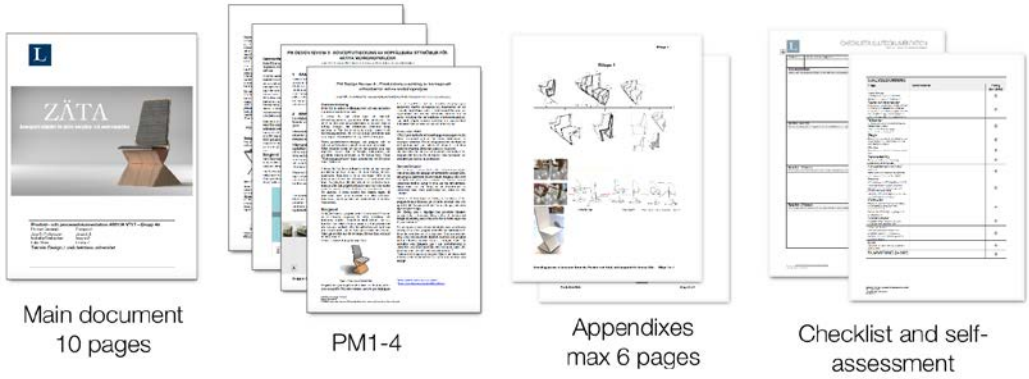

Figure 7 Final documentation.

From the interviews, it was clear that the student felt that they did not understand the difference between the final documentation and the four PM that they had delivered during the course, and they also explained that they did not know what was important to present in the final documentation. So to improve this for the 2018 course, a documentation workshop was introduced. In the workshop, all teams prepare by reading through the template for the final documentation and bring their four PMs. The goal of the workshop is to understand why documentation is vital in design projects and why we make technical documentation.

During the workshop all teams discuss specific questions regarding the documentation e.g.:

- *Why is this part of the report important?*
- *How can you describe customer needs?*
- *How do you describe your final product and its features?*
- *What are the most essential features, and why?*
- *Can a reader understand your design rational?*
- *Does the product fulfil all needs and requirements? Also, how to visualise this?*

After the team discussion, teams present their views in an open discussion in the classroom. To receive direct feedback Mentimeter was used (a web-based service where students can answer questions with the help of their mobile phones). Almost all student appreciated the workshop and liked the interactive discussions, after the workshop they felt much more confident on what should be in their final report.

To remove small errors and force the team to read and evaluate their documentation a checklist was also introduced. The checklist is inspired by Hörte (1999; 2010) and Hartley (2008). Since the focus of the final documentation in this course is not an academic report but technical documentation, also literature focusing on technical documentation was used (IBM, 1983), (Hargis ,2004).

Self-evaluation of documentation

The team also had to provide a self-assessment of their own documentation, using the same assessment rubric that was later on used by the teachers. In this assessment, they had to argue why they fulfil the criteria for the documentation. When comparing the self-assessment

with the final assessment of the teachers, students assessed their work a slightly better than the teachers (Maximum points 30, Student average assessment 25,9 points; Teachers average assessment 23,6 points).

Self-assessment of competences

At the end of the course, students perform a self-assessment of (Wikberg Nilsson & Törlind, 2016), see an example in Table 3.

Table 3 Self-assessment of written communication

Written communications				
NOVICE	ADVANCED BEGINNER	COMPETENT	SKILLED	EXPERT
Understand use and format a basic template	Apply a variety of reporting methods (lab reports, project reports, workbook, pm etc.)	Evaluate, assemble and convincingly formulate work, results and arguments in a credible manner	Select and develop the structure, content and format of written communication for different audiences	Communicate in writing in English

1. The student assesses their own competences and abilities and must describe how they meet the learning objectives (with examples from the course).
2. The student's self-assessment is then reviewed by their team members that give feedback on the student's individual assessments.
3. Teachers review the assessment and have the possibility to adjust the assessment.
4. The teacher also assesses the quality of the feedback given to their team members.

In the feedback team members often highlights personal competencies that students themselves may not be aware of, and also performs a 'sanity -filter' so the students cannot take credit for something they did not perform. By performing this assessment, students are given the opportunity to assess their abilities and compare them to the requirements and also the formal assessment by the teachers. This type of self-assessment is in agreement with Rendon (1994), which points to the importance of formative feedback on student competence. The difference between the self-assessment and teachers' final assessment was about 5%.

CONCLUSION

This paper shows the importance of continuous improvement and that an examiner can learn quite a lot from reviving the improvements that have been performed in a course. By comparing the feedback from course evaluation, quality of the written documentation and the amount of feedback given to the students the current implementation of the course is much better than when it was introduced 2012. The basic ideas and the structure are still the same, but by introducing formative feedback, peer-reviews, workshops, and self-assessment the quality of the written communication has improved. However, the most important part is that the student learns to give feedback, assess their capabilities and reflect over their performance. We can also see that the students' self-assessment is a little higher than the teachers (about 10% on the final documentation and 5% on the individual assessment) but the students have a quite accurate assessment of their own work. Also, the changes in the course are mostly based on active learning activities where students are activated instead of being passive. By introducing several peer reviews, and self-assessments most of the improvement does not need any extra work from the teachers.

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BIOGRAPHICAL INFORMATION

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