

Active learning and student peer assessment in a web development course

Trond Aalberg and Madeleine Lorås
Norwegian University of Science and Technology

Abstract

Active learning is a family of instructional practises that requires students to participate in learning activities and engages students in the learning process. For larger groups, however, this it is often challenging to implement. Peer assessment, where students or groups of students evaluate and give feedback to each other, complements many traditional learning activities very well and combined this is promising active learning method that potentially is independent of the cohort size. In this paper, we present an active learning approach that is implemented in a web development course at the Norwegian University of Science and Technology where we combine project based activities and use peer assessment to engage students in the learning. Reference group meetings and the annual survey at the department is used for evaluating the peer assessment method, and we present an analysis comparing the scores given by fellow students with the grades given by faculty for the exam. Our findings include the observation that students are willing to put a lot of effort into activities they know count towards a grade, including peer assessments. However, when assessing each other they tend to give scores in the high range, which makes it hard to differentiate between students. Students also tend to believe that the assessments they get from other students are less reliable and fair, although the analysis shows that the scores they get in the peer assessments of projects corresponds with the evaluation given by the teacher for the exam.

1 Introduction

Active learning is generally defined as an instructional practise that requires students to do meaningful learning activities and engages students in the learning process [2]. Active learning is somewhat orthogonal to other instructional methods and practises such as experiential learning [6], problem-based learning [14], project-based learning [1], team-based learning [9] and many others. Research shows that active learning performs better than traditional lecturing [4, 12] and a learning environment where the student has a more active role in the learning, is identified as a key to improve educational quality in Norway [7] as well as for Europe in general.

In computer science education, we generally recognize that learning needs to engage and activate the students and there are numerous ways to achieve this

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including tasks given during lectures, assignments or projects in parallel with the lectures, project only courses, or more novel methods such as flipped classroom. Choice of method needs to be based on a reasonable balance between available resources such as instructors and students available time, student motivation and skills, available assessment methods and formal regulations, nature of the course and maybe most important: the number of students. The engagement of students in the learning process, however, remains a challenge. In project-based courses e.g. the students tend to focus on the product rather than on the intended learning outcome. Summative assessment using a final exam or final project report is still the most common assessment method in higher education and formative assessment in the form of feedback intended to improve and accelerate learning is less frequently used due to the required resources. Lack of such feedback makes it difficult for students to engage in the learning and become so called self-regulated learners [11].

Peer assessment [16], where students or groups of students evaluate each other, complements many learning activities and may be used as a substitute for the teacher's formative assessment that is needed to engage students in the learning process. In a peer assessment setup, the students inspect and assess the performance of others using criteria defined by the teacher. Equally important as the feedback they give to and receive from others, is the implicit contextualization they get of their own performance. Peer assessment is however a challenging method with respect to reliability and validity [3], particularly if the results are to be used directly in grading. Different kinds of student performance can potentially be the subject of peer assessment. Typically, this will be a deliverable of some sort, but peer assessment is also used to grade students performance in group work. The assessments they give can also be subject of evaluation e.g. using the criteria presented in [8]. In many disciplines the ability to evaluate and comment the works of others is an inherent part of the learning outcome, which makes peer assessment even more relevant. A computer science professional will typically spend much of his or her time testing and evaluating the models, design and code of others. The lack of technology support for peer assessment is one likely cause for the the lack of systematic use in education. There are currently many standalone products such as Turnitin or Peergrade, but not many that are well integrated into common learning management systems (LMS) which at least in Norway makes it difficult to make use of peer assessment systematically. A well designed solution will enable the use of peer assessments in large classes [10], but equally important is that a peer assessment service needs to be adaptable to various usage scenarios. Many peer assessment software solutions tend to support a limited variation in how the assessment tasks are distributed, what kind of feedback mechanisms that can be used, and other aspects of organizing the assessments.

In this paper we present an approach to active learning that is implemented in a web development course at NTNU. Our main approach is a set of project assignments with well defined learning outcome that are complemented with peer assessment tasks intended to engage the students in the learning process. Our main research questions in the development and evaluation has been:

- What activities or project deliverables are suitable for peer assessment?
- What is the quality and consistency of scores and comments given by students?
- Can scores and comments from the peer assessments be used when grading?

During two years of organizing this course, we have built experience and collected general feedback from individual students, and the reference groups have served as focus groups for more in depth discussions. From the last year we have analyzed comments given in the annual survey on students course experience, and we have analyzed students use of scores and comments. Results so far show that the method of using peer assessment in combination with other learning activities allows for new ways of engaging students in the learning and assessments, but we have also identified major challenges that must be addressed in the further development of the method.

2 Implementing active learning

IT2810 Web Development is an intermediary level course electable for students in the third year of Bachelor of Informatics and fourth year of Computer Science at the Norwegian University of Science and Technology (NTNU). Prerequisites are knowledge in basic web technologies, software development, human computer interaction, databases, and we assume that students are experienced programmers. Key learning outcomes include knowledge about architectures, frameworks, solutions for developing web-applications and services, skills in designing, developing and testing, and skills in evaluating all layers of a web-application. Projects require use of various Javascript libraries and frameworks, such as node.js, jQuery, React, React Native and Angular. The design of the course is motivated by the following set of ideas:

- Students need experience in how to learn and experiment with new technologies. As software professionals, they regularly will be introduced to new programming languages, libraries, frameworks and tools – which they need to learn on their own and based on resources they discover by themselves. For this reason, we only give students short lectures focusing on the practical parts, and use teacher and skilled student assistants as resources available upon request for those that needed assistance beyond what they would find on the web or learn from others.
- To guide all students through the portfolio of technologies the course covers, we define multiple projects distributed over the whole semester. The intention is to ensure that students spend their efforts more evenly throughout the semester compared to what often happens when there is a single large project. A strict scheme for the projects is also a requirement when planning complementary activities related to the projects such as peer assessments.
- Requiring students to participate in regular activities on campus is important to ensure progress and stimulate the social learning environment. After all, professional development teams usually meet at the workplace to collaborate.
- Team work enables productivity, but the many challenges with the learning effect of group work are well known in higher education [5]. Students need to be motivated for collaboration and stimulated to create a learning environment within the team.
- Inspecting, explaining and evaluating code and design made by others is a common task for a professional developer, but is also a significant source of

knowledge and experience for students and professionals. For this reason, we introduce regular activities that require looking into the projects of others.

- To engage students in the learning process we utilize peer assessment of project deliverables. The intention is to enable students to learn from the solutions other have made for the same task and also relate their own achievements and learning outcome to others.
- To further motivate students to focus on their own learning, we include a final exam that last year counted 20%. This is also intended as a mechanism for differentiating between students in the same group having different knowledge and skills.

An outline of how the course was organized in 2017 is shown in table 1. Project 1 was an individual project where students developed an interactive web page with the topic "my favourite thing in life". Project 2 was a group work where they developed a website with responsive design for "favourite things in life". In project 3 the task was to develop a React application using HTML5 local storage for management of personal information (calender, notes, activities etc.). The project also included porting the web-application to React native for mobile devices. Project 4 was full stack development of a system for searching, filtering and sorting any kind of items in a catalogue, implemented using Angular and hosting a database on the server. Groups of 4-5 students worked together on the group projects and most of these groups persisted throughout the various projects. For all projects we listed learning outcomes and technological and functional requirements. Grading of the projects was based on scores and comments given by the students in the project peer assessments (discussed later). Students had to use GitHub classroom for collaboration, were a snapshot of the repository automatically is saved on the project delivery deadline set by the teacher.

Table 1: Learning plan

Week	Ongoing activity	Weekly task
34	Individual project 1	Introduction to the course
35	(up to 8p based on peer assessment)	Tutorial lecture
36	Group project 2	Project 1 peer assessment (2p)
37	(up to 8p based on peer assessment)	Tutorial lecture
38	Group project 3	Project 2 peer assessment (2p)
39	(up to 20p based on peer assessment)	Submit HOWTO (2p)
40	(up to 2p for group participation)	Project 3 code review (2p)
41		Project 3 testing (2p)
42		Project 3 peer assessment (2p)
43	Group project 4	Submit HOWTO (2p)
44	(up to 20p based on peer assessment)	Project 4 code review (2p)
45	(up to 2p for group participation)	
46		Project 4 testing (2p)
47		Project 4 peer assessment (2p)
50	Exam (Up to 20p)	

In addition to the project work, we arranged for weekly activities (tasks) were students could earn points when contributing and participating. The students were

asked to form ad hoc groups in the classroom when doing these tasks – to enforce a more social learning environment and facilitate communication between the different projects. All tasks were related to the projects in different ways and intended to simulate the collaboration in a real world project, but also to engage students in identifying and assessing the learning outcome and performance:

Peer assessment tasks where groups of students are assigned 4-5 projects they have to assess using an online form. All scores and comments for one project was compiled into a report that was used by the teacher when giving points for the project. The students were informed that it was the teacher that decided the final score, and that they could ask the teacher to revise the assessments made by the other students as long as they provided arguments for whatever they disagreed on (rebuttal). Participation in the assessment automatically gave points as long as the comments proved they actually had inspected the projects they assessed.

Code review where groups of students were asked to inspect, evaluate and give advice on the structuring and quality of the code in projects. Code reviews were compiled into reports passed on to the project groups, but were also available when assessing the project with an assessment criteria for whether they followed up serious code quality issues. Points were given for participation in the code review.

Testing where groups were asked to write test and document the testing in each others project. Points were given for participation in the testing assignment.

Howtos where students post short descriptions of technology use or best practise that they found relevant for the projects. Points were given by student assistants after checking that the submissions were in line with the requirements listed for the assignment.

Group participation were additional points that the teacher used to differentiate between students based on how they contributed to the projects. The groups had to submit reports showing how they collaborated and the work load of each group member. This was also very useful to identify students who are assigned to a group, but should not get any points because they never contributed.

During the two years the course has been taught, we have experimented with different types of tasks and setup of groups. In 2016 we used the Its Learning LMS tools for surveys, managing groups, keeping track of scores etc. Atlassian BitBucket git-solution and Piazza discussion board were external services used. In 2017 we have used Blackboard for managing the scores and the discussion boards for submitting the howtos. GitHub classroom turned out to be a very convenient solution for setting up repositories that teacher and assistants had easy access to, and the automatic submission of the repository upon deadline is very useful. Its Learning had other possibilities than Blackboard for group-based delivery, which caused a major change in how we could organize groups in 2017. Blackboard has a peer review module that we attempted to use in project 1, but it turned out to be rather problematic in use. On the other hand, Blackboard has a good discussion board suitable for submitting howtos, where the teacher could delay

the visibility of all posts until the deadline. We have looked for good solutions for designing and managing peer assessments, and found that Google forms was the most convenient because it supports a variety of question types. Data from Google forms is reasonably easy to convert into XML for producing assessment reports and statistics. An excerpt from the assessment forms is shown in figure 1. We used the scale 0-10 for scores with the wording "not acceptable" for 0 and "outstanding" for 10. All projects had public GitHub repositories and hosted their web applications on virtual machines. The use of a strict naming scheme made it easy for assessment teams to inspect code, project structure and documentation in the GitHub repositories, and access the web applications online. The report on how each student contributed to the project was the only document submitted in the LMS.

Del 3 av 8

2) Bruk av database

Rammer og krav som beskrevet i oppgaveteksten:

a) I webapplikasjonen skal det inngå en backend database som kjøres på gruppas virtuelle maskin. Type database og hvordan denne brukes er opp til dere å bestemme, men grensesnittet til databasen skal være godt designet iht. god praksis (bruk av REST ea).

b) Dere skal demonstrere både skrivning og lesing til databasen fra webapplikasjonen inklusive en form for søk (i praksis dynamisk brukerdefinert utvalg av det som skal vises).

2a) Vurder prosjektet i forhold til kravene over (både med tanke på om de har * besvart kravene og kvalitet og omfang av løsningen).

0 1 2 3 4 5 6 7 8 9 10

Ikke løst Løsning som utmerker seg

2b) Beskrivelse og tilbakemelding til spørsmålet over *

Lang svartekst

Figure 1: Sample question with scores and comments

3 Peer assessments

The use of peer assessment has been a major element in the design of this course. It is a method to engage students in the learning process and it is also a mechanism for producing a large number of assessments which particularly is relevant when a course has multiple smaller project assignments. Being able to inspect, evaluate and give constructive comments on the solutions of others is an important skill for a software professional and it can be argued that it also is a way of increasing the knowledge of the students participating in the assessment. On the other hand, this is a method that many students are unfamiliar with and the process is poorly explored particularly with respect to using the assessments actively in the grading of students.

Table 2: Peer assessments

Projects	Groups	Assessments	Students	Questions	Rebuttals
3	47	382	173	12	9
4	44	312	171	16	2

We will in the following only focus on the assessments that were made for the two last projects in 2017 because they had a richer and more developed set of questions. Some numbers showing the extent of the assessments are shown in table 2. A total number of 180 students received a final grade in the course. As the numbers show, almost all students participated in the assessments. Those that had good reason for not showing up in the classroom, were allowed to do the assessments the from home or on another day. The others formed ad hoc assessment teams of 2-3 students. We also allowed students to compensate for missing assessments, by doing extra assessments on another task. For project 3 we required 5 assessments from each team and got an average of 8 assessments for each project. For project 4 we required 4 assessments and received an average of 7 assessments for each project. Student assistants distributed the projects among the assessment teams manually in the classroom. Estimated time to do the assigned number of assessments was 2 hours, but average time was probably slightly above (this is based on answers we got when asking students while they worked on the assignment). If we assume 2 hours of work to perform 5 assessments which gives 24 min per assessment for project 3, we get a total of 153 team hours used. For project 4 we can assume 2 hours and 4 assessments which gives 156 team hours of effort. A single person doing the assessments, such as a teacher, would probably spend the same amount of time on each project and would end up with 19 hours needed to assess project 3, and 22 hours to assess project 4.

Assessments were compiled into reports with an example given in figure 2. There would typically be some variations between the scores given by different assessment teams and we used the maximum of the average and the median value as the final score for each sub question to avoid the impact of outliers. Weights were decided by the teacher based on how the evaluation questions performed. All questions in the assessment had a mandatory field for comments. As shown in figure 3, the scores students give each other tends to be in the very high end. The length of lines for each score indicates the distribution.

Regarding the rebuttal mechanism, we received 9 requests for project 3 and only 2 for project 4. Many of the rebuttals from project 3 were because they disagreed on outliers, typically one assessment team that gave completely different scores than the others. The strategy for solving this was to remove assessments the teacher agreed were incorrect, and recalculate the score. Groups asking for rebuttal sometimes got a small increase in the total score, but rarely more than 1 point in total. The reason for less rebuttals for project 4 can be that scores arrived in the middle of the exam period or that they had a better understanding of how the scores were calculated.

4 Evaluation

As a part of the departments course evaluation each semester, students were given the opportunity to comment on the course content and implementation. Many of the comments concerned the peer assessment process, and it is clear that the students'

VURDER PROSJEKTET I FORHOLD TIL BRUK AV DATABASE, BÅDE MED TANKE PÅ OM DE HAR BESVART KRAVENE OG KVALITET OG OMFANG AV LØSNINGEN (maks 2 poeng)

Vurderinger = (9, 7, 10, 10, 10, 10, 10, 8, 7) -> maksimum av (avg, median) -> 10.00, poengsum vektet = 2.00

Gruppen henter ut data fra "mongodb://applicationUser:ehysb7TXc2G7esapvF@it2810-27.idi.ntnu.no:27017/glassdoor", altså serveren. De har brukt mongodb og brukte mongoose for å kommunisere med databasen. Det finnes en company.txt fil i initDb mappen som inneholder mange bedriftsnavn. Usikker på hvorfor dette er nødvendig siden det er bare string, og man kan lett lagre det i databasen. Litt trekk på dette, men ellers ser det veldig fint ut da det er stateless http requests som blir sent ut. Vi kan sende HTTP get/post request for å kommunisere med databasen. I controllers mappa har gruppa skrevet kode for å hente og skrive til databasen, som å legge til/slette bedrifter, registrere brukere, legge til nye reviews til bedrifter. På websiden ser det bra ut: når vi legger til nye reviews blir det lagret, og ny ratings beregnet.

Databasen er satt opp på en enkel måte, de har brukt REST, kunne ha vært designet på en mer ryddig måte. Gruppen har både skrijving of lesing til databasen fra webapplikasjonen og mulighet for søk.

Gruppen bruker brukergenerert data til å fylle siden. De skriver nye firmaer, anmeldelser og brukere til databasen, og leser det som blir lagt inn i databasen tilbake til brukere. De har også en søk-funksjonalitet som henter alle firmaer som inneholder det man skriver i søkefeltet.

Bedrifter hentes fra databasen. Brukere registrering skriver til databasen. Det samme gjør kommentering av bedrifter. Veldig bra.

Gruppen skriver reviews av bedrifter til databasen når vi skriver dem. De blir hentet til profile-siden vår. Siden inneholder et REST api Alle krav er oppfylt. Gruppen har fulgt god praksis for eks. ved bruk av REST.

Gruppen bruker MongoDB med Mongoose. De demonstrerer skrijving og lesing til databasen med en serie veldokumenterte api-kall. Grensesnittet til databasen ser ut til å bruke MVC-prinsippet, og virker veldig gjennomført.

Gruppen viser at de kan håndtere en database. Det ser ut til at gruppen har valgt å bruke mongoDB som sin back-end løsning med mongoose som bindeledd mellom appen og DB. Under

Backend->src->controllers-> finner vi "company" og "review" som har tatt i bruk get, og set funksjonaliteter. Gruppen har implementert flere former for søk, bla på hjem-siden.

Søkefunksjonen oppfører seg litt rart, men fungerer, det er også tungvint med så få resultater i databasen, burde vært implementert flere som en start

Figure 2: Sample question with scores and comments

perception and experience varied. A total of 78 students submitted an evaluation, and 58 students gave a comment, which is 34% of the students. Many of these comments were negatively worded, and it is important to note that students who were satisfied with the course were perhaps less inclined to comment. Nevertheless, these comments reveal some important perceptions, misconceptions and issues which need to be addressed for peer assessment to be successful.

The students' experiences can be grouped into three categories: feeling of unfairness, assessment by non-experts and learning effectiveness. Students reported that they experienced the peer assessment as unfair. Many students questioned their peers' ability to be objective and stated that they thought students graded more harshly in order to place their own group higher. Furthermore, students were concerned with the level of knowledge of the peer assessors, and stated that they would prefer an expert to assess their work. Lastly, the students stated that they did not feel that the activity was effective towards their own learning. They said it was too time consuming, and did not enhance their learning.

The course was also evaluated with reference group meetings. The main concern in these meetings was the practical organization of the course and the workload. In general the course seemed to be well accepted by students who are enthusiastic about the content, and the use of activities rather than lectures was often mentioned as positive. Students in the reference group also had some concern about how the assessments turned out, but mainly addressed the need to improve the criteria and quality of comments.

From the teacher perspective, the impression is different. When examining the projects that requested rebuttal, the observation was often that students received a slightly higher score than the teacher would have used. The teacher found the

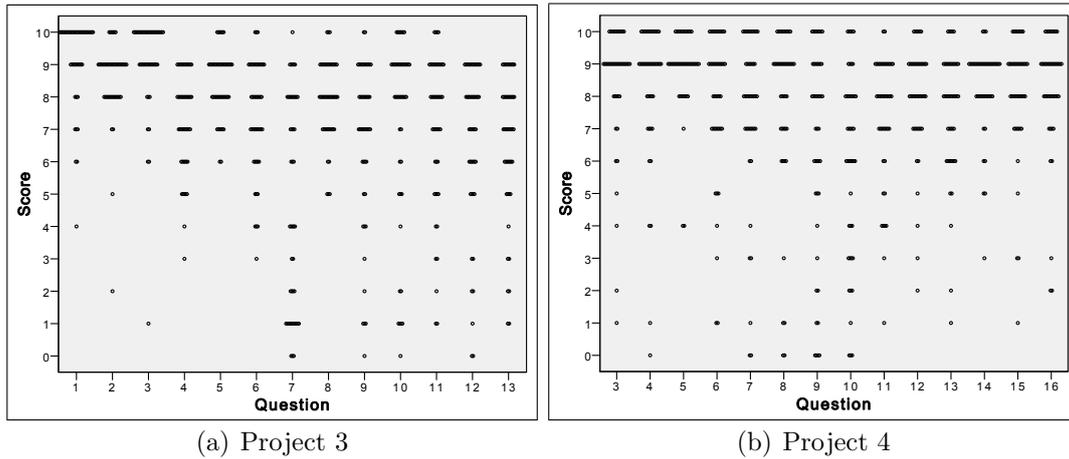


Figure 3: The distribution of scores given by students in the peer assessments.

comments to have a higher level of detail than what the teacher would have been able to identify, and if when all comments are put together they gave a good overview.

To conclude, a main question is how "realistic" the student assessments are and can they be used as input in the actual grading. Research by Topping found that peer assessment was reliable and valid in most studies (compared to teacher evaluation), and more than self-evaluation [16]. Research also shows that peer assessments, if applied successfully, can have positive effects on self-confidence, transferable skills and social skills. Peer assessment needs to have well defined objectives, well organized peers, clearly stated assessment criteria and activities, needs to include feedback and the process must be supervised.

Validity and reliability of peer assessment

In order to investigate the validity and reliability of the students' peer assessments the researches decided to compare the project and exam results. As described, the project results are, with a few minor exceptions, based on peer assessment, while the exam was assessed by faculty staff only. Concurrently, students experienced peer assessment as unfair and unprofessional. Therefore, the we wanted to analyze project and exam results to test the hypotheses:

- H1: There is a relationship between peer assessment results and exam results.
- H2: Students who receive higher peer assessments will perform higher on the exam.

When testing H1 the we decided to use Pearsons Correlation [13] on the project and exam results. This indicates whether there is a relationship between the variables and how strong it is. Table 3 summarizes the results of this analysis. All the correlations were significant at the 0,05 level. This means that there is a relationship between peer assessment results and exam results, therefore confirming H1. However, the correlations are not very strong ($<0,50$) and they do not indicate a direction of the relationship. That is, if students who receive higher peer assessments will perform higher on the exam. Therefore, the researchers decided to use linear regression (OLS) to create a model for exam results (dependant variable) and project results (independent variables) [15]. The results from this analysis is shown in Table 4.

Table 3: Pearsons correlation analysis of exam and project results

	Exam	Project 2	Project 3	Project 4
Exam	1,00			
Project 2	0,22	1,00		
Project 3	0,32	0,41	1,00	
Project 4	0,31	0,30	0,50	1,00
N	172			

Table 4: Regression analysis (OLS) of variation in exam results based on results in Project 2, Project 3 and Project 4.

	Exam	B	SE _B	t	Sig.t
Project 2	0,26	0,25	1,06	0,291	
Project 3	0,25	0,12	2,15	0,033	
Project 4	0,17	0,07	2,31	0,022	
Constant	0,85	2,28	0,38	0,707	
N	172				
R^2	0,14				
F(3, 168)	9,02				

As the table indicates only Project 3 and 4 are significant at the 0,05 level, which can be explained by the degree of difficulty of the projects. Nevertheless, since B is positive, students who received a high grade in project 3 and 4 also performed high on the exam, thus partially confirming H2. Furthermore, these independent variables explain 14% of the variance of exam results, which shows that the model is a good fit.

The exam questions were directly related to design and implementation in the projects and the knowledge that they were expected to have gained from the project work.

5 Conclusion and further work

In this paper we have presented the design of a course that emphasizes learning activities and peer assessments intended to engage the students in the learning. Peer assessments are also used in the grading, but all grading is still inspected and formally decided by the teacher and therefor well within what is acceptable practise. From the teacher perspective we have found that peer assessment can be used to generate a large number of comments and the amount of work that is put into this exceeds what could have been done by the staff. Peer assessment is a promising method that can facilitate the introduction of more learning activities and also potentially increase the learning from the activities.

We have used peer assessment to evaluate the final project deliverable, but have also used the same assessment method for design and code review. The main challenge has been to define activities where the assessment has a learning effect that students relate to. The final project deliverable is often the easiest to set up assessments for due to well defined technology use and functional criteria and intended learning outcome. Students put an effort in doing these assessments, but it is so far difficult to determine the actual learning outcome of this process.

On the quality and consistency we have found that students tend to put less trust in the assessments than the teacher. Scores are generally in the high level – higher than the teacher would have given – but we have found that there is a correlation between the assessments made by students on project and the assessments of the exam which is done by the teacher.

Finally, we will argue that the scores and comments from the peer assessments can be used in the grading, but not yet in a fully unsupervised way. The major issue is that the quality of the comments varies, and that students do not trust the scores and feedback that they get from fellow students. This should not be interpreted as arguments against the method, but rather as arguments for revising and improving the process.

Suggestions for further work on the peer assessment process includes mechanisms for detecting the quality of student assessments which for instance can be solved by asking students to rate each others assessments, or to include the assessments as a deliverable that counts towards the grade. Students that consistently get low rating are likely to write unreliable assessments. Support for supervising the process and teachers quality assurance through selecting what assessments to include or not, is also another improvement that can be made. For next years version of the course we plan to work further with the peer review with a particular focus on the problems we have discovered. There are also other changes that will be made to the course, such as some revisions to the projects and how groups are organized. Given that students show a tendency to give (too) high scores we also plan to reduce the number of scores the students are able to receive from peer assessments and instead have the teacher or student assistants add extra score based on their interpretation of the students assessments and their own inspection of the project.

Peer assessment is a method where digital tools can contribute with new solutions if they are designed correctly, but none of the tools available today have the flexibility and ease of use that would have made them suitable for the setup used in this course.

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