Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Hans Kristian Hoel

A study of how peer review used in group and individual assignments in Computer Science impacts students' learning outcome

Master's thesis in Applied Computer Science
Supervisor: Christopher Frantz
Co-supervisor: Mariusz Nowostawski, Rune Hjelsvold
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Abstract

Peer review is a method of learning that has existed for many years, and has been applied in several ways in different educational contexts. For this thesis, the goal was to find out how using peer review for an individual assignment versus a group assignment impacts the learning outcome for computer science students in the context of programming assignments.

In order to be able to compare students' learning outcome when using peer review for an individual assignment versus a group assignment, in this research a novel group management functionality was developed for the existing peer review system *Computer Science Assignment Management System* (CSAMS). CSAMS only allowed for individual assignments with peer review, but with the new functionality, it is capable of handling group assignments while enabling individual peer review of other projects. With the new functionality, CSAMS was used in the Cloud course (PROG2005 - Cloud Technologies) at NTNU Gjøvik, in which students both performed an individual assignment and a group assignment throughout the course. As part of this, this project required the deployment and operation of the system throughout the spring semester in order to explore its utility both for lecturers and students. To collect data about the students' learning outcome from using peer review on these assignments, surveys were created and given to the students following their peer review activity.

The surveys offered interesting insights into the learning opportunities associated with peer review. One such example was that there are two main factors that affect how much a student learns during a review in a peer review process, the first one being skill level of the reviewer, and the second one being the effort put into the review. Based on these and further findings, this work reveals that students have a higher learning outcome when using peer review for a group assignment over using peer review for an individual assignment only. The thesis concludes with further directions for advanced research in this area, as well as recommendations for feature extensions to make the system more useful in course settings.

Sammendrag

Peer review er en læringsmetode som har eksistert i mange år, og som har blitt brukt på forskjellige måter i ulike læringssammenhenger. Målet for denne masteroppgaven var å undersøke på hvilken måte læringsutbyttet påvirkes ved bruk av peer review for en individuell oppgave kontra en gruppeoppgave for informatikkstudenter i forbindelse med programmeringsoppgaver.

For å kunne sammenligne studentenes læringsutbytte når man bruker peer review for en individuell oppgave kontra en gruppeoppgave, ble det i denne forskningen utviklet ny funsjonalitet for gruppeadministrasjon for det eksisterende peer review systemet *Computer Science Assignment Management System* (CSAMS). CSAMS tillot tidligere kun peer review av individuelle oppgaver. Med den nye funksjonaliteten håndterer nå systemet både gruppeoppgaver og individuelle peer reviewer av andre prosjekter. Den nye fuksjonaliteten i CSAMS ble brukt i Cloudfaget (PROG2005 - Cloud Technologies) på NTNU Gjøvik der studentene både gjennomførte en individuell oppgave og en gruppeoppgave i løpet av semesteret. Som en del av arbeidet, var det behov for å klargjøre og drifte systemet gjennom vårsemesteret for å kunne vurdere nytten det hadde både for forelesere og studenter. For å kunne samle data om studentenes læringsutbytte ved bruk av peer review av disse oppgavene, ble det utarbeidet spørreundersøkelser som ble gitt til studentene etter at de hadde gjennomført peer review.

Spørreundersøkelsene ga interessant innsikt i læringsmulighentene ved bruk av peer review. For eksempel var det to hovedfaktorer som påvirker hvordan studentene lærer gjennom et review i en peer review-prosess. Den første faktoren er ferdighetsnivået på revieweren og den andre er innsatsen som legges inn i å gjøre reviewet. Basert på disse og ytterligere funn, viser dette arbeidet at studentene har høyere læringsutbytte når de gjør peer review for en gruppeoppgave enn når de gjør det for en individuell oppgave. Avslutningsvis i denne masteroppgaven presenteres forslag til videre forskning på området, i tillegg til anbefalinger til nye fuksjoner for å øke nytten av systemet ytterligere i ulike fag.

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This thesis would not have been possible without the opportunity to develop a group management functionality for Computer Science Assignment Management System (CSAMS). As well as having had the opportunity to follow the Cloud course during the spring semester at NTNU Gjøvik, and to involve the students and lecturers of the course in my research.

I would like to give special thanks to my supervisor Christopher Frantz and co-supervisors Mariusz Nowostawski and Rune Hjelsvold for their excellent support, insights, and guidance on my way through this academic process. Their insights and knowledge have been of invaluable help throughout this project.

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Contents

Figures

Tables

Chapter 1

Introduction

1.1 Keywords

- Peer review
- Group assignments
- Programming courses
- Learning Outcome
- Computer Science Education
- Development

1.2 Motivation

Peer reviewing is a method of learning used by many people around the world. It can be used in multiple areas such as work, research, and education. Most people will most likely have their first interaction with peer review at some point during their time going to grade school, high school, or university. There are many different ways of conducting a peer review, e.g. in writing, through discussions, or using a digital peer review system. An example of a digital peer review system is ComPAIR[1], which is a system developed and used by the University of British Colombia for educational purposes. While there are several ways of conducting a peer review, there are also multiple use cases for it. One can perform a peer review on written assignments, projects, coding, individual tasks, group tasks, and more.

There is a lot of research on trying to find and achieve the best learning outcome when using peer review. For example, [2] looks into if the learning outcome is higher when one completes one versus multiple reviews during a peer review. There is also research looking into learning outcomes when doing peer review on an individual assignment, and research looking into learning outcomes when doing peer review on a group assignment. But there is little to no research on comparing both.

Seeing this gap leads to a motivation of trying to explore and gain additional insight into this gap. It clearly indicates that there is a lack of research when it

comes to comparing the learning outcome of doing peer review on an individual assignment versus on a group assignment.

This motivation leads to a range of research questions that this thesis aims to explore.

1.3 Research Questions

The goal of the research questions created for this thesis is to get a better understanding of how peer review affects students' learning outcome when used for individual assignments as well as for group assignments. The aim is also to look into how students learn best, and what their preferred method of learning is. With these goals in mind, the following research questions were formulated:

1. RQ1: To what extent does the writing as well as receiving of peer reviews on group and individual assignments respectively impact the student learning outcome (with respect to that assignment)?
2. RQ2: Does a computer science/programming student learn more from individual work or group work when it comes to programming skills?
3. RQ3: Do computer science students prefer to learn coding individually or in a group?

1.4 Contribution

The contribution of this thesis can be divided into three parts, which are development, hosting and maintaining, and research.

As part of this thesis, the existing peer review system called Computer Science Assignment Management System (CSAMS) has been extended with a novel group management functionality. While being used for individual assessments, the ability to allow for reviews of group submissions had not so far been covered by existing functionality. This novel group management functionality is a feature that is the basis for the evaluation performed as part of this research. At the same time, it is a permanent feature extension to CSAMS that will be used for peer review of group work.

Being the developer of this new feature also required taking the responsibility of deploying and maintaining the system throughout the semester for given courses, which were the basis for the evaluation. This included making sure everyone got access to the system, responding to issues by fixing any errors and bugs that occurred, and redeploying patched versions while ensuring data integrity across deployments. At the same time, operating on an existing code base also required addressing existing bugs, i.e., bugs that were existing prior to the addition of the new functionality, in order to ensure a smooth operation.

In the field of research, this thesis contributes to a better understanding of the difference between learning outcomes from peer reviewing a group assignment and peer reviewing an individual assignment. Due to this research being targeted

at computer science students, the outcome of the research will primarily give insight into computer science students and their specific disciplinary interests, but also into the particular types of deliverables in computer science courses (e.g., code), as well as specific aspects of collaboration that differs from other environments (e.g., collaborative versioning based on git). Outcomes and insights might hence differ for other fields, even if using the same tool set. To this end, this thesis seeks to provide insight into the value of peer review for group projects in the context of software development specifically.

1.5 Outline

Responding to these objectives, the remainder of this thesis is structured as follows:

Chapter 2 - Background
The goal of this chapter is to provide the reader with a general background in the area of peer review in the context of computer science courses in Gjøvik.
Chapter 3 - Related Work
In this chapter, both literature and related work will be shown and reviewed in a systematic literature review.
Chapter 4 - Methodology
In this chapter, the methodology used will be presented. This includes research, development, and data collection. This chapter is built up of several sections where each section describes a method used in this process.
Chapter 5 - Results
The Results chapter turns to the reporting of the findings from the different methods, which it compiles and analyzes.
Chapter 6 - Discussion
This chapter will summarise the thesis provided before it goes into discussing the proposed solution. Finally, it will conclude the thesis. As well as it will provide information about potential future research, both from the scientific perspective and opportunities related to the future development of CSAMS.

Chapter 2

Background

Peer review is a method used in different ways, it can be used for learning, revising, quality control, and so on. In this thesis, the focus is on the learning aspect of peer reviewing. Using peer review for learning purposes is often found in an educational context, such as in colleges and universities where it is used to better achieve the learning outcome of various subjects, tasks, or skills. The goal of the peer review is to learn by reviewing other people's work. When using peer review in computer sciences/programming courses, the goal is often to learn by reviewing other students' code. Through reviewing code, one can learn other ways or better ways to solve a problem, test and debug, and learn what to do and what not to do. Depending on the coding skills of the reviewed and the reviewer the learning outcome will vary.

At NTNU Gjøvik they currently use a peer review system called Computer Science Assignment Management System (CSAMS). CSAMS is a peer review system that allows teachers to create assignments with peer review for the students. Once the deadline for the assignment is passed, the students will get access to review other students' assignments. All reviews are anonymous so neither the reviewer nor the reviewed, will know who they are reviewing or who are reviewing their work. CSAMS is managed by several professors in the IE[3] faculty and is used regularly for their courses. Using the same system for multiple courses, where some of the courses have more than 100 students, makes this a highly trafficked system. Before the work with this thesis started, CSAMS was a peer review system only capable of handling individual assignments. The system was originally built by three bachelor students, as part of a bachelor thesis in 2019. After that, it has been up to the teachers to maintain and update the system as they used it.

With CSAMS only having the capability of handling individual peer reviews, there was an opportunity to expand the system with group management functionality to allow the students to deliver as a group before conducting a peer review. By adding the group management functionality to CSAMS, it could be used to measure students' learning outcome when doing peer reviews on group assignments. With the already existing feature for individual assignments, students learning outcomes on individual assignments can be measured. By measuring both indi-

vidual and group assignments, the results can then be analyzed and compared. This analysis will help to answer the three research questions of this thesis. Developing the group management functionality to CSAMS, will also add functionality to the system that the professors have been missing for several years.

Further, in the thesis when discussing the "Cloud course" it refers to the course *(PROG2005 - Cloud Technologies)*[4] at NTNU Gjøvik.

The following chapter will turn to provide a background in research in the area of peer review more generally, with focus on peer review in group work settings specifically.

Chapter 3

Related Work

In this chapter, the process of searching for articles and the literature review will be described. In order to respond to the first research question, this thesis relies on a systematic literature review. This review follows the principles laid out in [5].

The purpose of this literature review is to obtain more knowledge on using peer review for learning outcomes and find already existing research that relates to this topic. Identifying existing research will help in the analysis of the topic discussed in this thesis and prevent duplication of existing work.

This chapter is structured as follows, first, it will go into how the literature search has been performed. Secondly, it will go into the literature review, before the chapter is completed with a summary and conclusion of the literature review.

3.1 Search of articles

The search for articles was done between September and December of 2022. To select the relevant literature from the extensive selection of literature in this time period, some conditions were used. First of all, Google Scholar has been used [6] to search for articles. Scholar allows searching for articles from multiple databases and publishers. Some of the well known publishers represented with articles were Springer, Elsevier, and IEEE. Another condition for the search was that the articles needed to be either free to access or accessible through the NTNU network.

When it comes to searching for articles relevant or related to this research, the following search parameters were used:

- Peer review
- Group work
- Individual work
- Learning outcomes
- Computer sciences

These parameters were used in the following combinations:

- "peer review"

- "peer review" "learning outcome"
- "peer review" "learning outcome" "computer science"
- "peer review" "learning outcome" "group work"
- "peer review" "learning outcome" "group work" "computer science"
- "peer review" "learning outcome" "individual work" "group work"
- "peer review" "learning outcome" "individual work" "group work" "computer science"
- "peer review" "learning outcome" "individual work" "versus" "group work"
- "peer review" "learning outcome" "individual work" "versus" "group work" "computer science"

Since peer review is a method that has been used for learning for many years, identified articles range all the way back to before the year 2000. Because of the big time span of articles, a year limit was set to 2015, i.e. the search was limited to articles from 2015 or newer. Later on in the search the time limit was changed to 2005 to allow for finding older research that could also be related.

With the conditions set, there were still a lot of articles found. The next step was to identify articles that were related and useful for this thesis. The following conditions were, thus, used to select articles: 1. Title, 2. Type of article, 3. Keywords, Abstract, introduction, conclusion, 4. Whole article.

First when selecting an article, the title was reviewed. If the article name seemed relevant, it would go further on in the selection process, if not it would be passed. A lot of the articles found from the search, were not relevant, due to the reason that they just came up because they contained one of the search words.

Next was to check that the article was a journal or conference article, and not a blog post or something similar. If the article met these criteria, it would go on to the next step of the process, else it would be dropped.

The next step in validating the article was to look at the keywords and read the abstract, introduction, and conclusion. Based on the impression and overview gathered of the article after reading these sections, the decision to keep the article for the next step was made. If it was very obvious that the article was not relevant, it would be dropped. If there were any uncertainties the article was relevant, it would be forwarded to the next step, as would articles that seemed relevant.

The last step to select articles was to read the whole article. After reading the article, if it appeared to not be as relevant as anticipated, it was dropped. Relevant articles would be used for the literature review.

3.2 Literature Review

This section is about the literature review done for this thesis. The literature review will be used to acquire knowledge on the topic that will be used for the research and to help answer the research questions. The articles and knowledge reviewed can also be used as building stones for the discovery. Secondly, a review like this one allows for discovering and gaining knowledge on what projects and

research that have already been done on this topic.

The articles in this review, have been divided into three main categories. Each category is set as a subsection, and the sections are called: **Group Related**, **Learning Outcome** and **Peer Review**. In the category *Group Related* the articles' main focus is on group work. While in the category *Learning Outcome* the articles' main focus is on learning outcome. Lastly in the category *Peer Review* the articles have the main focus on peer reviewing.

3.2.1 Group related

Do they have to like it to learn from it? Students' experiences, group dynamics, and learning outcomes in group research projects [7]

In this article, the researcher reviews existing data on learning outcome in groups, and test what a student's learning outcome is during a group project. The article goes in depth on different aspects of how group work can contribute to learning. Some of the aspects mentioned are: "Group Processes in Small-group Pedagogies", "Cooperative learning pedagogy" and "Collaborative learning pedagogy"[7]. Further on in the article, the researchers look into the aspects and variables that go into group work, identified by the help from the data collected from the students, of their experience from working in groups.

The findings were ambiguous where the answer to their research question "Do students have to like group research projects in order to learn from them?" was both yes and no. There are several factors going into this statement. The findings showed that it did not matter whether a student did not like the group or working in a group. Because this had little impact on the results of the grades. There were also data shoving the opposite. This meant that the impact varies from person to person.

Thoughts:

Based on the good research work and use of earlier articles, this research is valid. The researchers are able to use earlier work for reference in this research. The article shows that there has been done thorough work in finding and researching the aspects that exist in group work and using it for the conclusion. One thing that would improve this article, is to write a separate conclusion section to make the conclusion more accessible. It is a bit hard to see what is being concluded in the discussion chapter.

Self and peer assessment – does it make a difference to student group work?[8]

In this article, the researchers look at the problem of free riders in a group. They acknowledge free riders as a common problem in group assignments, and that it reduces the motivation and irritates the other members of the group that have to work with them. A lot of the students think it is unfair that free riders get the same grade as the members of the group that have actually done the work.

To try and solve this problem the researchers propose a self and peer assessment strategy.

The strategy is divided into two assessments. The first is a self assessment, where the students will assess their own work, and show what they have done and contributed to the group project. The second assessment is a peer assessment. The goal of this one is to allow the students to give assessments of the other group members' contributions. With these assessments, the teachers will be able to give different grades to the free riders in the group and prevent the problem of students getting good grades for free.

The strategy showed to be successful and worked as intended. With the self and peer assessments, they were able to discover the free riders and give grades based on the work each student put into the group assignment. While it worked the researchers also discovered that students were giving good feedback to the members of the group that showed that they had had personal problems and were unable to contribute as much as the others. This can potentially lead to an unfair grading of students that do not contribute as much but hides their personal problems. This was then mentioned as feature research.

Thoughts:

While the proposed strategy is interesting and shows that it works, this was a very small scale experiment. They had 17 students contributing to their testing. To be able to clarify that this works on a broader basis, there need to be done experiments on a bigger scale. This research discusses a well-known problem of free riders in group work and suggests a way to solve it. The knowledge gained from this research will be taken into account for the implementation of the group functionality in CSAMS. Free riders are also something to watch out for in this research.

Does Cooperative Learning Improve Student Learning Outcomes? [9]

In this article, the researchers look into whether cooperative learning improves the learning outcome. The researchers do this by comparing normal lectures to cooperative lectures. By cooperative lectures, they talk about lectures where the students work together in groups. This experiment has also been done on group assignments and exercises. Throughout the article the researchers go into what cooperative learning is, how they will test it, and earlier work done in the field, and give an in depth explanation of how they have measured the learning outcome of cooperative learning.

This research gives a good insight into why cooperative or group learning can and should be used for learning. throughout the experiment, the researchers are able to establish that cooperative learning improves the learning outcome. They have also collected feedback from students that says that they like having the ability to both learn from the teachers and from their group members. The researchers have chosen to not look into the problems that can occur in group work like for example free riders.

Thoughts:

This is interesting research showing the benefits of group work, and that working in groups opens up other ways for students to learn. This article covers the same area as the research done in this thesis and it will be useful. It will be useful in finding out what to compare between individual and group peer reviewing, and what to look for.

Students of a Feather "Flocked" Together: A Group Assignment Method for Reducing Free-Riding and Improving Group and Individual Learning Outcomes [10]

In this research article, the researchers look into a common problem in group work which is free riders. The researchers use earlier research done to establish their hypotheses that preselected groups reduce free riders more than self selected groups, and that this supports better learning outcomes. What they mean by preselected groups, is groups created based on the work time and motivation to work on the project that each student has.

The experiment was done on the same participants over different assignments. One assignment was done where the students could choose their own groups, whereas for the other assignment, the students were assigned a group. In these groups, the students were matched based on their time schedule, and how much they wanted to work with the project. This led to groups containing students with similar goals. Both group scores and individual scores were measured for both assignments to be able to compare them. While this was a small study and the researchers only had 16 groups to work with, they were able to see and conclude that there was a small difference between them. They found that in the preselected groups, both group learning and individual learning were higher and that there were fewer free riders.

Thoughts:

This was a very interesting study due to the fact that it looks into a problem in group work that most people know about, but few have researched. Since this is a small study, it is hard to say if the findings are applicable to larger groups of students. This is also why this topic should be repeated on a bigger scale. This study gives inspiration for developing the group functionally to CSAMS with a focus on preventing free riders.

3.2.2 Learning outcome

The effect of peer review on student learning outcomes in a research methods course [11]

The researchers of this article want to see how peer review affects students learning outcomes in a course where the topic is research methods. During their

research, they investigate how peer review affects learning compared to not doing a peer review. They refer to previous research showing that peer review is a good method of learning. With this in mind, they created three hypotheses based on the belief that students doing peer review will get higher grades, score higher on learning outcomes, and have higher changes in performance. The experiment was conducted over two semesters on the same course. Students taking this course were given the opportunity to choose which course path they wanted to do. The option was between taking the peer review path or the non peer review path. The two paths or groups had the same lectures and learning materials, the only difference was that the group with peer review had peer review included in their course.

Throughout the course, the students had different assignments and tests that all counted against their grades. The group taking the peer review path got to do several peer reviews during the course for writing assignments. Students were randomly divided into groups of three for the peer review sessions. This allowed each student to get two reviews and prevented students from choosing their own group.

Analyzing and concluding their work the researchers found out that peer reviewing did not make any difference in the final grades the students got. It appeared that the students not doing peer review, were able to do just as well as the students doing peer review. They concluded that the reason for this could be that the students were using too much time on peer reviewing so they did not manage to catch up with the other students. There was one assignment where they could see that the students doing the peer review performed better, but this did not alter the overall scores.

In the future work section, they mention multiple methods and ways of future work. Some of them are: Doing similar research but having the review be anonymous, and peer review should be tested for other types of courses to see if it works better there.

Thoughts:

This research is capable of showing that although peer review has a reputation for being a good learning method, it might not always make a big difference. This article shows that there are cases where peer reviewing does not work as intended. If the reason for it not working is due to badly conducted practice or if it does not work for every subject, is hard to say without future research on this topic. This was also suggested as future research by the researchers. While this specific research topic is not the same as for this thesis, it will be kept in mind for the planning and performing of this research.

Using peer review as a vehicle for communication skill development and active learning [12]

This article takes another approach to using peer review, than the other articles do. In this article, an instructor of a computer sciences course decides to test if she

can use peer review to help the students learn more about the other group projects in the course. The course is followed by a small class of 11 students which are divided into four groups. Each group was given their own projects. The instructor wanted to use peer review to get students more active in questioning the other groups' work during the weekly presentations in class. She hoped that by knowing more about the projects that were being presented, the students would ask more questions afterward.

After using peer review in the course, the instructor realized that it did not actually make the students more active in questioning the presenters. However, she discovered that the review feedback that was produced, helped each group make their own projects better. She also discovered that the students learned a lot from reviewing other projects in the way that they discovered other methods and ways of doing things. The students themselves were very happy with the experience and enjoyed learning more about the other projects.

While these are interesting findings on the use of peer reviewing in a computer science course, the scale on which it was conducted is very small. There were only 11 test subjects in this experiment so to be able to say if the same outcome is applicable on a broader basis, the experiment needs to be conducted on a larger scale.

Thoughts:

This article is a good example of students benefiting from using peer review. The research done might have had another outcome than the researcher expected, but it shows the peer reviewing benefits to learning outcomes even when that was not the research goal. This research can help to find out what to ask for when creating a survey to collect data about group work.

Peer Assessment in the Algorithms Course [13]

In this research, the researchers look at how using peer review in computer science courses affects students' learning. In the article, the research has been limited to the specific course Algorithms. Following the algorithm course for one year the researchers conducted eight tests of peer review. For each test 6 to 8 students were given an assignment, the assignment gave the students multiple algorithm tasks that they were to complete in one week. Once the assignment was done, the submissions were anonymized and randomly given out to all the students in the class for feedback. The feedback was then given back to the students who had done the assignment. In this way, many students were given the opportunity to try it out and learn both through receiving feedback and giving feedback.

Through the testing and analyzing of the results the researchers were able to say that the experiment was a success and concluded that peer review helped learning. They also suggested that peer review should be used in other courses in computer science. To be able to analyze the results they made students give scores for each task in the assignments based on their criteria.

Thoughts:

While this research shows that peer review works for the case shown in this article, the method of only doing peer review for a small group in the class at a time is reducing the efficiency of peer reviewing. While it can also be an excluding strategy if there is not enough time to cover all students. This method of performing a peer review might work in this case, but it should get more testing on how efficient it actually is.

Self-discipline as a Key Indicator to Improve Learning Outcomes in e-learning Environment [14]

In this research article, the researchers look at how self-discipline can affect the learning outcome of a student. For this experiment, they target students that have digital courses and are in an e-learning environment. As they say in their article, in an e-learning environment a student has to work and learn independently, due to the fact that they take courses over the Internet. The researchers then want to measure to what extent self-discipline is an important factor for the student's learning outcome in this environment.

To test their hypotheses they run tests on the students to try to measure their self-discipline. By measuring both what students think about their own discipline and all the tasks and assignments they have done throughout the year. They found that self-discipline is a key factor for learning outcome. This experiment was done twice both where they followed the course and also with over 100 participants.

Thoughts:

This research is going to be relevant for this work and is something that should be taken into measure when assessing learning outcome. Although self-discipline is just measured for e-learning, self-discipline will 'be a factor in this research, too, due to the fact that the students have to learn to complete their assignments.

Peer reviewers learn from giving comments [15]

This is a research on peer review used in a writing course. The researchers want to go in depth on how commenting on a written task has an effect on the learning outcome. The experiment is done on 87 undergraduates in a physicist course. Before going into depth on their experiment, the authors discuss earlier work done in this area. They show good knowledge about what exists and how they are contributing to new research. They are also able to use earlier research to back their discoveries.

In the article, there is an in depth explanation of how they analyze and categorize their data. The explanation gets a bit technical. Throughout the explanation, they categorize the review comments into three main types: Surfaced features, micro-meaning, and macro-meaning. With these three categories, they are able to see what review comments give the best effect on the learning outcome and help the student that receives the review the most. They are able to conclude that giving comments on peer review, increases the learning outcome more than receiving

comments.

While they are able to find a conclusion, they also add that this topic needs more research, and they indicate what future research that they think should be done. The future research mentioned is: “why students review peer drafts differently from the manner in which they revise their own drafts” and “to investigate what student reviewers learn by giving comments on peer drafts and how that knowledge is transferred to their own writing”[15].

Thoughts:

This is a related article to this research and will be used for inspiration for the thesis. Inspiration can be taken from how they have completed their data analysis.

Assessor or assessee: how student learning improves by giving and receiving peer feedback [16]

The article looks at how the roles of assessor(reviewer) and assessee(receiver) of a peer review improve the students’ learning. This research has been conducted on 43 students studying to become teachers. To be able to conduct their research, the researchers created a web based peer review system. The system allowed each student to submit an assignment. Then they would receive two randomly chosen assignments to review. Each student would also receive feedback from two fellow students on their assignments. When the feedback was complete, each student was able to update their assignment based on the feedback before submitting the final version.

Through the testing, the researchers discovered that there were differences between good and bad feedback given. Bad feedback came from either lack of experience in giving feedback or not enough knowledge on the subject they were reviewing. This resulted in students with greater knowledge, would disapprove of the poor feedback they received, and try to find better solutions by themselves. The same happened when students received conflicting feedback and they had to find out what was right. The researchers concluded that both the assessor and assessee roles contributed to learning, although they were tested together.

Thoughts:

This article started in a weird way. Because based on the introduction and their description of the research, one gets the impression that they were going to research and compare the two roles, assessor and assessee, which they did not. They mention that these two roles should be compared to each other in future research.

Improving the effectiveness of peer feedback for learning [17]

The article lacks structure, and one has to read multiple pages before being able to identify the research questions and the hypothesis for this work. The authors dive into reviewing of similar work and while they have done good research on the topic, it is hard to link the literature research to the research topic at hand, due to the lack of information beforehand.

Only when they come to their research part, do they finally address what they will be researching. They will test the performance increase of students based on constructive feedback. In this experiment, the participants are students from 7Th grade. This means that they have young participants with less experience in giving feedback than older students. They see this as an opportunity to understand how the lack of experience in giving feedback through peer review, alters the learning performance of the students. Through their experiment, they concluded that there were improvements in learning when using peer review, but their conclusion can be unreliable due to the lack of controlled testing. The students did the test at home where the researcher was not able to control if they got help from friends or family. This decreases the confidence in the findings since they are unable to tell whether all the results were based on the student's performance of somebody else.

Thoughts:

While this research shows that feedback from peer review increases learning, it is difficult to say how well it actually works for these young students, due to the lack of a controlled environment. A controlled testing environment is important to achieve good and valid results and will be taken into consideration for the data collection and analysis of this thesis.

To give is better than to receive: the benefits of peer review to the reviewer's own writing [18]

In this article, the researchers look at the difference between learning and improving writing skills from the two different roles of peer review. They will see if one learns more from being a giver than being a receiver of feedback. The experiment has been done on 91 students from Brigham Young University through their writing classes. To be able to test their hypothesis that a giver of feedback learns more than a receiver, they have separated the two roles when it comes to peer review. This means that the givers will only give feedback, and not receive any feedback, while the receivers will only receive feedback, and not give any. All students have been given the same tasks to improve, where the givers will comment on how to improve the text, while the receivers will improve the text based on the feedback.

To be able to test the learning outcome, the students get tested both before and after the experiment to meassure any improvements. Through deep analysis of the different skills used when writing, the researchers are able to compare the results of the givers and the receivers. By comparing the outcome, they found that the givers have a higher learning outcome. They also identified that there are improvements in learning outcomes for the receivers as well but to a lesser extent. Thus, they believe that when the two roles are combined, as it normally is in a peer review, the learning outcome is even greater.

Thoughts:

The findings are interesting and useful research on peer review. It shows that

the different roles of peer reviewing can have different impacts on the learning outcome. Comparing learning outcomes between individual and group peer reviews, should be looked into, because it can have an impact on findings.

Learning by Reviewing [19]

The researchers wanted to test their hypothesis that ´´students may improve there own writing skills by engaging in peer review of writing" [19]. They start the article by summarising existing research on the peer review topic and explain how their research is different. This is a good approach, giving an overview of similar research interesting to the reader.

Further on in the article they go into their experiment. They explain how they have been able to get 61 undergraduate student volunteers from an introduction level laboratory physics course, 31 girls and 30 boys. During the experiment, the volunteers were divided into three groups. The first group would rate and give feedback to their peers, the second group would only give a rating, and the last group got to read some unrelated texts. Once this was done, all the students were given the same writing task with a topic unrelated to the topic they had just read. This allowed the researchers to evaluate the writing improvements in the different groups. The findings were backing their hypothesis and allowed the researchers to conclude that their hypothesis, that students may improve their writing skills by giving feedback in peer review, is true. They also found that gender did not matter for this outcome.

Thoughts:

While this experiment was successful for this group of students in this particular course, a bigger study should be conducted to be able to say if the findings also apply to other students taking other courses. This research supports that peer reviewing is a great method for learning and evolving better skills.

Evaluation on the Effectiveness of Learning Outcomes from Students' Perspectives [20]

The article looks at students' perspectives on expected learning outcomes for courses. The research has been done through a survey where all students participating were asked the same questions. The set consists of 185 students, both boys, and girls, from all years of a engineering program from the University of Technologies Malaysia.

Through analyzing the data collected, they found that about 60% were confident the learning outcomes were effective, while the rest were either not sure or did not agree. They did also discover that the students thought the learning outcome was less effective in the higher level classes. The researchers thought that this could be because the teachers did not go deep enough into the subjects and that the students were only taught the minimum. They did not test this hypothesis.

Thoughts:

This research was done well and had a sufficient amount of participants to

back their conclusions. Still, the researchers should have tested their conclusions further, or at least mentioned in their article that there should be future research in this area.

The article is relevant because it shows how they analyze to measure the effectiveness of learning outcomes. This will be similar to what will be done in this research, and thus, helpful to look at.

3.2.3 Peer review

A comparison of peer and tutor feedback [21]
In this article, the researchers look at whether there is any difference in receiving feedback from a teacher as compared to receiving feedback from peers. This research is based on computer science students completing assignments in an algorithm course. In their test, they do not focus on the effect of doing peer review, but only on comparing teachers' versus peers' feedback. To test their research, each student has to submit an assignment for the course. The students then have to do peer reviews on other student's assignments. In the end, each student will have received feedback from four of their peers and one feedback from a teacher.

With a deep analysis of the peer's feedback and the teacher's feedback, the researchers found that the teachers gave longer and more technical specific feedback, where as the feedback from the students was shorter and more general. The feedback from the four different peers, in total were more comprehensive than the feedback from a single teacher. They concluded that the different types of feedback have different advantages when it comes to improving the assignments. Even with these differences, there are no major benefits of one over the other, and they concluded that both kinds of feedback have many of the same benefits.

Thoughts:
This is an interesting research because it shows that receiving enough peer reviews gives the same benefits as getting feedback from a teacher. From this one can derive for instance that in big classes use of peer review, instead of feedback from the teacher, allows for reducing the workload for the teacher while still allowing students to get good feedback and to learn more.

Quality of Peer Assessment in CS1 [22]

In this article the researchers perform a big study on peer review targeted computer sciences students. They have used 1500 students and received over 10 000 peer reviews. In this study, they want to see whether student reviews are better than receiving reviews from a teacher. The study covered three courses: ´´Introduction to Engineering Computation and Software Development" in 2007, ´´Principles of Programming" in 2007, and ´´Introduction to Engineering Computation and Software Development" in 2008. In these courses, there were completed multiple assignments of which some used peer reviews and others used

teacher feedback as an assessment.

All the results and feedback have been collected and analyzed. They go in depth on the analysis and how the data were analyzed. They also compare the reviews from the peer to the reviews from the teachers. To summarize their findings they found that while a single peer feedback is shorter than a teacher's feedback, receiving multiple peer feedback, is as good as one teacher's feedback.

Thoughts:

This was a well conducted experiment. They have been able to get a large group of participants, which allows for better analysis and more valid results. They also refer to related work on the topic and relate that to their own work. There is a good use of tables and charts, which makes it easier to understand the data analysis. This research shows that peer review is not just a great method for learning, but also a great tool for reducing the workload and stress of a teacher.

Incorporating student peer-review into an introduction to engineering design course [23]

In this article, the researchers look at including peer reviews in an engineering design course. They look at the possibility of using calibrated peer reviewing(CPR) as a digital system created for peer reviewing. The work is from 2005 and early in the process of digital peer reviewing. The researchers want to find out whether using CPR is actually working, or whether it just ends up being extra work and few benefits.

The researchers are looking at both the outcome for students and teachers in this experiment. The testing CPR is done with writing assignments. Through the testing, they find that there at both good and bad aspects of using it. The bad part is mostly that it is time consuming both for students and teachers. This is mainly in their start period. The more the teachers and students use CPR, the less time consuming it gets since they start to understand how it works, and then benefit more from it. The good aspect of this is that the students are able to learn more about how to write. Which they learn through reviewing others' work, and through applying the reviews they receive on their own work.

Thoughts:

Since this article was focusing on using a peer review system in a student course, and not so much on researching the peer review methods as such, their testing of using a new digital peer review system is relevant for the development. They found that peer reviews can be complicated and time consuming if the system is not easy to use. If the system is not easy to use, it will decrease the learning benefits that come from peer reviewing because the students might end up focusing on the application, rather than the peer reviewing as such. This research has shown that it is important to focus on user friendly design, which will be important for the implementation to CSAMS.

A multi-peer assessment platform for programming language learning: considering group non-consensus and personal radicalness [2]

In this article, the authors want to find out how students' learning outcome is altered from doing a single peer review to doing multi peer reviews. In this case, single peer review means that a person only does a peer review on one submission, while multi peer review means that a person peer reviews multiple submissions. Over a period of two years, they develop a web application to help them test their hypothesis. The application allows students to deliver their assignments and then they will automatically be given one to five randomly chosen assignments to review. For this study, they have focused their testing on programming students, where the peer reviews will be on individual created programs.

The application has six steps to complete a peer review. Step one: The teacher creates and publishes a task for the students to do. Step two: A student(the author) completes the task given and submits his source code to the application. Step three: Each student(as a reviewer) will receive multiple codes to review and score. The score and review will be submitted to the application. Step four: The author receives his code reviews, and must now review both the reviews and scores he has done. Step five: the author has to revise his code based on the reviews and submit the new version. Step six: the teacher will overlook and summarize the task scores.

During their testing, they discovered both some non-consensus and radicalness. The main non-consensus where that some of the reviewers did not have much knowledge of or experience with coding, and ended up not understanding the code when they were reviewing a more experienced coder's work. This resulted in wrongly reviewing of the code, giving a bad review and an incorrect score. To solve the problem they added a feature to their application that would notify the teacher, and allow the teacher to step in and contribute. Radicalness that was discovered was students intentionally giving a to good score or a very bad score, both when reviewing other people's work and when reviewing their own reviews. To prevent this, the researchers developed a feature to detect when this occurred and notify the teacher, so that the teacher could deal with the problem.

The conclusion of their research was that they managed to develop and use a peer review system that allows for multi-peer reviewing. With the application and help of surveys, they were able to study whether students learn more from doing multiple reviews than from only doing one. Through their analysis, they came to the conclusion that the students learned better doing three to five reviews than only one. They also concluded that they were able to discover non-consensus and radicalness, but said that their research on this was simple and would need future work.

Thoughts:

The research done in this article is relevant to my work in the way that they research peer review in computer sciences students, even though this research targets a different area of peer reviewing, the same target group will be used for this

research. The researchers discovered that there were non-consensus and radicalness that needs to be taken into consideration when creating the surveys for my work. One non-consensus which is impotent to be aware of for this study is that students can have a lack of experience or knowledge when doing a peer review. This needs to be taken into account when concluding.

Engagement in peer review, learner-content interaction and learning outcomes [24]

This is a newer research where the researchers want to look into how the engagement has an effect on peer reviews. The research is done on a class of students with 45 students participating in the study. Throughout the course, the students are made to participate in multiple peer review activities relevant to their work. The peer reviewing was done through a web based peer review system. To collect data and analyze the results, the researchers used surveys. The data collected was then organized and scored after a five-point Likert scale.

The main part of the article is presenting an in depth analysis of the data. In this way the researchers allow the readers to join the journey of their thought process. This is a good strategy because it allows others to reproduce the research, and also for replicating the research on a bigger scale. All these calculations make the article very technical and heavy to read.

The researchers found that using peer review to learn, was engaging for the students. Most of the students liked using it. They also discovered that the students were more engaged in giving peer reviews for others, as compared to receiving them. The study also shows that students learn more from giving the review.

Thoughts:

From this article, the idea of using a Likert scale for the questions will be adopted for the surveys in my work since a Likert scale can help make the analysis of the results easier, while it will give more accurate answers. The researchers' statement about students having higher engagement for giving peer reviews, will be taken into consideration for this study.

3.3 Summarizing of the literature

In this section, all the articles presented earlier will be summarized. The research gaps found and how the articles will help for this thesis, will be discussed. Firstly there will be a summary of each of the three categories before they all come together in a conclusion. The articles are summarized per category in the tables: 3.1, 3.2 and 3.3.

There are several common findings in the articles in the group related category. First of all, we may conclude that most students have a good learning outcome from working in groups. Group work create learning outcome. There are, however, also problems with group work. Free riders is a problem that both [8] and [10]

Table 3.1: Articles in category Group Related

Article	Subjects	Future work / Gaps
[7]	Group work, Learning outcome	Negative group dynamics
[8]	Group work, Free Riders, Peer assessment	Unfairness by personal problems
[9]	Group work, Learning outcome	Consider free riders
[10]	Group work, Free Riders, Learning outcome	Test more ways to prevent free riders

try to solve. While they both found possible solutions, they also mention that this is a problem that needs more research. From these articles, we acknowledge that there are gaps in the research of group learning, where one gap is associated with understanding how to solve or prevent contribution differences whether it is free riders or other differences found in a group.

From the articles in the learning outcome category, we may conclude that peer reviews contribute to better learning outcome. There are, however, cases where this is not true, e.g. in [11] they found that the students not participating in peer review actually performed better than the ones who did. The reason for this is that either peer reviews were not used in the right way, or that peer reviews are not the best tool for every learning situation.

In [12] the researcher tried using peer reviews as a tool for the students to help them learn more about the topic that other student groups were working on. During this experiment, it was discovered that while they learned more about the other topics. The students also discovered new methods and approaches to the task at hand which they were able to reuse for improving their own work. This research shows that there are multiple ways of using peer review for learning outcome. Both [18] and [19] look into the differences in learning outcome when it comes to the different roles in peer reviews. They use different approaches and tests to test their hypothesis, but still, both end up showing that students learn more from reviewing than receiving.

When looking for gaps between these articles, no big gaps can be found. There are, however, a few smaller gaps, which are: More qualitative studies on roles in peer review, making peer review efficient, and looking into the difference between anonymous and non-anonymous peer reviews.

In the category Peer review, the articles look into how to perform peer review and the quality of feedback created through peer reviewing. Both [21] and [22] compare the quality of the feedback from students through peer review with the quality of the feedback received from a teacher. They have different approaches and methods for testing the same problem, but both end up with the same con-

Table 3.2: Articles in category Learning Outcome

Article	Subjects	Future work / Gaps
[11]	Learning outcome, Peer review	Anonymous peer review, test other courses
[12]	Learning outcome, Peer review	More research using peer review to learn new topics
[13]	Learning outcome, Peer review	Efficient peer review
[14]	Learning outcome, Self discipline, E-learning	Self discipline in group work
[15]	Learning outcome	Why students review peers different from own work
[16]	Learning outcome	Compare roles assessors vs assessee in peer review
[17]	Learning outcome, Peer review	More advanced peer review, controlled environment
[18]	Learning outcome, Peer review, Roles	More qualitative study
[19]	Learning outcome, Peer review, Roles	Compare with receiving role
[20]	Learning outcome	Difference between course learning outcome and actual learning outcome

clusion. They both found that receiving several feedback through peer reviews is equally good as receiving one feedback from a teacher. A gap in these articles is that they do not cover if one gets a different outcome if one student receives either only bad or only good feedback.

In [23] the researchers look into the usability of a digital peer review system. Even if this is an old study from 2005 when the use of computers was very different from today, the research emphasizes how important usability is, and how it can affect the efficiency of peer reviews. Having a system with poor usability can end up decreasing the positive effects of doing peer reviews, due to all the energy that goes into trying to use the system instead of the peer review itself.

Gaps found in this category will be a lack of comparing bad versus good feedback, and to prevent the problems created when people lack the knowledge to be able to give a good feedback.

Table 3.3: Articles in category Peer review

Article	Subjects	Future work / Gaps
[21]	Peer review, Feedback	Test more on number of review feedback needed to beat teachers feedback
[22]	Peer review, Feedback	Look more into bad versus good feedback
[23]	Peer review, Application	Need updated research for this digital era
[2]	Peer review, Application	More research on non-consensus and radicalness
[24]	Peer review	Look into impact of individual differences

3.3.1 Conclusion of literature review

While there are gaps in these three categories, there are also gaps between them. One gap is the lack of comparing the differences in learning outcome when using peer reviews on an individual assignment versus on a group assignment. There has already been established that both result in increased learning outcome, but not which one is better. Through the research question, the goal is to make this gap a little smaller. As mentioned earlier there are other gaps, but it is not possible to close them all at once. Therefore the main focus has been on the gap between individual and group peer reviews.

The knowledge gained through this review and the discovery of the gaps, will be used both for the development needed to test the research questions and for the surveys to collect data. Both free riders and usability will be a focus during the development.

The following chapter will go over the methods used in this thesis.

Chapter 4

Methodology

The methodology chapter will cover the steps done to be able to answer all the research questions. The different methods are presented in the order they have been completed during the thesis. The different methods are: Research, Planning the development, Implementation, Integration, Production, and Surveys.

Several of the methods in this thesis are based on the work done in the courses Advanced Project Work - IMT4894 and Research Project Planning - MACS4000, which were held in the fall semester of 2022.

The research section is about the research conducted to be able to plan and guide the thesis, and also helping to answer the research questions. Planning of development, implementation, integration, and production are all sections related to the development of CSAMS. These sections cover the steps taken to create group management functionality in CSAMS. The group management functionality was essential to be able to collect data for the research questions. To collect the data for analyzing and answering the research questions, two surveys have been conducted. The creation of these surveys is described in the survey section. The different methods are prensentet in this order, is because they are dependent on each other in the way that it would be hard to complete the methods in any other order.

Examples of the methods relying on each other: The development process is based on knowledge obtained from the research e.g. developing the group management functionality to try to prevent free riders in groups. This challenge was first identified in the literature review. Another example is that the surveys are designed to answer the research questions using the knowledge obtained from both research and development.

By completing all of these tasks, the goal was to respond to the research questions. Each method giving its contribution to finding the results.

4.1 Research

During this thesis, two types of research have been conducted. First, the literature review was discussed in Chapter 3. Through the literature review knowledge

was obtained about existing research on peer review. The review allowed for preventing duplication of existing research, and also help answering the research questions. The literature review done in this chapter was a systematic literature review.

The second type of research was the research on the application CSAMS. This was done to get a better understanding of the system and will be discussed in the next section Planning the development.

4.2 Planning the development

The section goes into the process of planning and designing the development of the group functionality added to CSAMS.

4.2.1 Researching CSAMS

First of all, CSAMS is a web application system. To be able to do any development to CSAMS, a better understanding of the system was needed. Acquiring more knowledge about the system was done by setting up and deploying CSAMS to a local computer. This allowed for testing of the system and, thus, gaining knowledge of how it worked. During the testing, a better understanding of how the application was working, both from a student's perspective and from a teacher-/admin perspective, was gained. Having better understood the system, recognizing and planning for what needed to be developed, and how to integrate it into the system, was now achievable. The step also allowed for seeing how the code structure was built.

Further on in this section the planning of the frontend and database changes will be described, starting with the frontend.

4.2.2 Frontend

During researching the CSAMS application, three pages i.e. screens were discovered and assigned as the most important changes needed to be done to the frontend. The pages were newAssignmentPage see figure: 4.1, adminGroupPage see figure: 4.2 and showGroupPage see figure: 4.3. All these three pages were planned and iteratively designed using Figma[25].

With the first draft designs, it would be easier to implement the pages later since most of the designs had already been planned. This being just a first draft, the end result might end up looking a bit different.

4.2.3 Database

To be able to start on the development, the database needed a revision. To be able to support the new features which are dependent on a database capable of storing the relevant information supporting group management, the database was

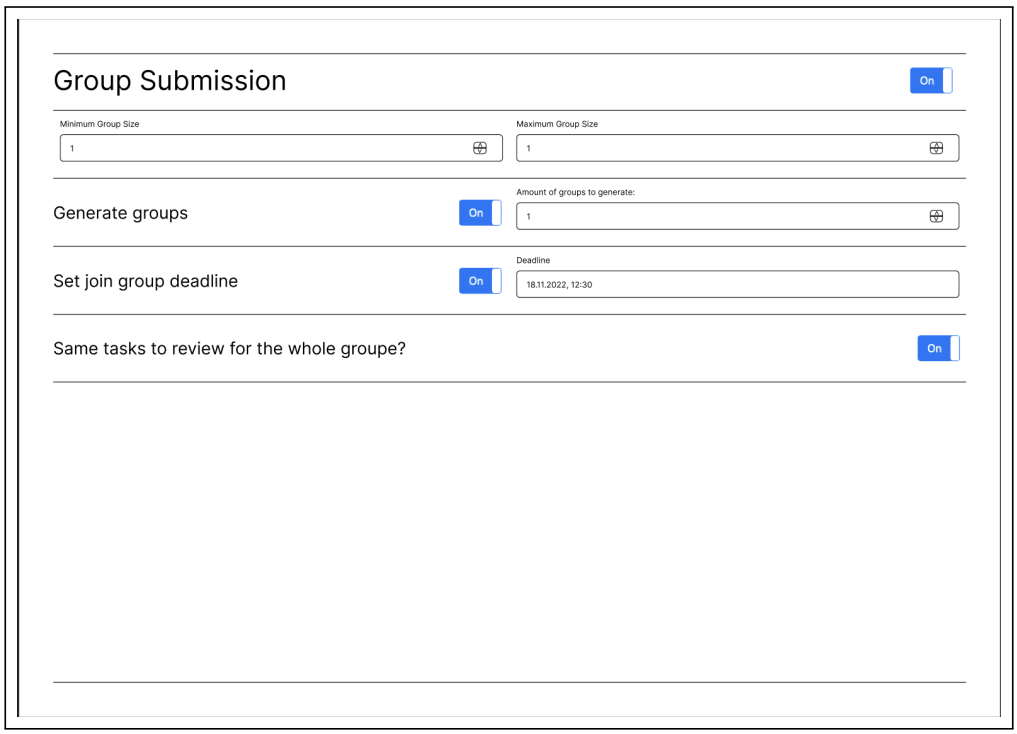


Figure 4.1: First iteration of design for the create a new assignment page, an admin page

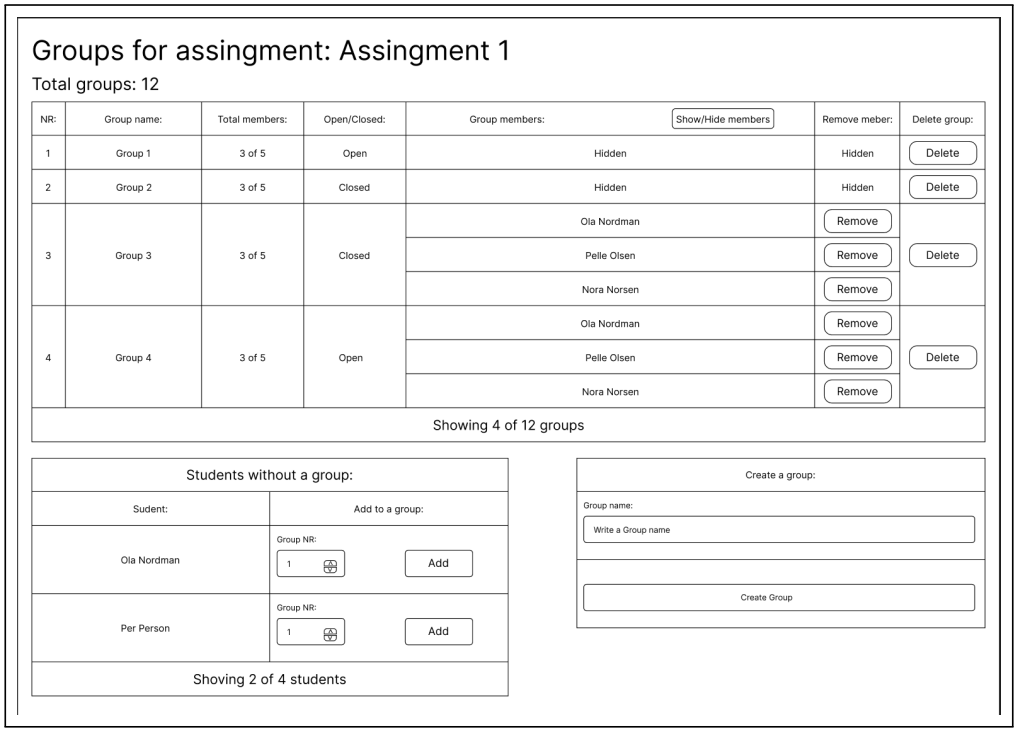


Figure 4.2: First iteration of design for the admin group overview page, an admin page

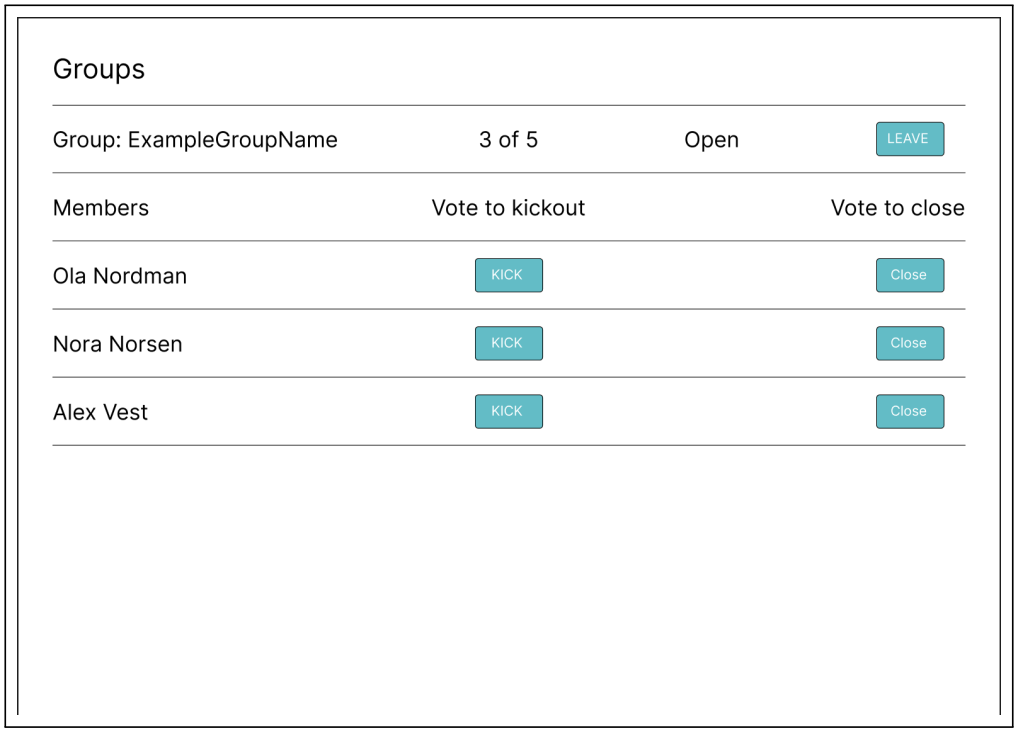


Figure 4.3: First iteration of design for the student group page, a student page

revised accordingly. In order to revise the database with the new modifications, an understanding of its structure was needed. Due to the lack of any documentation of the database (e.g., diagram), documentation needed to be written. To achieve this, the SQL file from the code was used, as was Adminer[26] to visualize the database. The new diagram can be found in Figure 4.4.

With the information gathered through the recreation of the database diagram, a basis for revision was established. Making the structure capable of supporting the upcoming group management functionality, several data classes were added and updated to support the new relations. The following classes were updated with new data fields: assignments, user_submissions, assignments_groups. The new classes added to the structure were: group_vote and voters. Due to the existence of the classes: assignments_groups and assignments_group_members, few new classes were needed. The revised database can be seen in Figure 4.5.

The tool used to create the diagrams was Drawio[27], which is a web based drawing tool that allows users to create different kinds of diagrams.

4.3 Implementation

The implementation consisted of three parts: frontend, backend, and database. The first step of the implementation was to update the SQL database file based on the new database diagram. Once updated the system needed a redeployment

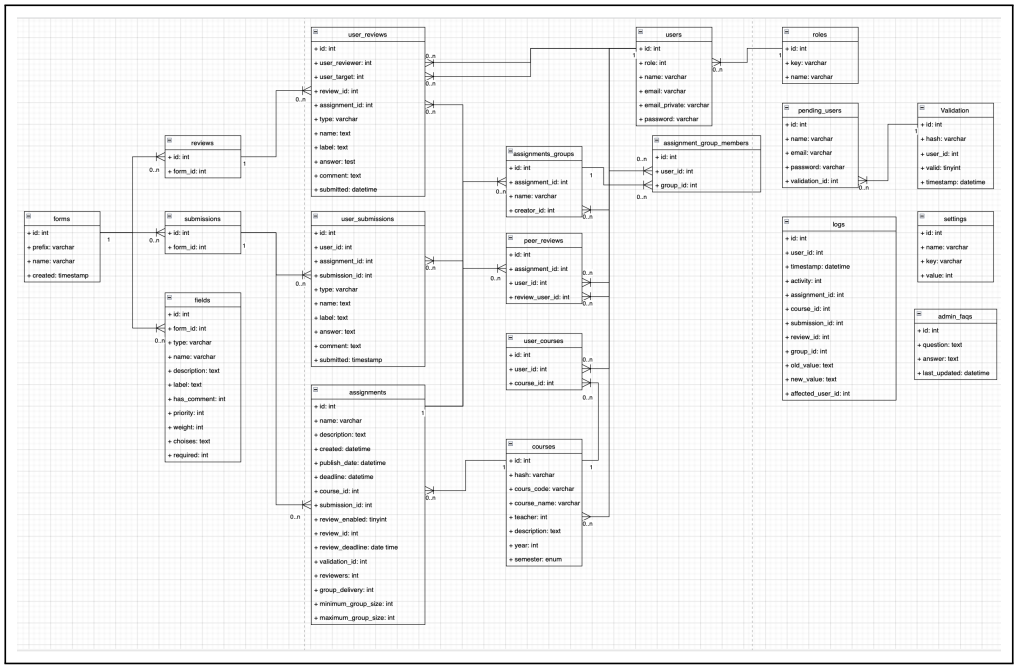


Figure 4.4: Database diagram of the old database structure

to allow the database to work with the changes. The system was then ready for development of frontend and backend.

The next step was to implement the code for both backend and frontend. The structure of the implementation was the order of the pages, and one page would be completely built frontend to backend before moving on to the next.

The rest of this section is divided into two subsections, one for the backend and one for the frontend. They tell about the implementation that was done. First out is the implementation done in the backend.

4.3.1 Backend

The backend needed to be updated to work with the changes in the database, meaning that the structs for the classes needed to be updated accordingly. This was done by adding the new data fields to the structs. Once this was done the functions using and handling data from this class, needed to be updated to use the new data fields and prevent errors from occurring due to missing the new data fields.

The next step was to create all the functionality that was needed, for the group functionality. The functions were developed when needed which allowed for focusing the development on one page, and its functionality, at a time. When creating the needed functionality, several steps were followed. Since the application code was divided into three groups: controller, service, and repository, it was important to keep following the same structure throughout, to maintain the readab-

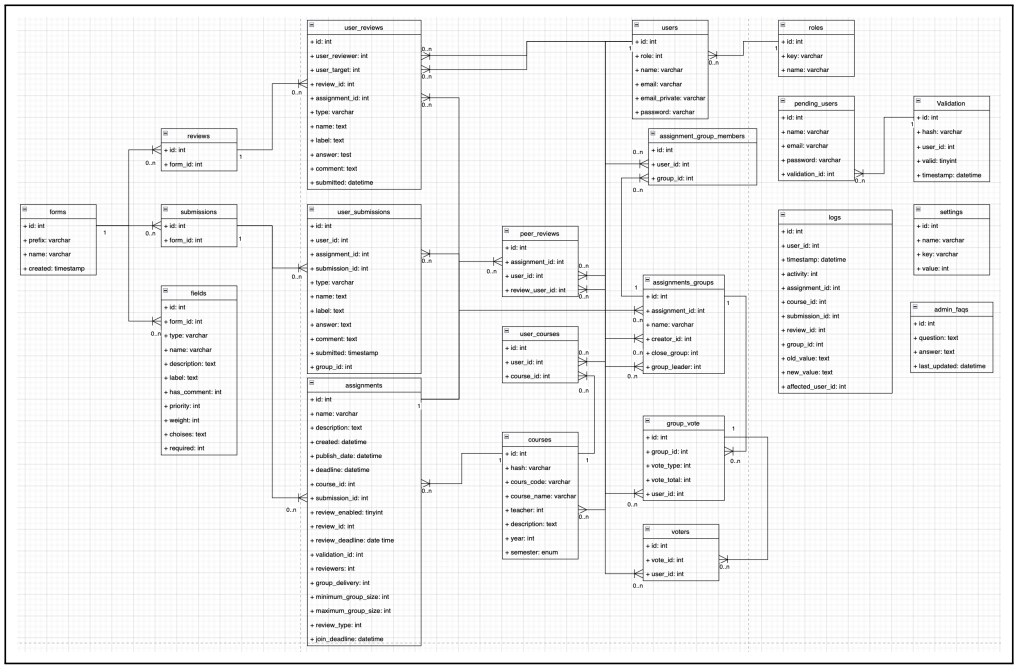


Figure 4.5: Database diagram of the new revision database structure

ility and usability of the code. Figure 4.6 shows an illustration of the CSAMS code structure.

In the backend the controllers were the functions that connected directly to the frontend. Every functionality for a page was created here. Each function was set up with its own endpoint that could be called from the frontend. All endpoints were set up in a *http.Handler* function called *Routes*. For the controller to be able to collect, alter or add data to the database, one of the services had to be called. There are multiple services, each service corresponds to one repository. It is the service's task to talk to the repository and send its data to the controller. A service contains multiple functions that can be accessed from the controller. The objective of these functions is to add, get or alter data, based on the parameters received from the controller. The operations can be as simple as passing data back and forth to a function in the repository, to do multiple operations and calling multiple functions in the repository, and then return a response to the controller. It is the repository's responsibility to handle all operations talking to the database. Each repository corresponds to one table in the database. In a repository file, each function has its own purpose to manipulate the table. The purpose can be anything from inserting, retrieving, updating, and deleting data in the database. Depending on what is needed for the specific table, a repository can have a few or many different functions. Thus, when creating new functionalities in the controller, new functions often had to be created in both the corresponding service and repository to be able to fulfill the functionality.

To be able to access the new functions created, the route file had to be updated.

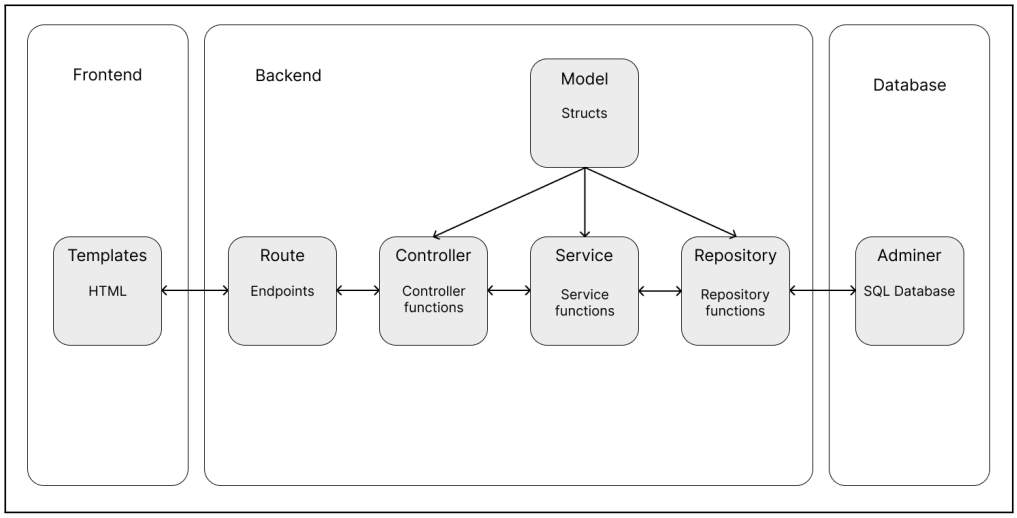


Figure 4.6: Illustration of the code structure to CSAMS

The *Routes* file is the system handler. In this file, all controller functions are linked by being assigned to an endpoint accessing it. Depending on the functionality, the function has an endpoint assigned by a GET, POST, or DELETE method.

4.3.2 Frontend

Developing the new pages for the frontend, was done in stages. The stages focused on one page at a time such that the implementation of both fronted and backend would be completed for one page, before moving on to the next one. The original plan was to create and develop all functionality in the backend first, and then create the frontend. When starting on this approach, it was soon realized that it might be easier to develop the frontend first, and then create the code and functions in the backend as needed. The reason was that this was an addition to a large existing backend code base.

When building the new pages, the first draft designs created earlier were used. While trying to follow the designs, there were also changes made to make sure that the new pages had the same design and style as the rest of the system. With this in mind, there ended up being some changes to the end results. The end result can be found in figures 4.7, 4.8, 4.9 and 4.10.

In figure 4.7 you can see the 'user join a group page'. This page allows the users to see all groups they can join. Here they get an overview with general information about each group. They can see the group name, how many members there are in the group, if the group is open or closed, and a button to join the group. If the group were to be closed or full, the join button will be disabled and the user will not be able to join the group. A user can also create a new group by pressing the button 'Create new'. This button can be disabled by the teacher when he sets up the assignments.

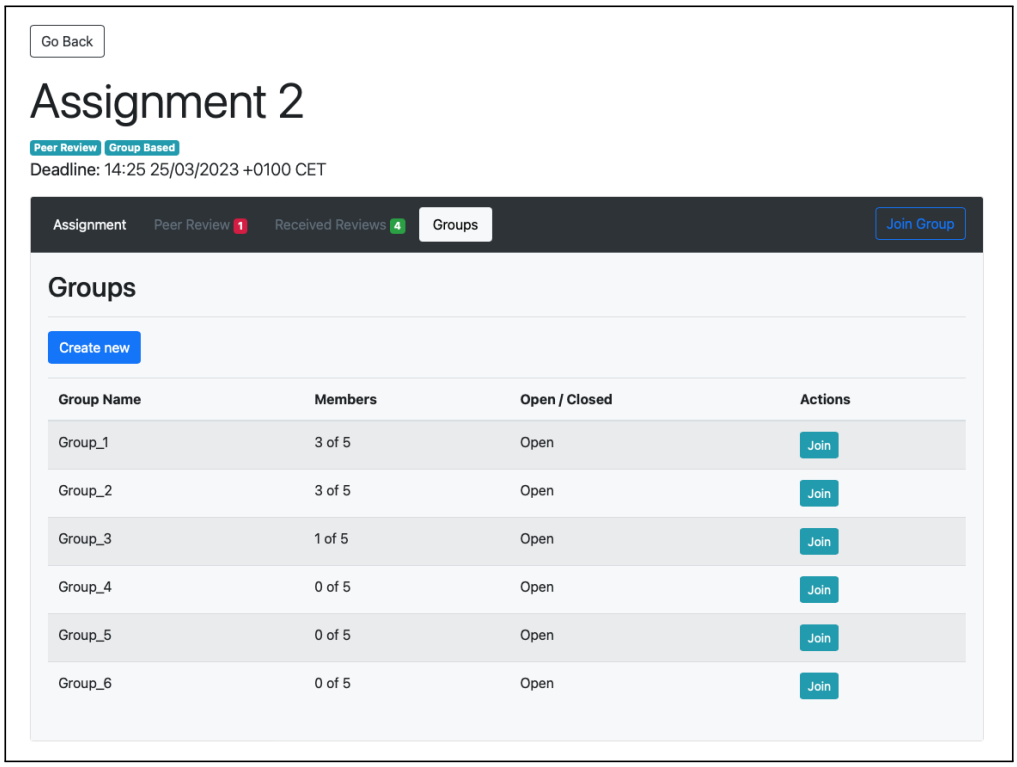


Figure 4.7: End result of the student join a group page, a student page

Figure 4.8 shows the user group page. A student will only be able to see this page once they have joined a group. On this page, the student gets an overview of their group. Here they can see the group name, total of group members, open/closed status of the group, and they can see all the group members. On this page the students have multiple options, first they can leave the group by pressing leave group. If this button is pressed, the student will get a warning asking them to confirm their choice. The other options are two types of voting systems. The first vote allows the user to vote for removing a member, while the second vote allows the user to vote to close the group. These voting systems have been built to create democracy in the group and reduce the amount of work a teacher has to do to administrate the groups. To be able to close the group and prevent more students from joining, the whole group has to vote to close it. There needs to be a minimum of two students in the group to be able to close it. Once the group is closed, the vote will be updated to allow the users to vote to open the group again. This works in the same way as closing it.

With the ability to remove members from the group, the group gets the power to remove free riders from the group without involving the teacher. To be able to remove a member from the group, the whole group has to vote to remove the same member. A member will at all times be able to withdraw their vote if they were to reevaluate their choice. Once the deadline for delivering has passed, the voting system will be disabled, to prevent people from being removed from the group after delivery.

Figure 4.9 shows the 'create a new assignment page', which is an admin page. This page was already existing but has been upgraded to allow for creating a group assignment. To access the options for a group submission, the teacher has to click on the button that turns on group submission. Once this is turned on, the different options for group submissions will appear. Here the teacher has to select several options to be able to create the submission. The teacher has to set the minimum and maximum of members of a group and set a deadline for joining a group. There are also two optional settings for more customization. The first option allows the teacher to predefine a set of groups that students can join. The teacher can generate as many groups as wanted. There is an optional setting that allows the teacher to activate the functionality for students to manage groups on their own. By default, this option is turned off, which means that students can´t create groups.

Lastly, 4.10 shows the 'admin group overview' page. On this page, the teacher has full access and an overview of all groups and students. Here the teacher can see a table that shows all existing groups with the following information: *groupID*, *group name*, *total members* in the group, whether the group is open or closed, and the name of each member in the group. In this table, the teacher is able to remove a student from a group and delete a group. Both empty and non-empty groups can be deleted. If a group with members is deleted, the members are automatically removed from the group before deleting it. To the bottom left of this page, there is a table that shows all students that are currently not in a group. Here the teacher

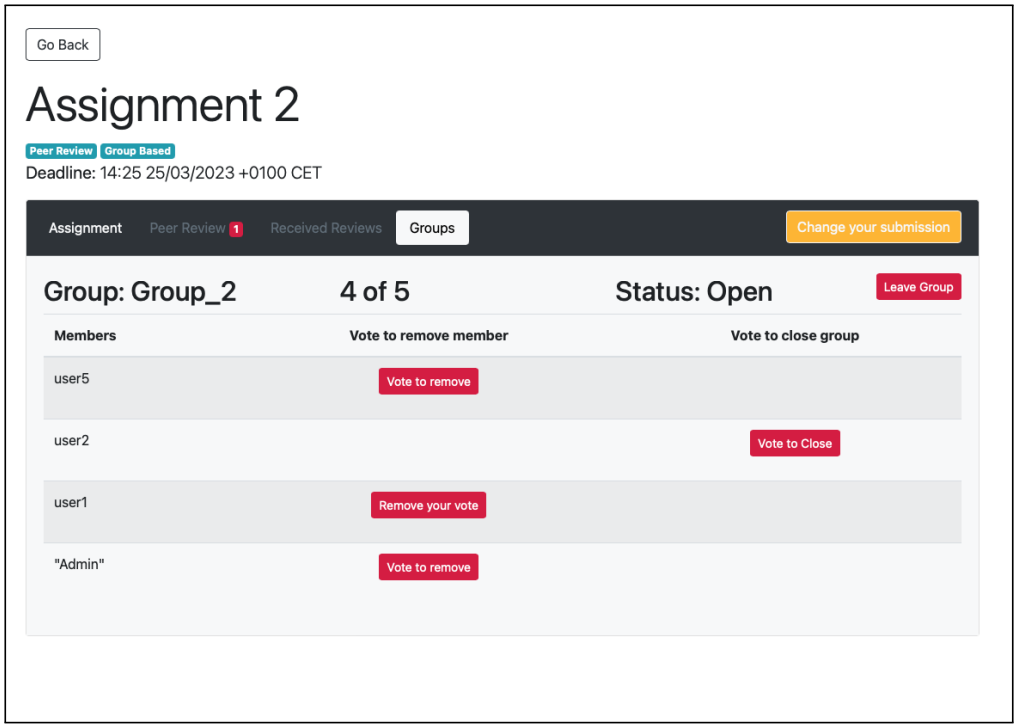


Figure 4.8: End result of the student group page, a student page

can see the students' names and has the option to add individual students to a group. Adding a student only requires the corresponding *groupID*. To the bottom right the teacher has the opportunity to create a new empty group, the teacher only needs to define a group name.

These four pages have been the ones with the most substantial updates in the system and are the most important pages to this system upgrade. There have, however, been smaller updates and changes to several other pages in this system for them to work with the new group functionality.

4.4 Integration

The integration of the development was important to make sure the system was up and running, ready to use, and working as it was supposed to especially since it would be used in a production setting in a classroom. There were a few important considerations needed to be able to integrate the system into the master branch. First of all, the master branch had to be up and running with the new features before the end of February since it would be used from the beginning of March. Secondly, there was another master's student working on the same application, but he was working on another part of the system. Thirdly, the deployment required setting up an instance on Skyhigh to run a server hosting the application. Skyhigh[28] is NTNU Gjøvik's own internal version of OpenStack[29].

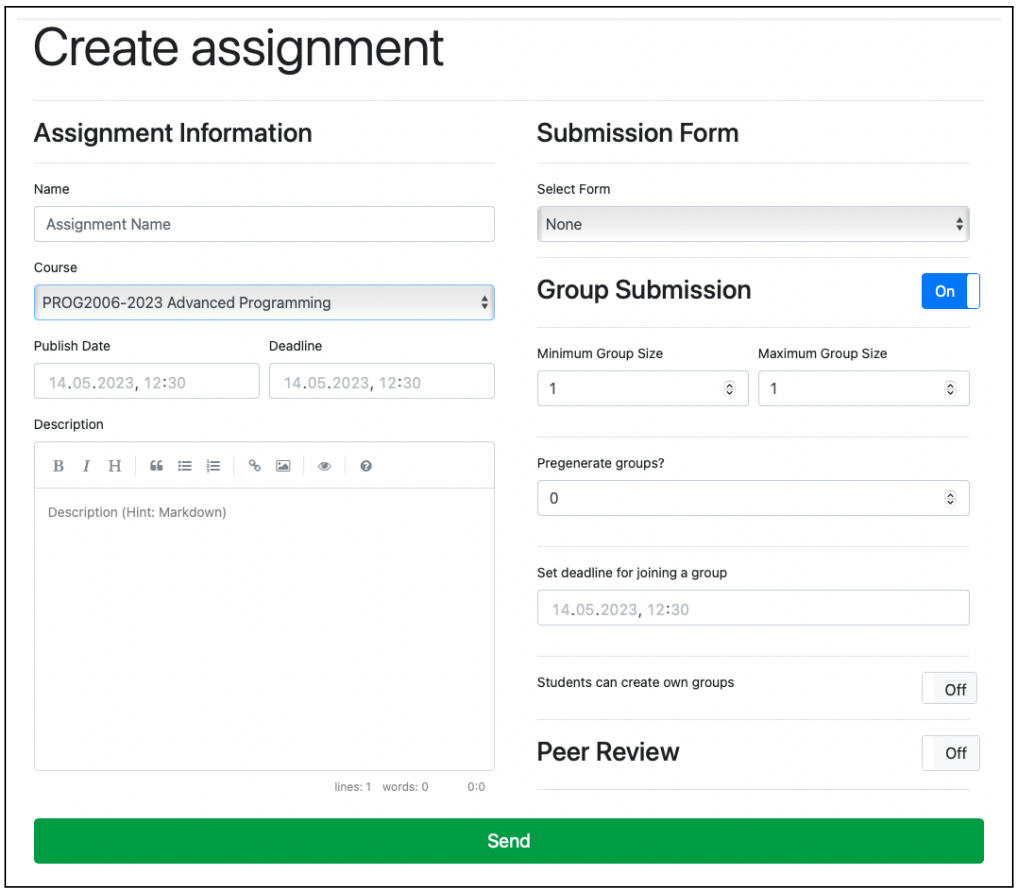


Figure 4.9: End result of the create a new assignment page, an admin page

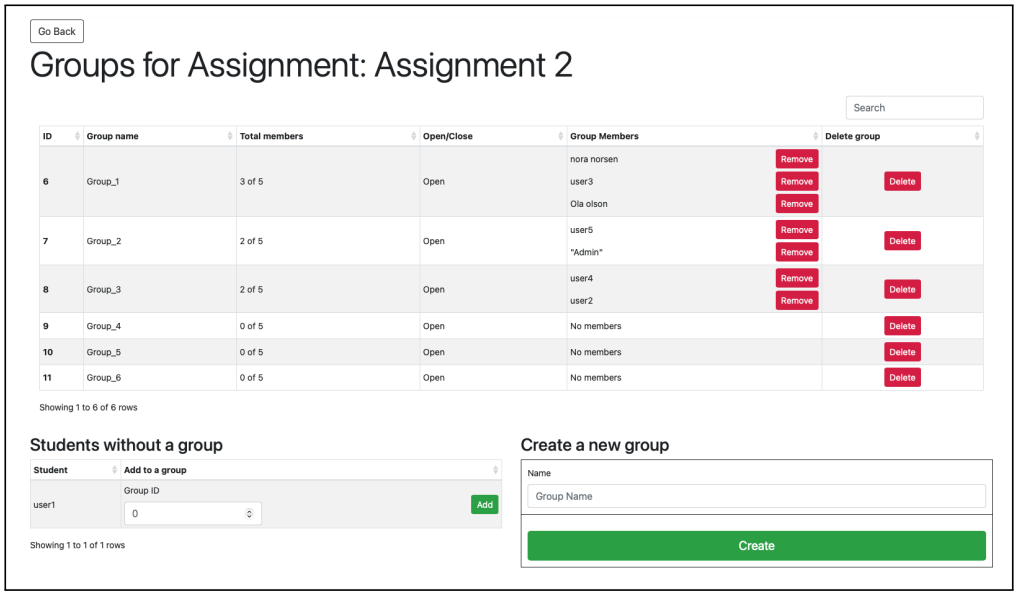


Figure 4.10: End result of the admin group overview page, an admin page

After finishing the development of the group management functionality, it was time to push the code into the master branch. The group feature was developed in a branch of the master branch, and had, thus, all the existing code. Therefore, when it was time to merge it, there were no conflicts since there had been no changes to the master branch during this development. The potential problem was that the other master's student also worked on the application, and he also branched out from the master branch. To try and reduce the merge conflict probability, the group management functionality was merged first into the master. This was because this feature had the most changes to the database, and it was completed first. Another factor was the limited time left before the system needed to be up and running. Since the other master's student was not finished with his code before we needed the system, it was necessary to include his changes in the database and then add the rest of his code later when it was ready. The system can not accept changes to the database once it is in production (or require additional migration scripts to adjust the database schema while preserving existing data). This was deemed an unnecessary and avoidable risk, given the production use of the system.

To make the system available and accessible for the students and the teachers, a production server was set up in SkyHigh. Through a discussion with my supervisor (the teacher for the Cloud course in which CSAMS was primarily used), it was concluded that two servers were needed for running CSAMS. One instance was used for production, which is the one that will be used in the course, and one for testing code prior to entering production. The test server was accessible to the teacher, the teaching assistants, and myself. This server allows for testing of potential fixes and updates needed in the production system. Fixes could be

reviewed and verified, before deploying them in the production environment.

The production server is the one that was going to be used in the Cloud course. Since I was setting up the server, it was my responsibility to add the teacher to the system and give him admin rights. Once the teacher was accepted into the system, he could add his teaching assistants, the students in his course and create the assignment they were supposed to deliver in the system.

4.5 Production

Being the production owner came with a lot of extra responsibilities such as making sure the server was up and running, fixing any bugs, and keeping it secure. During the production, there were several bugs appearing. Some of them were from the old code and some from the new features. Luckily, none of them were critical and needed immediate attention (or led to any data loss). Although they did not need immediate attention, the goal was to address the bugs relatively quickly after discovering them, with the intent to harden the system further.

At one point in the middle of March, all of a sudden a critical and time sensitive problem materialized. All the students had gained access to selected admin pages in the system and notified us. Given the students' access to data that they were not supposed to see, this emergency needed immediate action. The first cause of action was to take the server offline to prevent the students from exploiting the weakness. The second step was to find and fix the problem causing the students to get elevated privileges. This was a problem that took several hours to solve. The problem was that the function checking for if a user is an admin in the sessions had been altered. It was supposed to check if a user was both logged in and had admin rights, but it was now checking whether a user was logged in or had admin users. This meant that all users now had admin rights. Once the problem was identified, it was easy to find out how this had happened. Earlier that week a maintainer of the system had tried to clean up and remove old branches in the repository, and at some point during merging the breaches back into the master branch, this function had been altered without anybody noticing it. This massive branch merging had also altered a few other functions, creating a few other bugs in the system, all of which were addressed. To take an extra security precaution before giving the students access to the system again, the decision of creating a new server was made, to make sure there were no hidden exploits in the system. To set up a new server a new instance in OpenStack needed to be created, and then the application needed to be set up from scratch. Once the application was set up, the data in the database from the old production need to be exported and then imported to the new production server. When the system was ready, the last thing to do was to make the system available again (i.e. assigning the previous IP address to the new production server), so that the students were able to access and use the system again. No data was lost in the process, however, it highlighted the challenges of running a production environment while having ongoing development by different contributors.

4.6 Surveys

This section will cover how the surveys were designed and the tools used. Due to the strict rules of data handling Nettskjema [30] was used to create the survey and deliver it to the students participating. Before creating the surveys in Nettskjema, the questions needed had to be made.

Further on in this section the process of creating the survey will be described. First to be described is the first survey, this one was for the individual assignment. Lastly is the second survey, this one was for the group assignment.

4.6.1 First survey

The process of finding relevant questions measuring learning outcome from peer review, and using a five point Likert scale, was soon discovered to be a hard process. Trying to come up with relevant and precise questions by myself, was a hard task. Thus, there was a need for help on this task, and the process of looking for what tools and persons could help on this subject started. The first thought was to ask the supervisors for help during our meetings. However, at the same time, the AI tool ChatGPT [31] appeared, and raising the idea of whether it would generate good and useful questions for this survey.

To find this out ChatGPT was asked to create questions to measure learning outcome on coding assignments with peer reviewing. The responses given were useful, and it generated well formulated questions that had a three point Likert scale answers. ChatGPT only created six questions at a time, the process was repeated to generate more questions with different focus until it had generated 60 different questions. The questions created from ChatGPT were then copied and added to the list of questions already made. In total the list of questions had now passed 80 and was used as the first draft. The first draft can be found in the appendix under “First draft of survey questions for individual assignment”.

With the first draft in place, it was time to go through all the questions and find the ones that were going to be used. This was an iterative process. For the first iteration, all the questions were reviewed, and the questions that were not relevant were discarded. I quickly decided to focus on the questions created from ChatGPT since they were more relevant and better formulated than the self made ones. The discarded questions were divided into two groups, one was the ’not relevant’ ones and the other was the ’maybe relevant’ ones. After discarding those questions, there were 41 questions left. In the next iteration, overlapping and similar questions which would collect the same or very similar data, were assessed. Here ChatGPT was used again, this time all 41 questions were sent to ChatGPT, and asked for it to find the questions that were overlapping or similar to each other. It responded with which questions were overlapping. In the response, the questions were highlighted in the same color as the questions they were overlapping. Once all questions were given a color, they were grouped together by color to easier compare them. The next iteration was to find which one of the over-

lapping questions, was better to use and by that reduce the number of questions again.

Between each iteration, meetings with the supervisors were held to discuss the questions. These meetings helped to reduce the number of questions. As well as altering the questions to become better. These meetings were also important for getting others' opinions. Due to the fact that the supervisors have been using peer review for their courses for several years, they have more experience and expertise on the subject, and they know better how students respond to surveys.

After this reduction of questions was done, 16 questions were left. 16 questions were considered a good amount for the survey, given that it was short enough for the students to be willing to complete. Still, it also had enough questions to be able to collect the data needed for the research. To make these questions even better and more precise the three point Likert scale answers were upgraded to a five point Likert scale answer. With a range of five answers, the data collected will be more precise. Lastly, some of the questions were rephrased to be more accurate and easier to understand. With this, the final version of the individual assignment questionnaire was finalized and then set up in Nettskjema to be sent out to the students. The final version for the individual assignment survey can be found in the appendix under "Final version of survey questions for individual assignment"

4.6.2 Second survey

For the second survey, the questions needed to be altered to take into account the differences for a group work assignment. The questions needed to collect the same data, but they had to take group work into consideration. The questions were rephrased to ask about the groups' code instead of the persons' code. There was also a need, to ask questions more specific to the group work itself, and thus a few more questions were added to the survey. To ease the analysis later the new questions were added at the end of the survey. In that way, the same order was kept for the existing questions, which would ease the comparison of the two surveys. To finalize these questions, a meeting was held with the supervisors to go through and discuss them. The final version of the group assignment survey can be found in the appendix under "Final version of survey questions for group assignment"

In the next chapter, all results collected through these surveys will be analyzed.

Chapter 5

Results

This chapter will focus on how the data is collected, analyzed, and compared. Each survey will be analyzed separately before comparing them.

This chapter is divided into four sections. The first section is 'Data collection' this one will go over how the data was collected. The second section is 'Individual assignment' and will analyze the data collected with the survey for the individual assignment. The third section is 'Group assignment' and will analyze the data collected with the survey for the group assignment. The final section is 'Comparing both assignments' and will compare the results from both assignments.

5.1 Data collection

The data collection worked the same way for both surveys, and relies on Nettskjema[30] for survey design and collection. To be able to start collecting data through Nettskjema, the survey first needed to be opened. Once it was opened the system created an URL to access the survey as a participant. This URL was then sent to the teacher who shared it with the students. The survey was not compulsory for the students, but they were encouraged to participate as a reflection on their use of the system and the impact of peer review more generally.

Once a student submitted a survey response, the data was collected and saved in the system. Nettskjema allows for seeing the current status of the survey. At the end of the survey, all the data collected was downloaded as an Excel file which was then used to analyze the results. This will be discussed in the upcoming sections.

One problem during the data collection, was to get students to participate in the survey. This was difficult when it was not compulsory for their course. Thus, the number of participants was lower than hoped for, but it was still enough to be able to analyze the data, with a participation level close to 20 percent for both surveys.

5.2 Individual assignment

In the individual assignment, there were 87 students that submitted the assignment. Of them, 17 submitted to the survey for the individual assignment. In this section, the results from this survey will be analyzed. First of all, in this assignment, each student got the same task. They were going to create a "REST web application in Golang that provides the client to retrieve information about universities" [32]. For more information about the overview of the individual assignment, see "Overview of assignment 1" in the appendix. Once the students had finished their task, they had to deliver it in CSAMS. Once the deadline for the assignment passed, the peer review stage would open, and allow the students to review other students' tasks. Here each student was required to perform at least two reviews. When the deadline for the peer review passed, the survey for the individual assignment was sent out to the students. It was distributed to the students during class and in the course forum, and students were reminded about it several times in the hope of getting more participants.

The data collected from the survey was both collected answers to the questions given, as well as extra comments from the students. For each question, students were allowed to provide extra comments on the answer if they wanted. Several students gave extra comments, which helped to clarify their answers further.

At this stage, the results from this survey will be analyzed. First, the results from the questions will be analyzed, then the comments will be taken into the analysis.

All data collected through the survey can be found in the appendix under "Results and comments from survey 1"

5.2.1 Overview of the questions given to the students in the individual survey

All questions have a five-point Likert scale answer.

- Question 1: What is your previous experience with peer review?
- Question 2: How effective was the peer review to reflect on the overall quality of the assignment submission?
- Question 3: To what extent did you understand the code you were reviewing?
- Question 4: How helpful was the feedback received from your peers in terms of learning new programming skills?
- Question 5: To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
- Question 6: How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
- Question 7: How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?

- Question 8: Did knowing about participating in peer review increase your engagement with the assignment?
- Question 9: How much time did you spend reviewing the code of your peers?
- Question 10: To what extent did the peer review process improve your critical thinking?
- Question 11: To what extent did you benefit from the peer review process in terms of your professional growth?
- Question 12: How much did you agree with the feedback received from your peers during the review process?
- Question 13: How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
- Question 14: How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
- Question 15: Was the peer review process a fair way of evaluating your code and the code of your peers?
- Question 16: How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?

5.2.2 Analysis of data

First of all, it is smart to establish the students' experience with peer review before this assignment. This can be done by looking at the first question of the survey. The first question was "What is your previous experience with peer review?" and the results can be seen in figure 5.1. Looking at the graph it is easy to see that 47% of the students have never had any experience with peer reviews, or just heard about it. While 53% have participated in peer reviews before. Looking just at the students who have participated in peer review before 66.7% (This is 35.3% of all the participants of the survey) have participated in peer review more than 3 times. With only 5.9% having done one peer review before, the students can then be divided into two groups. The first group is the students with no or little experience with peer review which equals 52.9% of the participants. The second group would be the students with some or a lot of experience which equals 46.3% of the participants.

Looking at the extra comments to this question, some of the students have elaborated on where their earlier experience with peer review comes from. Some of the comments say "Have had peer reviews in Advanced Programming, Databases, and taken Cloud once before.", "Done something similar in other subjects, but nothing at this scale." and "Mostly from this course before and PROG2006". Looking at these comments one can see that some of the students have their experience from other courses and from retaking this course. It is possible to assume that this most likely is the same case for the other ones with earlier experience.

Further on in this analysis, the rest of the questions will be grouped together in categories based on their similarity. They are grouped into the following cat-

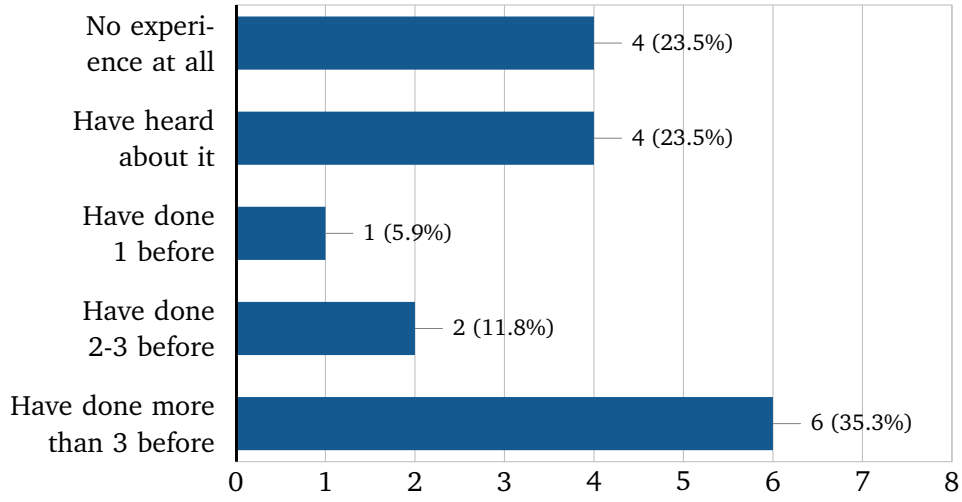


Figure 5.1: Survey 1 - Question 1: What is your previous experience with peer review?

egories: *General aspects of peer review*, *Reviewing of peers*, and *Receiving feedback*.

General aspects of peer review:
The questions in this category are the questions that cover the general aspects of peer review, namely questions 2, 8, 9, and 15.

In question 2 the goal was to measure the effectiveness of using peer review to reflect on the overall quality of the submission from the five answer options: **Not effective at all** - 0(0.0%), **Slightly effective** - 3 (17.6%), **Moderately effective** - 6 (35.3%), **Very effective** - 6 (35.3%), **Extremely effective** - 2 (11.8%). Looking at the results, the students found the overall effectiveness to be moderate to very effective. The comments received on this question introduces some explanations to the answers. All students who answered 'slightly effective' commented on this answer. The similarities found in their comments were that they found the feedback they had received to be badly executed. Looking at the comments from the students answering on higher effectiveness of the scale, there also seems to be a lack of good feedback. They found, however, that reviewing others' tasks was helpful. Some of the students found the feedback to be very helpful.

Question 8 tries to find out if the students' engagement with the assignment increased when they knew about participating in peer review afterward. Based on the answer options, the answers received were: **Did not increase engagement at all** - 5 (29.4%), **Slightly increase engagement** - 5 (29.4%), **Moderately increase engagement** - 6 (35.3%), **Very much increase engagement** - 1 (5.9%), **Greatly increase engagement** - 0 (0.0%). Analyzing the results and the comments received, it looks like the increase in engagement was based on whether the student cared about if other students reviewed their assignment or not. Most of the comments to this question came from the students who answered that it

'did not increase their engagement'. And these students all said that they did not care if someone, other than the teacher, reviewed their code. While the other comments show that some tried to make their code more readable, some increased engagement simply because it was mandatory. Some had misunderstood the question. To conclude, it does not look like students increase their engagement in the assignment even if they know that peer review is a part of it.

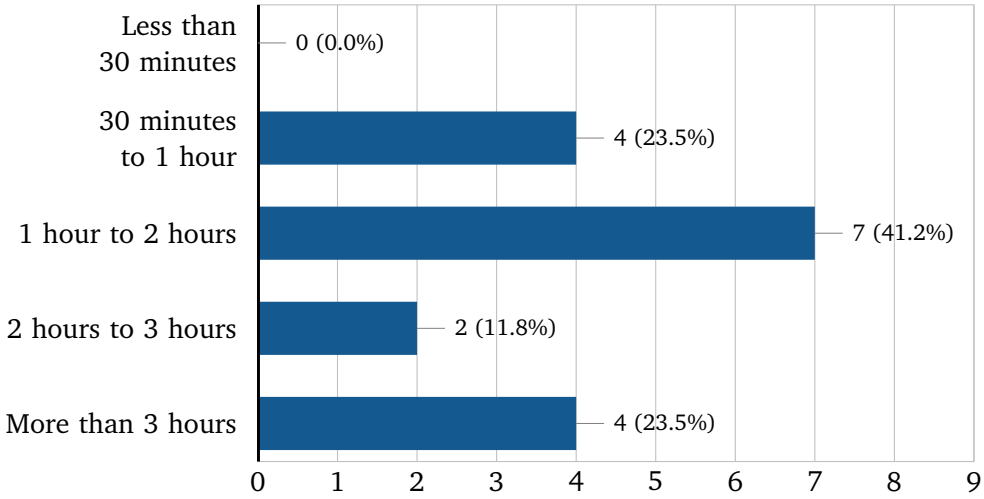


Figure 5.2: Survey 1 - Question 9: How much time did you spend reviewing the code of your peers?

The goal of question 9 was to establish how much time the students have used on reviewing the other students. The results received here can be seen in figure 5.2. The comments indicate that the question was lacking clarification because students have interpreted the question differently. They have either interpreted the question as if it was asking for the time used per review they completed, or as if it was asking for the total time they used. Luckily, many clarified this through their comments. Based on the comment most of the students who answered either '2 hours to 3 hours' or 'more than 3 hours', had answered the total time, and had used around one hour per review. While some of the students who answered a lower time, said that this was the time they had used per review. Based on this, and that each student was only required to complete two peer reviews, it is possible to assume that the average time used per peer review was one to two hours.

With question 15 the goal was to find out if the students thought that the peer review process was a fair way of evaluating their and their peers' code. These were the answers collected for this question: **Not at all fair** - 2 (11.8%), **Slightly fair** - 3 (17.6%), **Moderately fair** - 5 (29.4%), **Very fair** - 5 (29.4%), **Extremely fair** - 2 (11.8%). Based on these answers, most students found it to be moderate to very fair to use peer review for evaluation. The comments indicate that students who did not find it fair, were afraid that their course grades would be based on the feedback, and the experience of receiving poor feedback from their reviewers.

In the Cloud course, this is not a problem since peer review is used for learning, and the students' grades are not based on the feedback they receive.

From the students' responses, the peer review process seemed to be moderate to very effective both when it comes to reflecting on the overall quality and evaluating their code. The increase in engagement in knowing about participating in peer review varied. It looks like most students still used one to two hours for giving a review to their peers.

Reviewing of peers:
The questions found in this category are the ones focusing on the reviews the students completed, namely questions 3, 5, 10, 11, 13, 14, and 16.

In question 3 the goal was to find out how much the students understood of the code they were reviewing. For this question the following answers were received: **Did not understand anything** - 0 (0.0%), **Understand very little** - 1 (5.9%), **Understand a moderate amount** - 2 (11.8%), **Understand a lot** - 10 (58.8%), **Understand completely** - 4 (23.5%). From these results, it is clear that the students understood most of what they reviewed. With a total of 58.8% saying they 'understand a lot' and 23.5% saying they 'understand completely'. The comments to this question are mostly on students further explaining their answers.

With question 5 the goal was to find to what extent the students learned new programming concepts and techniques from reviewing their peers. To this question the following answers were collected: **Did not learn anything** - 3 (17.6%), **Learned very little** - 7 (41.2%), **Learned a moderate amount** - 7 (41.2%), **Learned a lot** - 0 (0.0%), **Learned a great deal** - 0 (0.0%). The results indicate that most students learned a little to a moderate amount of new concepts and techniques, while some did not learn anything new. Looking at the comments, some of the students have explained that they learned a few new techniques and approaches to the problem. There were also comments about reviewing other students' assignments that were solved in the same way as they had done themselves, and, thus, they did not learn anything new.

The goal of question 10 was to find out to what extent the peer review process improves the students' critical thinking. For this question the following answers were collected: **Did not improve at all** - 4 (23.5%), **Slightly improved** - 4 (23.5%), **Moderately improved** - 7 (41.2%), **Improved a lot** - 2 (11.8%), **Improved significantly** - 0 (0.0%). Analyzing these results, it is clear that peer review improves most students' critical thinking slightly to a moderate amount. There are some exceptions where students did not learn anything or learned a lot. Looking at the few comments to this question, the reason for this comes from the difference in skill level and effort put into the review.

Question 11 tries to measure to what extent a students' professional growth benefits from the peer review process. The results from this question can be seen in figure 5.3. There were very few comments for this question, and, thus, they do not provide much clarification. The results indicate that most students have

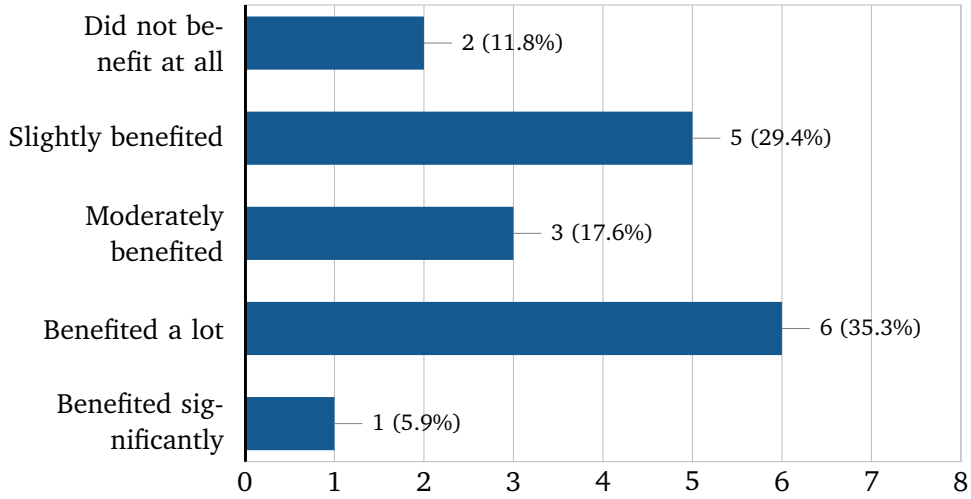


Figure 5.3: Survey 1 - Question 11: To what extent did you benefit from the peer review process in terms of your professional growth?

professional growth to a degree. Seeing that 35.3% 'benefited a lot' while 29.4% 'slightly benefited' and 17.6% 'moderately benefited', it is possible to say that the degree to which a student benefits from professional growth varies from student to student. Based on the results of the earlier questions, this most likely is due to differences in skill level. Assuming that the students with lower skill level benefits more than a student with a higher skill level.

For question 13 the goal was to find out how confident the students were in giving constructive feedback and suggestions while reviewing. The answers collected to for this question was: **Not confident at all** - 2 (11.8%), **Slightly confident** - 1 (5.9%), **Moderately confident** - 5 (29.4%), **Very confident** - 6 (35.3%), **Extremely confident** - 3 (17.6%). Analyzing these results, one can quickly see that most students felt confident in giving feedback. The majority of the student found themselves to be moderate to very confident. Looking into the comments collected for this question, one can see that the ones answering 'not confident at all' or 'slightly confident', either commented that they felt underqualified to give feedback due to being a lower-performing student, or that this was their first time doing a peer review and they did not know how to execute it. When looking at the comment of the more confident students, several of them state that they believe they gave good and helpful feedback. Some of them also stated that they felt even more confident in the second review they executed.

In question 14 the goal was to find out how the students felt the peer review process helped improve their communications skills when it comes to explaining technical concepts and making suggestions. For this question these answers were collected: **Did not help at all** - 2 (11.8%), **Slightly helped** - 8 (47.0%), **Moderately helped** - 5 (29.4%), **Very much helped** - 1 (5.9%), **Extremely helpful** - 1 (5.9%). Analyzing the results, it is clear that most students did not feel they

improved their communication skills very much. With 47.0% answering 'slightly helped' and 11.8% answering 'did not help at all', that is 58.8% feeling they did improve a little to noting on their communication skills. 29.4% answered 'moderately helped', which means that very few found that their communication skill improved more than a moderate amount. For this question, there were very few comments, Which did not have much basis for further analysis.

The goal of question 16 was to find out if the peer review process helped students to improve their ability to debug code and identify errors. The answers collected for this question were: **Did not help at all** - 4 (23.5%), **Slightly helped** - 5 (29.4%), **Moderately helped** - 4 (23.5%), **Very much helped** - 4 (23.5%), **Extremely helpful** - 0 (0.0%). For the first time, the answers are equally distributed. Comparing the result with the few comments for this question, it looks like this is a question based on experience with debugging from before. The students that already have much experience in debugging, said that they did not learn much, while the students with less or no experience said they learned a lot. Based on that, some of the earlier results were affected by skill level and the few comments on this question. One can assume that for most students the degree to which they improved their debugging skills, was affected by their existing knowledge.

Throughout the questions related to reviewing other students, one factor found in most of the questions that affect the results is skill level. Both the skill level of the student reviewing and the quality of the code the student reviews, affect how much the student learns from reviewing. The way CSAMS is built now is that a student receives a random assignment to review. This means that they can either get an assignment completed by a higher-performing student, a same-level performing student, or a lower-level performing student. Only reviewing lower-level students might limit the learning outcome, since the student reviewing might not learn any new skills and techniques which they could have done by reviewing higher-performing students.

Receiving feedback:
In this category, the questions here are the ones with a focus on the feedback, namely questions 4, 6, 7, and 12.

In question 4 the goal was to find out how helpful the feedback received was to learn new programming skills. The answers received her was: **Not helpful at all** - 2 (11.8%), **Slightly helpful** - 10 (58.8%), **Moderately helpful** - 4 (23.5%), **Very helpful** - 1 (5.9%), **Extremely helpful** - 0 (0.0%). With 58.8% answering 'slightly helpful' and 11.8% answering 'not helpful at all'. It is clear that a majority of the students did not find the feedback to be any helpful in learning new programming skills. All comments received on this question are from the students who answered 'slightly helpful' or 'not at all helpful'. Most of them commented on receiving poor feedback. They only mention the problems, but did not elaborate on how to solve them.

For question 6 the goal was to find out how helpful the feedback received was to identify and fix errors in the students' code. For this question the following an-

swers were collected: **Not helpful at all** - 2 (11.8%), **Slightly helpful** - 6 (35.3%), **Moderately helpful** - 7 (41.2%), **Very helpful** - 2 (11.8%), **Extremely helpful** - 0 (0.0%). Analyzing these answers, one sees that the students found the feedback more helpful when it comes to identifying and fixing errors in their code. Almost half the students found it 'moderately helpful'. Looking at the other answers, it is clear that the helpfulness is still at the lower end with 35.3% as 'slightly helpful' and 11.8% as 'not helpful at all'. Looking into the comments one can see that there also is a problem of poor or missing feedback.

The goal of question 7 was to find out how good the feedback received was in clarifying the suggestion and comment they were giving. For this question the following result were collected: **Not helpful at all** - 2 (11.8%), **Slightly helpful** - 7 (41.2%), **Moderately helpful** - 5 (29.4%), **Very helpful** - 3 (17.6%), **Extremely helpful** - 0 (0.0%). Analyzing the result for this question, there are a lot of similarities with questions 4 and 6. As earlier, most of the answers are found on 'slightly helpful' to 'moderately helpful'. While some have answered 'very helpful', a majority still found the clarity in the feedback to be on the lower part of helpful. Looking at the comments for this question, they mostly clarified the lack of helpful comments, but there were a few that found parts of the feedback to be helpful.

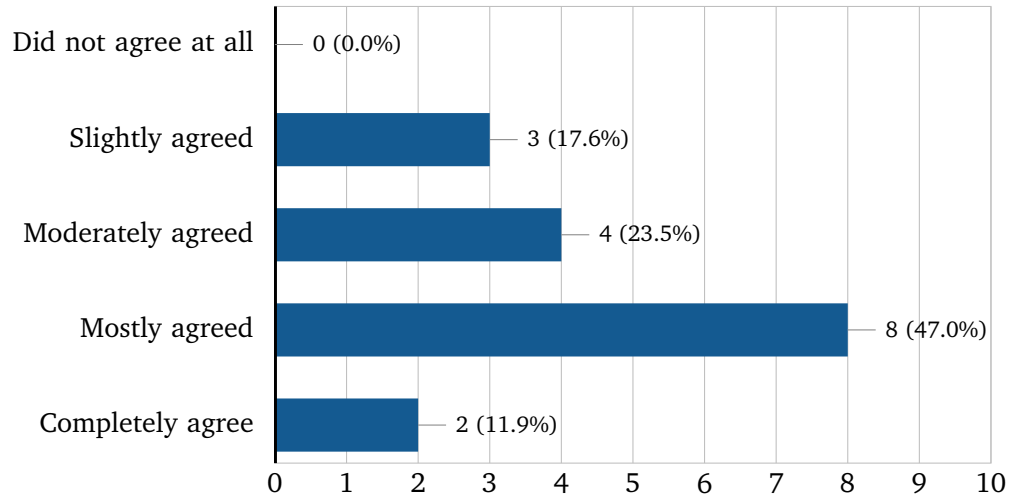


Figure 5.4: Survey 1 - Question 12: How much did you agree with the feedback received from your peers during the review process?

Question 12 had the purpose of finding out how much the student agreed with the feedback received. The results can be seen in figure 5.4. Looking at the results it is clear that most of the students mostly agreed with the feedback they received. There are also some students that 'moderately agree' to 'slightly agree' with their feedback. This was to be expected, based on the earlier results of feedback. There were not so many comments for this question, but a few students commented that their reviewer had misunderstood their code and focused the feedback on the misunderstanding.

From these four questions related to feedback, it is clear that most students learned a slightly to moderate amount from the feedback. It seemed that the learning outcome was on the lower part due to that many students seemed to have received poor feedback. There were some exceptions where students had received good feedback and they seemed to have learned much more. While the feedback was not so good, most students seemed to agree with the feedback they had received.

5.3 Group assignment

In the group assignment, there were 27 groups submitting the assignment. Through all these groups, there were a total of 84 students participating. That is 3 students less than in the first assignment. In the Cloud course, it is normal that there are some students that drop out after the first assignment. Of all of the students participating in this assignment, there were 15 that participated in the survey for the group assignment. In this section, the results from this survey will be analyzed. First of all, this assignment was the first time the group management functionality in CSAMS was used. Students were allowed to create and populate their own groups in this assignment. All groups got the same assignment and had to create a "REST web application in Golang that provides the client with the ability to retrieve information about developments related to renewable energy production across countries"[33]. For more information about the overview of the group assignment, see "Overview of assignment 2" in the appendix. With the new group management functionality, only one student per group had to submit the assignment. When it comes to the peer review stage it works the same way as for an individual assignment. Each student individually would review other groups' codes. The group they review is randomly selected, this means that students in the same group can end up reviewing different groups. A student is not able to review their own group.

As for the individual assignment, this survey was sent out to the student right after the deadline for peer review was passed. This survey followed the same structure as the first one, where students had to choose one of five options per question. The students also had the option to elaborate more on each question by giving comments. Now the results from this survey will be analyzed. Both the answers and comments will be taken into consideration.

All data collated in this survey can be found in the appendix under "Results and comments from survey 2"

5.3.1 Overview of the questions given to the students in the group survey

All questions have a five-point Likert scale answer. The first 16 questions are the same as the survey of the individual assignment.

- Question 17: How would you rate your own level of participation and contribution to the group project?
- Question 18: How do you prefer to learn: by working individually or in a group?
- Question 19: How much do you feel you learn from doing an individual assignment versus a group assignment?
- Question 20: To what extent do you think there were unequal contributions in your group?
- Question 21: Did working in a group increase your engagement with the assignment?
- Question 22: Was there any difference in reviewing an individual assignment versus a group assignment?
- Question 23: Was there any difference in receiving reviews for an individual assignment versus a group assignment?
- Question 24: Do you have any comments about the new group functionality to CSAMS? Something you liked or something you did not like? (Text answer and optional to answer)

5.3.2 Analysis of data

First of all the students' experience with peer review before this assignment needs to be established. Their experience is expected to be changed from the last survey, due to the fact that the students should now at least have been through one peer review. By looking at figure 5.5 one can see that 73.3% of the students have done two or more peer reviews before the second assignment. While there are 20.0% that say they have 'no experience at all' and 6.7% say they 'have heard about it'. Since this is the second peer review in the cloud course, one can assume that these students have misinterpreted the question. From the few comments to this question, the comments only mention where they have done peer review before.

Further on the questions will be analysed and categorized in the same way as the first survey. The new questions will be put in separate categories. The categories are *General aspects of peer review*, *Reviewing of peers*, *Receiving feedback*, *Group work*, *Group versus individual*, and Feedback on the group management functionality.

General aspects of peer review:
The questions that have been placed in this category are the questions that are based on the general aspect of peer review, namely questions 2, 8, 9, and 15.

In question 2 the goal was to measure the effectiveness of using peer review to reflect on the overall quality of the submission. From the five answer options the answers were: **Not effective at all** - 0 (0.0%), **Slightly effective** - 2 (13.3%), **Moderately effective** - 7 (46.7%), **Very effective** - 5 (33.3%), **Extremely effective** - 1 (6.7%). Analyzing these results one can see that 46.7% of the students found using peer review was 'moderately effective' to reflect on the overall quality of

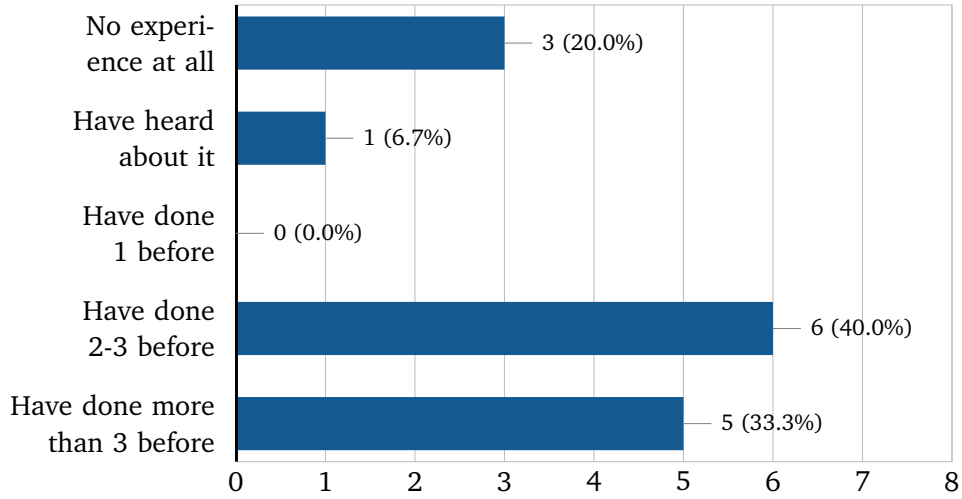


Figure 5.5: Survey 2 - Question 1: What is your previous experience with peer review?

the assignment. While 33.3% found it to be 'very effective'. In total one can say that most students found it to be moderate to very effective. Looking at the comments for this question, one can see that most of the comments complain about the feedback they received. Some of the comments are from students answering 'moderately effective' and 'very effective', but the ones answering 'moderately effective' were the ones to complain the most.

Question 8 tries to find out if the students' engagement with the assignment increased when they knew about participating in peer review afterward. Based on the answer options the answers revived was: **Did not increase engagement at all** - 5 (33.3%), **Slightly increase engagement** - 5 (33.3%), **Moderately increase engagement** - 3 (20.0%), **Very much increase engagement** - 0 (0.0%), **Greatly increase engagement** - 2 (13.3%). Looking at these results, one can see that 66.6%, which is 2/3 of the students, found their engagement not to increase at all or only slightly when they know about participating in peer review afterward. While there were 20.0% choosing 'moderately increase engagement' and 13.3% 'very increase engagement'. This shows that for some there was an increase in engagement. Most of the comments received for this question, were from the students who answered 'did not increase engagement at all'. These students comments that they already strive to do their best, and that participating in peer review did not alter it. There was also one of the students who chose 'moderately increase engagement', who commented that the peer review motivated him to write cleaner code, use comments and create a reamed file for the project. Based on both the answers and the comments, it looks like the increased engagement for the assignment was based on the students' goals, and if they wanted to put extra effort to make their code more readable for the ones to review it.

The goal of question 9 was to establish how much time the students have

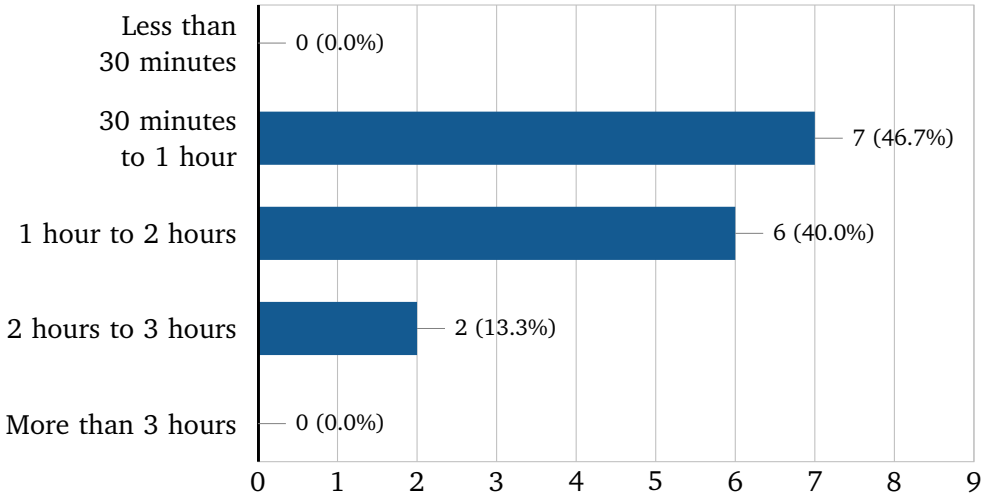


Figure 5.6: Survey 2 - Question 9: How much time did you spend reviewing the code of your peers?

used on reviewing the other students. The results received here can be seen in figure 5.6. For this question, it was clarified in the survey that this question asked for how many hours they used per review they did. Looking at the result on can see that 46.7% said they used '30 min to 1 hour', while 40.0% used '1 hour to 2 hours'. This equals 86.7% of the students and one can therefore say that most students used around one hour per review, but there were also some students using between two to three hours. Looking a the comments, it seems like the time varied from review to review and that there were several factors influencing the time used. The students mentioned that project size, how well the assignment was done, their expertise, and the effort they put in, were key factors.

With question 15 the goal was to find out if the students thought that the peer review process was a fair way of evaluating their and their peers' code. This was the answers collected for this question: **Not at all fair** - 1 (6.7%), **Slightly fair** - 5 (33.3%), **Moderately fair** - 4 (26.7%), **Very fair** - 4 (26.7%), **Extremely fair** - 1 (6.7%). Analyzing these results, it is possible to say that it looks like the students have different opinions. While there are a bit more students answering 'slightly fair', the majority of the students are almost divided equally on the three choices in the middle: 'slightly fair', 'moderately fair', and 'very fair'. Looking at the comments, it seems that the students who found it not to be fair at all or slightly fair, have commented that they found it depending on who did the peer review. Due to there being variations in good and poor feedback, and how critical the students were. Some were also concerned about how the peer review affected their grade. There was also one who commented that he found it to not be truly anonymous because students were able to recognize the code for the people they know, and would be more nice to them.

Reviewing of peers:

The questions found in this category are the ones focusing on the reviews the students completed, namely questions 3, 5, 10, 11, 13, 14, and 16.

In question 3 the goal was to find out how much the students understood of the code they were reviewing. For this question the following answers were received: **Did not understand anything** - 0 (0.0%), **Understand very little** - 1 (6.7%), **Understand a moderate amount** - 1 (6.7%), **Understand a lot** - 11 (73.3%), **Understand completely** - 2 (13.3%). Looking at these results, it is clear that most students understood a lot with 73.3% answering 'understand a lot' and 13.3% answering 'understand completely'. For this question there were some comments, the comments for the most part said that they understood the code, but there were some students that had got some code that didn't make sense. Some students also mentioned that they had seen different methods to solve the problem.

With question 5 the goal was to find out to what extent the students learned new programming concepts and techniques from reviewing their peers. To this question the following answers were collected: **Did not learn anything** - 1 (6.7%), **Learned very little** - 5 (33.3%), **Learned a moderate amount** - 5 (33.3%), **Learned a lot** - 3 (20.0%), **Learned a great deal** - 1 (6.7%). Analyzing these results one can see most students finding themselves to be between learning very little and learning a great deal. With 1/3 on both 'learned very little' and 'learned a moderate amount', and 20% on 'learned a lot'. It is safe to say that most students were between learning very little to learn a lot when it comes to learning new programming concepts and techniques from reviewing. From the few comments to this question, some students mentioned that they had learned new techniques due to their reviewing other solutions to the problem, or reviewing something they had not done before. There was also one student that said he had learned a lot due to all the effort he put in.

The goal of question 10 was to find out to what extent the peer review process improves the students' critical thinking. For this question the following answers were collected: **Did not improve at all** - 1 (6.7%), **Slightly improved** - 7 (46.7%), **Moderately improved** - 5 (33.3%), **Improved a lot** - 0 (0.0%), **Improved significantly** - 2 (13.3%). Based on the results of this question, one can see that most students improved their critical thinking through peer review by a slightly to moderate amount. While there are some exceptions where students improve significantly. From the few comment, there were not much to analyze.

Question 11 tries to measure to what extent a student's professional growth benefits from the peer review process. The results from this question can be seen in figure 5.7. Looking at the results, it is clear that most students' professional growth moderately benefited from the peer review process, while there were a few that only slightly benefited and some that benefited a lot or significantly. From the very few comments to this question, there was one student that mentioned that it was good training for giving constructive feedback instead of negative feedback to their peers.

For question 13 the goal was to find out how confident the students were in giving constructive feedback and suggestions while reviewing. The answers collec-

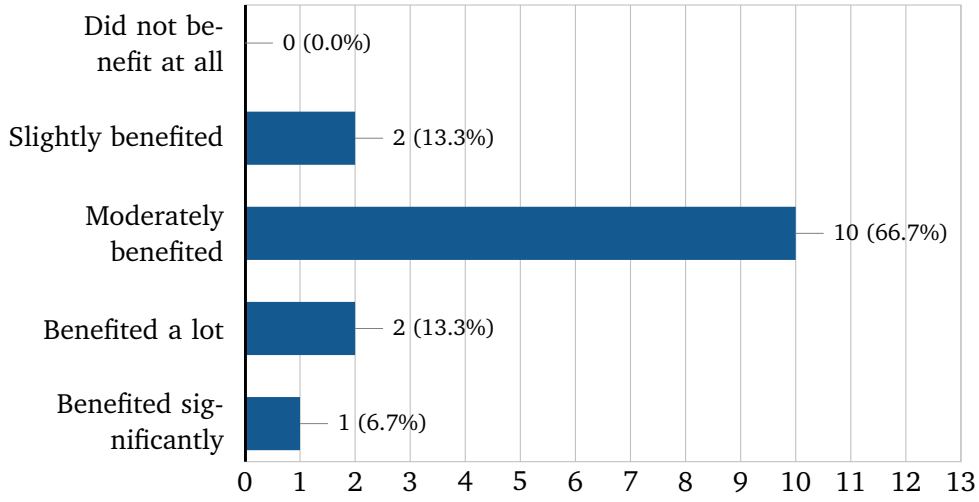


Figure 5.7: Survey 2 - Question 11: To what extent did you benefit from the peer review process in terms of your professional growth?

ted to for this question were: **Not confident at all** - 0 (0.0%), **Slightly confident** - 3 (20.0%), **Moderately confident** - 7 (46.7%), **Very confident** - 2 (13.3%), **Extremely confident** - 3 (20.0%). Analyzing the results of this question, one can see that just around half of the students found themselves to be moderately confident. While 33.3% were 'very confident' or 'extremely confident'. From the few comments to the question, one can see that for some of the students, their confidence when reviewing could be associated with their knowledge of the code they were reviewing. To conclude this question, most students found themselves to be moderately confident or higher when giving feedback.

In question 14 the goal was to find out how the students felt the peer review process helped improve their communications skills when it comes to explaining technical concepts and making suggestions. For this question, these answers were collected: **Did not help at all** - 2 (13.3%), **Slightly helped** - 6 (40.0%), **Moderately helped** - 5 (33.3%), **Very much helped** - 1 (6.7%), **Extremely helpful** - 1 (6.7%). For this question there was only one comment, which did not add anything to the analyses. Looking at the results, one can see that 'slightly helped' has received the most votes with 40.0%, next is 'moderately helped' with 33.3%. These two equals 73.3% of the students, the are also a few who vote: 'did not help at all', 'very much helped', or 'extremely helpful'. But all in all, one can say that most students found that the peer review process slightly to moderately helped in improving their communication skills. This result is most likely affected by the poor feedback students gave, which has been seen from earlier questions.

The goal of question 16 was to find out if the peer review process helped students improve their ability to debug code and identify errors. The answers collected for this question was: **Did not help at all** - 2 (13.3%), **Slightly helped** - 4 (26.7%), **Moderately helped** - 4 (26.7%), **Very much helped** - 4 (26.7%),

Extremely helpful - 1 (6.7%). Taking the few comments into consideration while looking at these results, there seem to be several factors for the distribution of the results. From the comments, one student says that he thinks he did not use enough time to try and debug the code of others. Another student says he had no experience in debugging with Go before and found the peer review process helpful. While these are only a few comments, one can see that they fit the pattern found in the earlier questions where skill level and the effort put in, are key factors to how much they learn, in this case how much they improve their skills to debug code and identify errors. One can assume that this is the reason for the distribution of the results. One also needs to keep in mind, that the code the students are reviewing can have some effect on it as well.

Receiving feedback:
In this category, the questions here are the ones with a focus on the feedback, namely questions 4, 6, 7, and 12.

In question 4 the goal was to find out how helpful the feedback received was to learn new programming skills. The answers received her were: **Not helpful at all** - 2 (13.3%), **Slightly helpful** - 3 (20.0%), **Moderately helpful** - 6 (40.0%), **Very helpful** - 3 (20.0%), **Extremely helpful** - 1 (6.7%). Looking at these results, one can see that students are spread all across the scale. Most students answered 'moderately helpful' with 'slightly helpful' and 'very helpful' right behind. In total these three groups equal 80% of the students. Looking at the comments to this question, there were several comments saying that the feedback was either only referring to bugs, lacking insights for improvement or just picking on small errors. In all, they show that the feedback found small problems in their code, but it was lacking comments on how to improve it, and was therefore not very helpful. Seeing that some students answered 'very helpful' or extremely helpful shows that there are some students that give good feedback.

With question 6 the goal was to find out how helpful the feedback received was to identify and fix errors in the groups' code. For this question the following answers were collected: **Not helpful at all** - 3 (20.0%), **Slightly helpful** - 3 (20.0%), **Moderately helpful** - 6 (40.0%), **Very helpful** - 1 (6.7%), **Extremely helpful** - 2 (13.3%). Analyzing these results, one can see that the majority of the students found the feedback to be on the lower side when it comes to identifying and fixing errors in their groups' code. With 80% answering between 'not helpful at all' and 'moderately helpful'. There were two comments from the two students who answered 'extremely helpful'. They said that the feedback helped them see problems they had not seen, and that it helped make the program better. The rest of the comments were on how the feedback was not so helpful.

The goal of question 7 was to find out how good the feedback received was in clarifying the suggestion and comment they were giving. For this question the following result were collected: **Not helpful at all** - 2 (13.3%), **Slightly helpful** - 3 (20.0%), **Moderately helpful** - 8 (53.3%), **Very helpful** - 2 (13.3%), **Extremely helpful** - 0 (0.0%). Looking into the results, it is clear that around half of the students found the feedback to be moderately helpful in clarifying the suggestions

and comments it provided. For the rest of the students, most of them found the feedback to be, 'not helpful at all' to 'slightly helpful'. There were, however, a few who found it to be 'very helpful'. All in all most of the feedback seems to be moderately helpful to not helpful at all. The reason for this can be that students do not put effort into the feedback they give. There were very few comments on this question.

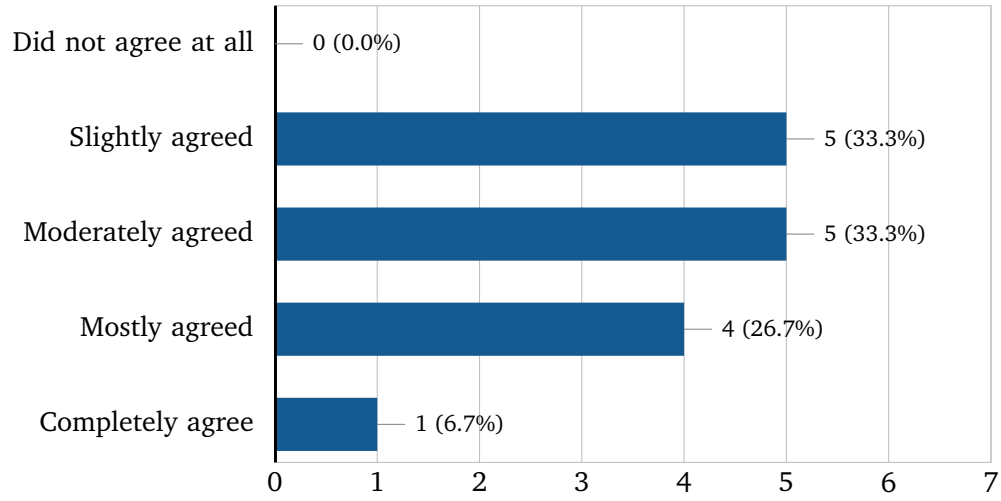


Figure 5.8: Survey 2 - Question 12: How much did you agree with the feedback received from your peers during the review process?

Question 12 had the purpose of finding out how much the student agreed with the feedback received. The results can be seen in figure 5.8. Looking at these results, one can see that there is almost an equal spread between 'slightly agreed', 'moderately agreed', and 'mostly agreed'. They are almost equal to 1/3 of the students each. Looking into the comments for this question, it seems that several students received feedback that was both correct and false which is most likely the reason for the distribution of the results.

Group work:

The questions in this category are the ones related to group work, namely questions 17, 20, and 21.

With question 17 the goal was to find out how the students rate their level of participation in the group. For this question the following answers were collected: **No contribution at all** - 0 (0.0%), **Slightly contributed** - 0 (0.0%), **Moderately contributed** - 5 (33.3%), **Very contributed** - 5 (33.3%), **Extremely contributed** - 5 (33.3%). By analyzing these results, one can see that the students have placed themselves in the three highest levels of contribution. With the three groups containing 1/3 of the students each, there is some variation in how much the students contribute to the group work, but no students will admit to free-ride through the assignment. The two comments to this question, both were from students saying that they had contributed extremely to the group project. One of them said he had

done the assignment alone, and the other one said that he had done most work on the project, thus, there might have been some free-riders in the group work after all.

In question 20 the goal was to find out if the students thought there were unequal contributions in their group. The answers collected for this question were: **Contributions were completely equal among all group members** - 3 (20.0%), **Contributions were somewhat unequal, but the impact was negligible** - 5 (33.3%), **Contributions were moderately unequal, and this had some impact** - 6 (40.0%), **Contributions were significantly unequal, and this had a noticeable impact** - 1 (6.7%), **Contributions were extremely unequal, resulting in some members carrying the majority of the workload** - 0 (0.0%). Looking at these results, one can see that most students found there to be some unequal contribution in their group. The students that had experienced unequal contributions in their group, were almost split in two when it comes to if unequal contribution impacted their group or not. Looking at the comments for this question, the unequal contribution comes from how they divided the workload, and from the difference in engagement between the members.

Question 21 had the goal of finding out if students' engagement with the assignment increased working by working in a group. For this question the following answers were collected: **Did not increase engagement at all** - 3 (20.0%), **Slightly increase engagement** - 3 (20.0%), **Moderately increase engagement** - 3 (20.0%), **Very much increase engagement** - 5 (33.3%), **Greatly increase engagement** - 1 (6.7%). Analyzing these results, it looks like there is a big variation in if the students get more engagement when working in groups or not. Looking at the numbers, one can see that about half of the students moderately to very much increase their engagement with the assignment when working in groups. Based on the few comments to this question, it looks like some students' engagement increases, due to feeling responsible for the other members, or if they end up in a good group.

Group versus individual:

In this category are the questions that specifically look at the differences between group and individual work. The questions in this category are 18, 19, 22, and 23.

With question 18 the goal was to establish if the students prefer to learn individually or in a group. The answers collected for this question can be seen in figure 5.9. From the results, it is clear that almost half of the students have no preference for learning individually versus in a group. Looking at the other half of the students, one can see that more students somewhat prefer learning individually to learning in a group. Looking into the comments for this question, some of the students find it hard to decide on their preference. They like both, but it looks like it depends on what type of task they are doing, and what group they are in.

Question 19 had the goal of finding out if the students felt they learned more from doing an individual assignment versus a group assignment. For the question the following answers were collected: **Learn much more from individual assignments** - 1 (6.7%), **Learn somewhat more from individual assignments**

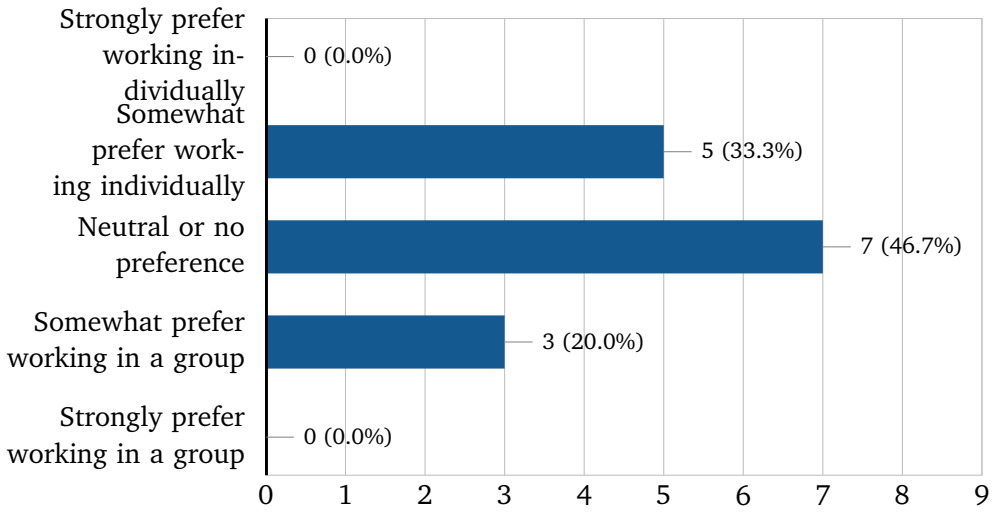


Figure 5.9: Survey 2 - Question 18: How do you prefer to learn: by working individually or in a group?

- 4 (26.7%), **No difference** - 4 (26.7%), **Learn somewhat more from group assignments** - 5 (33.3%), **Learn much more from group assignments** - 1 (6.7%). Looking into these results, one can see there are similarities with the results from question 18, but for this question, fewer students said that they feel no difference. When it comes to what students feel they learn more from, there is barely any difference between individual assignments and group assignments. From the very few comments to this question, some students say that it depends on the type of assignment, or that they will learn regardless of what the assignment is.

For question 22 the goal was to find out if there were any differences in reviewing an individual assignment versus a group assignment. The answers collected for this question were: **No difference at all** - 5 (33.3%), **Minor differences** - 6 (40.0%), **Moderate differences** - 1 (6.7%), **Significant differences** - 3 (20.0%), **Completely different** - 0 (0.0%). Analyzing the results, one can see that 1/3 of the students found 'no differences at all', while around 40% found there to be 'minor differences'. The rest found there to be 'moderate differences' to 'significant differences'. Based on this, it is clear that there are some differences, but how much, appears to change from which group a student is reviewing. Several students commented on the difference they found which were: larger repositories meant more to review, there are different coding styles in the same repository making it harder to review, and some have higher quality and are easier to review. Some students ended up reviewing a one-person group, and they did not find that to be different from an individual assignment.

For question 23 the goal was to find out if there were any differences in receiving reviews for an individual assignment versus a group assignment. The answers collected for this question were: **No difference at all** - 8 (53.3%), **Minor differences** - 3 (20.0%), **Moderate differences** - 4 (26.7%), **Significant differences**

- 0 (0.0%), **Completely different** - 0 (0.0%). Looking at these results, it is clear that there were few differences in receiving feedback between an individual assignment and a group assignment. With over half saying no difference and the rest saying they were minor to moderate differences. There was not much to take from the comment to this question, but one student said that the feedback was more general on the group assignment.

Feedback on the group management functionality:
The last category is for the feedback collected for the new group management functionality. The feedback was collected with question 24. Question 24 was an optional text-answer question, to collect the thoughts the students had about the new feature in CSAMS. The goal of this question was to find out if there is something that should be changed or added to this feature. In total, there were only six answers to this question, not all of them about the new group management functionality, but also about other features in CSAMS. The answers regarding the group functionality were: "Worked surprisingly well" and "It's nice to have a group function, in fact I might prefer it over individual work in the cloud course.". Only two answers mentioning this feature is not much to go on, but the answers indicate that there does not seem to be any problems with the new functionality.

Two of the other answers said that it would be nice to have an auto-save function for the review feature. This is a feature request to the system itself, and not specific to the group management functionality since the review feature is used for both individual and group peer review. Such a feature would be useful for CSAMS and would increase user experience. It will be mentioned as a possible future development task.

The two last comments were mostly course concerns not specific to CSAMS, but one of them suggested maybe renaming the change submission button to "Inspect submission".

5.4 Comparing both assignments

Now that both surveys have been analyzed, the results from the two can be compared to see if there are any differences in learning between an individual assignment with peer review and a group assignment with peer review.

Comparing the results from both surveys for question 1, one find that the students had more experience with peer review for the group assignment. This result was expected since the students had already completed peer reviews for the individual assignment. Based on the results one can see that from the individual assignment 47.1% had done two or more peer reviews before, while for the group assignment, this had increased to 73.3%.

With that in mind, it is time to look into the differences in the general aspects of peer review. When it comes to measuring how effective the peer review process was to reflect on the overall quality of the assignment. There is little difference between the individual and the group assignment. Looking into whether the students increased their engagement with the assignment when they knew that

they would participate in peer review afterward, the results are also very similar. One can, however, see the engagement was barely higher on the individual assignment. On the individual assignment, 41.2% answered moderately increased engagement or higher, while in the group assignment, only 33.3% answered the same. For both assignments the average time a student used to complete a peer review was around one hour. There were indeed exceptions with some students using much shorter time, and some students using much longer time. Finally, when it comes to how fair the students found the peer review process was to evaluate their and their peers' code, slightly more students found it to be fairer for the individual assignment. Based on the results that 70.6% answered moderately fair or higher for the individual assignment, while only 60.1% said the same for the group assignment.

Now we will look at whether there are any differences between an individual and a group assignment when the focus is on the review a student performs. Starting with to what extent the students understood the code they were reviewing, and comparing the results from both assignments, one can see that the results are almost the same. For the individual assignment, 58.8% understood a lot and 23.5% understood completely which equals 82.3% of the students. For the group assignment 73.3% understood a lot and 13.3% understood completely which equals 86.6% of the students. Based on this, it is clear that most students understood a lot of the code they were reviewing in both assignments. Fewer students understood the code completely in the group assignment, this can be due to that the code repository in the group assignment was bigger and written by multiple students.

Comparing the results of to what extent the students learned new programming concepts and techniques while reviewing, one can see that there were more differences in these results. For the individual assignment, 17.6% did not learn anything and 41.3% learned very little, which means that 58.9% said they learned nothing to very little of new concepts and techniques, while the remaining 41.2% learned a moderate amount. In the group assignment, 6.7% did not learn anything new, and 33.3% learned very little, which equals 40% of the students. Already here there is a noticeable difference from the individual assignment. Further on 33.3% learned a moderate amount while 26.7% learned a lot or more. This means that 60% of the students learned at least a moderate amount of new concepts and techniques. Based on this, it is clear that most students learned more new programming concepts and techniques from reviewing the group assignment.

When it comes to comparing to what extent the students improved their critical thinking from the peer review process, one can see there is only a minor difference between the individual and group assignments. From the results, one can see that for the individual assignment, 47% improved from nothing to slightly, while 53% improved moderately to a lot. For the group assignment, 53.4% improved from nothing too slightly, while 33.3% improved a moderate amount and 13.3% improved significantly.

Looking into how the students benefited in terms of professional growth for the peer review process, there is a clear difference between the individual assignment and the group assignment. Seeing that 66.7% of the students benefited a moderate amount from the group assignment, where as on the individual assignment students were more equally spread out. Here 29.4% slightly benefited, 17.6% moderately benefited, and 35.3% benefited a lot in terms of personal growth. Based on this, one can say that the professional growth was more stable among the student for the group assignment. One can, thus, expect a more consistent benefit in professional growth from a peer review process for a group assignment.

By comparing the results of how confident the students felt they were in giving constructive feedback and suggestions to their peers during the review process, one can see that the students' confidence in giving feedback has increased slightly from the individual assignment to the group assignment. The increase comes from the students that were the least confident. In the individual assignment, there were 11.8% that were not confident at all and 5.9% that were slightly confident. For the group assignment, there were none that were not confident and 20.0% that were slightly confident. This shows that those with no confidence at all, have increased their confidence in giving constructive feedback from the individual to the group assignment. When it comes to the more confident students there are no significant differences other than there being some more students moderately confident and some less very confident in the group assignment compared to the individual assignment.

When it comes to if the peer review process helped the students to improve their communication skills in explaining technical concepts and making suggestions, one can see that the results from both assignments were the same. Both show that the peer review process slightly to moderately helped the student to improve their communication skills. By looking at how the students felt that the peer review process helped them in improving their ability to debug code and identify errors, the results are also almost identical for both assignments.

Looking at the differences found in the feedback received, we start with the differences found when it comes to how the feedback the students received from their peers helped them to learn new programming skills. Comparing the results from both the individual assignment and group assignment, one can see that most students found the feedback received from the group assignment to be more helpful in terms of learning new programming skills. In the individual assignment, 11.8% found it not to be helpful at all, 58.8% found it to be slightly helpful, and 23.5% found it to be moderately helpful. For the group assignment, 13.3% found it not to be helpful at all, 20.0% found it to be slightly helpful, 40.0% found it to be moderately helpful, and 26.7% found it to be very to extremely helpful.

Looking at the differences in how helpful the feedback received from the students' peers was in identifying and fixing errors in their code, one can see that the results are very similar, but students just barely found the feedback to be more helpful from the group assignment. This is based on the results that show that

53% found the feedback from the individual assignment to be moderately helpful or better, while 60% found the feedback for the group assignment to be moderately helpful or better.

When it comes to how helpful the explanation provided in the feedback the students received from their peers in terms of clarifying the reasoning behind the suggestions and comments to their code, there are differences between the individual assignment and the group assignment. Looking at the results, one can see that for the individual assignment, 11.8% found it not to be helpful at all, 41.2% found it to be slightly helpful, 29.4% found it to be moderately helpful, and 17.6% found it to be very helpful. This means that 53% thought it to be slightly helpful or lower, and 47% thought it was moderately to very helpful. For the group assignment, 13.3% found it not to be at all helpful, 20.0% found it to be slightly helpful, 53.3% found it to be moderately helpful, and 13.3% found it to be very helpful. This means that 33.3% thought it was slightly helpful to lower, while 66.6% thought it to be moderately to very helpful. Based on these results one can see that most students found the feedback received from the group assignment to be more helpful in clarifying their suggestions and comments.

Comparing the results of how much the students agreed with the feedback from their peers during the review process, one can see that more students mostly agreed with the feedback from the individual assignment. This is based on the results which show that for the individual assignment, 47% said they mostly agreed and 11.9% completely agreed. For the group assignment, 26.7% said they mostly agreed and 6.7% completely agreed. From these numbers, one can see that in the individual assignment 58.9% mostly agreed or more, and in the group assignment, only 33.3% mostly agreed or more.

Further, the results will be discussed and concluded in the discussion chapter.

Chapter 6

Discussion

This chapter will first provide a summary of the thesis, followed by contributions made, and limitations regarding the thesis. Finally, a discussion of the results will be provided in order to conclude with a proposed solution to the research question, and possible future work will be proposed.

6.1 Summary

This thesis has looked into the subject of peer review, more specifically targeting the difference in learning outcomes when using peer review for an individual assignment versus a group assignment. From the literature review, research gaps were discovered. One of them was a gap in comparing the learning outcome that students have when using peer review for an individual assignment versus a group assignment. With the goal of closing a part of this gap, the research questions were formed.

In order to answer the research questions several steps were taken. First, group management functionality was developed for the peer review system CSAMS used in computer science courses at NTNU Gjøvik. This functionality allows students to submit an assignment to the system as a group, and then conduct peer reviews on other groups. Before CSAMS only allowed for peer reviews of individual submissions. With the new feature, an Openstack[29] server was set up and hosted with CSAMS. By being the production manager of the server during this spring semester, responsibilities for updating the system, correcting errors, and making sure both teachers and students got access with the privileges they needed, fell upon me.

To collect data for this thesis two surveys were created. The first one would be distributed to the students after they had completed their individual assignments with peer review. The second one would be distributed to the students after they had completed their group assignment with peer review. Both assignments were done in the CSAMS system. The students participating in the surveys, were computer science students taking the Cloud course at NTNU Gjøvik, which

is a bachelor's degree course. All data collected were analyzed and the data from the two surveys were compared against each other.

The results found in the data will be discussed later in this chapter.

6.2 Contribution

The contribution can be divided into three main categories which are development, production, and research. Further on in this section, the contribution of each category will be described.

Development:
The contribution to the peer review system CSAMS was the development of the group management functionality. This development includes designing new pages for the system, redesigning the database structure by adding and changing several data classes, and updating existing functionality to accommodate the changes to the database. New pages were added to the frontend, as was new functionality needed in the backend for the group management functionality. The development was done with HTML templates for the frontend and Go for the backend with a SQL database. The development of the group management functionality to CSAMS was necessary to be able to use it for the research. All this came together in an upgrade to the CSAMS system with a group management functionality that allows students to join a group, deliver as a group, and do peer reviews on group assignments, while the teachers have full access to create, change or delete groups, and to customize the group assignment as needed.

As part of redesigning the database structure a new and updated version of the database diagram was created.

Another development task has been fixing new and old bugs and errors found during production.

Production:
The contribution in the production phase was having the role of production manager and maintainer of CSAMS. The responsibilities covered setting up and hosting CSAMS on an OpenStack[29] server, updating the system and correcting errors discovered during production. CSAMS was used by over 100 students this semester, which meant that it was important to make sure the system was running at all times. Another part of this role was to give teachers and students access, and give the teachers admin rights.

To make sure that new updates and error corrections did not break the production server, a test server was set up. The test server was configured with the same setup and data. This made the role of production manager easier, and allowed me to test and approve new updates on real-time test data without having to be worried about crashing and losing the user data.

Research:
The contribution when it comes to research, was to conduct a literature review in order to identify existing gaps in the research related to peer review, as well as to gain knowledge. Secondly, two surveys were created to collect responses from

the students in the Cloud course. One survey was used to collect data about using peer review on individual assignments, and one was used to collect data about using peer review for a group assignment. The data collected were analyzed and compared against each other to answer the research questions.

6.3 Limitations

The limitation section will follow the same structure as the contribution section. Here the limitations for the categories of development, production, and research will be described.

Development:
There were two limitations when it comes to the development of the group management functionality. The first one was the limitation of the database. The infrastructure of the database could not be changed once the system was in production. All changes to the database had to be completed before the production server went live. The server went live towards the end of February in order to be ready to use for the first assignment in the Cloud course. This meant that all changes to the database had to be implemented by then.

The second limitation was that there was another masters student working on another feature of CSAMS. This was a limitation because we were both working on many of the same files, and needed to be careful not to destroy each others work.

Production:
The production shares a limitation with the development and that is the database. Any error found, could only be corrected as long as they did not depend on any changes to the database. The reason the database structure could not be changed while in production, was that the system needs a full reset in order for the changes to work. A full reset will delete all current data in the system.

Research:
The were several limitations when it come to the research. First of all due to the scope being limited to computer science students, and in this case limited to computer science students taking the Cloud course at NTNU, the number of students accessible for this study, has been limited. This semester 87 students were taking the course. Since doing the surveys for this thesis was not mandatory for the students, the results collected were limited because it was hard to get students to participate. This resulted in the total amount of participants being 20% of all students in the Cloud course.

Another limitation was that this thesis was following the Cloud course, which means that it was depending on the first and second assignments in the course. To collect data about students' experience with peer review, the survey had to be sent to the students after they had completed peer reviewing for their assignment. This was limiting the time to collect data, and was mostly a problem for the second assessment because the deadline got extended to May 8, which gave little time to collect data before the thesis had to be delivered.

While analyzing and discussing the results collected through the surveys, it was discovered that there should have been more questions about how students learn better from an individual assignment or a group assignment, and how they prefer to learn. With the lack of more relevant questions here, the results used to conclude both RQ2 and RQ3 were lacking data. This was mostly a limitation for RQ3, but also a bit limiting for RQ2.

6.4 Research questions

In this section, the proposed solution to each research question will be presented one at a time. First, the research question will be stated, then the results related to this question will be discussed before a conclusion will be presented.

In this thesis, several steps and methods have been used in order to collect data for the research questions. There have been some challenges, of which the major one has been getting students to participate in the surveys. At the start of the thesis, the expectation was that it would be easy to get a lot of participants in the survey since there were 87 students in the cloud course. This expectation was quickly challenged once the first survey was sent out to the students. One week after publishing the survey, less than five students had participated. Through republishing the survey to the students' course page and getting the course teacher to mention the survey in class several times, the number of participants for the first survey ended at 17 students, after almost five weeks.

From this experience, it was clear that this was going to be a problem for the second survey too, but for the second survey, there was no time to wait for five weeks to collect answers. Due to these surveys being dependent on the first and second assignments in the cloud course, the second survey could not be published to the students before they had completed the peer review process for the second assignment. In the cloud course there were delays to the assignment and the deadline for the peer review was extended to May 8, when it originally was supposed to be at the end of April. This gave even less time to collect answers for the second survey, but there were still collected answers from 15 students. From this experience, one can say that it is hard to get students to participate in a survey that is not mandatory for the course, or they receive any rewards for participating.

With 17 students from the individual assignment and 15 from the group assignment, one needs to take into consideration the number of students who participated and were used for the results equals about 20% of the total students in the course. There were 87 students participating in the individual assignment and 84 students participating in the group assignment.

RQ1 - To what extent does the writing as well as receiving of peer reviews on group and individual assignments respectively impact the student learning outcome (with respect to that assignment)?

Students had more experience with peer reviews for the group assignment than for the individual assignment, because they had already performed peer re-

views on the individual assignment. Some of the students had also used peer reviews in other courses. With more experience, people usually get more confident in what they do. An increase in confidence is also found in the results. In this setting, the confidence increased in giving constructive feedback and suggestions to their peers when performing a review. The confidence increase was found among the least confident students. This can be seen from the result where for the individual assignment there were 11.8% of the students that were not confident at all, while for the group assignment, there was none that were not confident at all. This shows that the ones who were not confident at all have become more confident in giving constructive feedback and suggestions. While more experience in peer reviews can be one reason for this, an increase in the skill level of students because it is later in the course, can be another. On the other hand, we find that the share of those most confident i.e. **Very confident** and **Extremely confident** fell from 47.1% for the individual assignment to 33.3% for the group assignment. This can be due to the increased complexity of the group assignment mentioned by several students pinpointing that the repository in the group assignment was much bigger and the code harder to read since it was made by several students.

Most of the students understood a lot of the code they were reviewing in both assignments. The results also show that the average time a student used on completing a review was around one hour, but there were some using much shorter time and some using much more time. This average goes for both assignments.

One thing found during the analysis, was that students learned more from reviewing others' code than from the feedback they received. Both the individual and group assignments had this outcome. These findings correspond to what was found in the articles [18] and [19] from the literature review. In this research, we found that the students learned less from the feedback because most of it was poorly executed by the other students. The feedback the students received in this course seems to be so bad, that even getting feedback from several students can not replace the feedback from a teacher. This contradicts the results found in [21] and [22], where they stated that receiving feedback from several students can be as good as receiving feedback from one teacher.

We looked at several aspects related to how the students learned by reviewing. The aspects were learning new programming concepts and techniques, improvement of their critical thinking, improvement of their communication skills, improvement of their debugging skills, and how they benefited in terms of professional growth. From the comparison of the results, one can see that students learned most new programming concepts and techniques from the group assignment where 60% of the students learned a moderate amount or more of programming concepts. While for the individual assignment there only were 41.2% who learned a moderate amount. When it comes to the improvement of critical thinking, there were minor differences between the two. For both assignments, about half of the students improved their critical thinking by a moderate amount or more, while the rest reported less improvement. When it comes to the improvement of communication skills, and debugging and identifying errors the results

were the same for both the individual and the group assignment. The improvement of communication skills was on the lower side of helpfulness. While debugging was mostly spread between slightly helpful, moderately helpful, and very helpful.

When it comes to how the peer review process benefited the students in terms of professional growth, there are clear differences between the individual assignment and the group assignment. For the individual assignment, 1/3 did not benefit from professional growth more than slightly, while another 1/3 reported to benefit a lot. For the group assignment, the professional growth was concentrated on moderately benefited with 66.0%. This shows that more students benefit from professional growth in the group assignment, but the benefit is more moderate. Showing that one can expect more students' professional growth to benefit at the same level for a group assignment with peer review.

By combing all of the aspects of learning from doing a peer review, one can see that there are several aspects almost identical between the individual assignment and the group assignment. However, looking at the differences found in both learning new programming concepts and the benefit of professional growth, it is clear that the total learning outcome from doing a peer review is higher when reviewing a group assignment. There can be several reasons for this. One reason can be that the repositories in group assignments are larger, which means that there is more code to review. Another reason can be that there are several students working on one assignment, the student reviewing the group code will then be exposed to several coding approaches, styles, and techniques at the same time compared to an individual assignment. Consequently, the learning potential is greater.

Going over to look at how the students learn by receiving feedback, there were several aspects to observe. An initial aspect was: did the feedback received help the students to learn new programming skills, was the feedback received helpful in identifying and fixing errors, did the feedback received provide a helpful explanation in terms of clarifying the reasoning behind the suggestions and comments, and did the students agree with the feedback they received. As found from comparing the results, most students seem to find the feedback received from the group assignment more helpful in learning new programming skills. When it comes to identifying and fixing errors, there were barely any differences. In the group assignment, 60% found the feedback to be moderately helpful or better, while in the individual assignment, 53% found the same. The same goes for clarifying the reasoning for the suggestions and comments in the feedback, this was also more helpful in the group assignment, but here the difference was a bit larger. When it comes to agreeing with the feedback, there were more students that mostly agreed with the feedback from the group assessment.

When combining the results of these aspects, one can see that the feedback received from the group assignment, was better for the overall learning outcome. This is based on that it was both better at learning new skills and giving helpful feedback. Still many comments from both surveys show that the overall quality of feedback received was poor, but slightly better on the group assignment. One

reason why the feedback was overall better in the group assignment, could be that the students are more confident in reviewing and has got more experience. Based on the comments collected during the group assignment survey, several students said they felt more confident and wanted to put more effort into their review.

The analysis identified two main factors affecting how much a student learns from reviewing other students' code. These two factors were skill level and effort. A student with a lower skill level reviewing a high-skill level student's code, would learn more than a high-skill level student reviewing a low-skill level student's code. This was found in both the individual and group assignments. The amount of effort the student puts into a review also affected how much the student learned from reviewing. A difference between the two assignments, was the effort put into reviewing. It seemed that some students felt more experienced and had a greater knowledge of how to perform a peer review, and therefore chose to put more effort into reviewing assignment two. Since the second assignment was a group project, it was a bigger repository to review than in assignment one.

To further get the students' perspective on the differences between using peer review for individual assignments and group assignments, they were asked two questions. The questions were "Was there any difference in reviewing an individual assignment versus a group assignment?" and "Was there any difference in receiving reviews for an individual assignment versus a group assignment?". When it comes to the difference in reviewing 1/3 of the students said there was no difference, while 40% said there were minor differences and the last 26.7% said there were moderate to significant differences. This shows that there are some differences between the two. Based on the comments to this question, the differences were mainly that the group assignment had a bigger repository to review and that one was exposed to several coding styles while reviewing it. When it comes to the difference in receiving reviews, there was even less of a difference. With 53.3% saying there were no differences and the rest saying there were minor to moderate differences. This shows that there was a bigger difference when giving a review for an individual assignment versus a group assignment.

Based on this discussion the proposed solution to **RQ1** is that using peer reviewing for both group assignments and individual assignments impacts the students' learning outcome. The learning outcome is slightly higher when using peer review on a group assignment. This is dependent on that students put in the same effort for both assignments. This is also based on that the peer review process has been conducted in the same way for both assignments. The main difference is that by reviewing a group assignment the student has a bigger repository to review, and is exposed to multiple people's coding techniques at the same time. While this is based on about 20% of the students participating in the cloud course, there is reason to believe that one will get similar results with a higher percentage of participants.

RQ2 - Does a computer science/programming student learn more from

individual work or group work when it comes to programming skills?

To measure if the students learn more from an individual assignment as compared to a group assignment there are several aspects to look at. The first is to look at students' self-perception of participation in the group. From the results earlier, the students have placed themselves in three groups. 1/3 said they contributed a moderate amount, 1/3 said they contributed highly, and the last 1/3 said that they contributed extremely as part of the group. From these results, one can expect there to be some differences in contribution in the groups. Next, the students were asked if there was any unequal contribution in their group. Her 20% said that the contribution was completely equal among all members, while 33.3% said there were somewhat unequal contributions but it did not affect the results. The rest said there were moderately unequal contributions and that it had some effect on the results. The results seen in these two questions relate to each other. There are variations in how much the students contributed, and in how unequal the contribution was in the groups. There are several reasons why there were unequal contributions. Based on the comments to the question one of the reasons was the way the group split the tasks between themselves, and some of the tasks were bigger than the others. Another reason is probably that the students put different amounts of effort into the group assignment. This is a factor that was also seen in the peer review process. It is also interesting to note that none of the students say that they contribute less than a moderate amount, i.e. none of the students admits to be free-riders. Whereas in the second question, and some of the comments, other students clearly indicate that there have been free-riders in their group. Free riders were a problem seen in [8] and [10] where they came up with solutions to prevent it.

When looking at whether students' engagement with the assignment increases when they work in a group, 60% said their engagement increased moderately or more, while the rest said it slightly or did not increase their engagement with the assignment. When 60% increase their engagement with the assignment when they work in a group, this can also be one of the reasons for the unequal contributions in the groups. Thus 60% of the students put more effort into the assignment. Some of the students commented that the reason for their increase in engagement was that they felt responsible for the other group members.

Lastly, the students were asked if they felt they learned more from an individual assignment versus a group assignment. Here 26.7% said there were no differences. 1/3 of the student felt they learned somewhat or more from an individual assignment. While the last 40.0% felt they learn somewhat or more from a group assignment. With the results being so close to each other is difficult to indicate whether one method is better for learning than the other, especially given the confounding factors of learning effects from the individual assignment prior to engaging in the group assignment.

Based on this discussion the response to **RQ2** is that it can vary if a computer science student learns more from an individual assignment than from a group

assignment. This is because, in an individual assignment, a student has to perform the entire task. In a group assignment, however, there are so many factors that can affect how much a student learns. For example, if there are unequal contributions in a group and one student ends up doing most of the work. He has the possibility to learn much more because group assignment often is bigger and more challenging. There is also the possibility of learning new coding skills from the other member of the group. This was based on 20% of the students participating in the cloud course, but there is reason to believe there would be similar results if there had been a higher number of participants. Lastly, learning effects could relate to the group work per se, i.e., the need for coordination and cooperation, that show in aspects of project management as well as practical aspects such as branch merging in git, an aspect that is of limited concern in individual assignments. However, the questions in this study do not explicitly focus on these secondary aspects of learning, and can hence not lend a conclusive insight.

RQ3 - Do computer science students prefer to learn coding individually or in a group?

To be able to answer this question the students were asked if they prefer to learn by working individually or in a group. The results collected show that 46.7% were neutral or had no preference while 20.0% somewhat preferred learning by working in a group, and 33.3% somewhat preferred learning by working individually. Some of the students who were neutral, commented that they liked both, but their preferred method was based on the current task they were given. With almost half of the students being neutral, it is hard to make a general conclusion.

When discussing this research question there has been a realization that there could have been more questions in the survey related to this question to get a better sense of which aspects may be preferably learned in an individual setting, and the ones in a group setting. This offers opportunities for refinement for future studies.

Based on this discussion and that slightly more students somewhat preferred learning by working individually a tentative response to **RQ3** is that more students prefer to learn by working individually. Given that these results are from about 20% of the students, one can challenge the representativeness. An aspect that warrants evaluation over a larger number of students, and ideally, different cohorts.

6.5 Future work

Finally, the thesis will be concluded with suggestions for future work. This section is divided into two subsections, *Implementation* and *Research*. The *Implementation* subsection will go over possible future work for CSAMS found during this thesis. While the *Research* subsection will mention possible future work related to the thesis.

6.5.1 Implementation

CSAMS is a system that is under constant evolution since the experience of using it increases year by year, and the teachers get new insight into how they can evolve it. One feature that can be implemented to give more functionality to the group feature, is to implement the ability for a teacher to choose if all students in a group should review the same groups or different groups. Today all students in the same group review different groups from each other. This feature was thought about during the upgrade of the database, and should therefore be possible to implement without having to alter the database.

Another feature of CSAMS that will create a better user experience, is an auto save feature for the existing review function. This will fix the problem of students timing out while reviewing an assignment, and having to redo their review. This feature was suggested by students when asking for feedback related to the CSAMS system.

6.5.2 Research

For future research, one can revisit **RQ1** again, but this time with the mechanic of sharing the peer review activity amongst all group members for a given assignment to be reviewed. The purpose of this would be to see if the results are different when a group completes the review as a group, instead of individually as done in this thesis.

During this thesis, we have seen that lack of good feedback has been a problem for both the individual and the group assignment. Therefore a future research could be to see how students can be trained into giving good feedback in peer reviews, and if this has any effect on the learning outcome for the students receiving the feedback.

6.6 Concluding remarks

Overall peer review has a place in an educational setting, it offers an opportunity to learn from other students. There are no strict rules for how to use peer review, which allows the teacher to customize it to best fit the needed purpose.

While this thesis has looked into the difference between using peer review for individual and group assignments, where peer reviews were performed by individuals in both cases, there is also a possibility to perform the peer review as a group for the group assignment.

Bibliography

[1] 'Compair.' (2023), [Online]. Available: https://isit.arts.ubc.ca/compair/ (visited on 20/04/2023).

[2] Y. Wang, Y. Liang, L. Liu and Y. Liu, 'A multi-peer assessment platform for programming language learning: Considering group non-consensus and personal radicalness,' *Interactive Learning Environments*, vol. 24, no. 8, pp. 2011–2031, 2016.

[3] 'Faculty of information technology and electrical engineering.' (2023), [Online]. Available: https://www.ntnu.edu/ie (visited on 21/04/2023).

[4] 'Prog2005 - cloud technologies.' (2023), [Online]. Available: https://www.ntnu.edu/studies/courses/PROG2005#tab=omEmnet (visited on 31/05/2023).

[5] C. Okoli, 'A guide to conducting a standalone systematic literature review,' *Communications of the Association for Information Systems*, vol. 37, 2015. [Online]. Available: https://doi.org/10.17705/1CAIS.03743.

[6] 'Google scholar.' (2023), [Online]. Available: https://scholar.google.com.

[7] R. A. Monson, 'Do they have to like it to learn from it? students' experiences, group dynamics, and learning outcomes in group research projects,' *Teaching Sociology*, vol. 47, no. 2, pp. 116–134, 2019.

[8] N. Elliott and A. Higgins, 'Self and peer assessment–does it make a difference to student group work?' *Nurse Education in Practice*, vol. 5, no. 1, pp. 40–48, 2005.

[9] S. Yamarik, 'Does cooperative learning improve student learning outcomes?' *The journal of economic education*, vol. 38, no. 3, pp. 259–277, 2007.

[10] L. M. Harding, 'Students of a feather "flocked" together: A group assignment method for reducing free-riding and improving group and individual learning outcomes,' *Journal of marketing education*, vol. 40, no. 2, pp. 117–127, 2018.

[11] J. A. Crowe, T. Silva and R. Ceresola, 'The effect of peer review on student learning outcomes in a research methods course,' *Teaching Sociology*, vol. 43, no. 3, pp. 201–213, 2015.

[12] K. Anewalt, 'Using peer review as a vehicle for communication skill development and active learning,' *Journal of Computing Sciences in Colleges*, vol. 21, no. 2, pp. 148–155, 2005.

[13] D. Chinn, 'Peer assessment in the algorithms course,' in *Proceedings of the 10th annual SIGCSE conference on Innovation and technology in computer science education*, 2005, pp. 69–73.

[14] A. Gorbunovs, A. Kapenieks and S. Cakula, 'Self-discipline as a key indicator to improve learning outcomes in e-learning environment,' *Procedia-Social and Behavioral Sciences*, vol. 231, pp. 256–262, 2016.

[15] Y. H. Cho and K. Cho, 'Peer reviewers learn from giving comments,' *Instructional science*, vol. 39, no. 5, pp. 629–643, 2011.

[16] L. Li, X. Liu and A. L. Steckelberg, 'Assessor or assessee: How student learning improves by giving and receiving peer feedback,' *British journal of educational technology*, vol. 41, no. 3, pp. 525–536, 2010.

[17] S. Gielen, E. Peeters, F. Dochy, P. Onghena and K. Struyven, 'Improving the effectiveness of peer feedback for learning,' *Learning and instruction*, vol. 20, no. 4, pp. 304–315, 2010.

[18] K. Lundstrom and W. Baker, 'To give is better than to receive: The benefits of peer review to the reviewer's own writing,' *Journal of second language writing*, vol. 18, no. 1, pp. 30–43, 2009.

[19] K. Cho and C. MacArthur, 'Learning by reviewing.,' *Journal of educational psychology*, vol. 103, no. 1, p. 73, 2011.

[20] A. A. Aziz, K. M. Yusof and J. M. Yatim, 'Evaluation on the effectiveness of learning outcomes from students' perspectives,' *Procedia-Social and Behavioral Sciences*, vol. 56, pp. 22–30, 2012.

[21] J. Hamer, H. Purchase, A. Luxton-Reilly and P. Denny, 'A comparison of peer and tutor feedback,' *Assessment & Evaluation in Higher Education*, vol. 40, no. 1, pp. 151–164, 2015.

[22] J. Hamer, H. C. Purchase, P. Denny and A. Luxton-Reilly, 'Quality of peer assessment in cs1,' in *Proceedings of the fifth international workshop on Computing education research workshop*, 2009, pp. 27–36.

[23] P. A. Carlson, F. C. Berry and D. Voltmer, 'Incorporating student peer-review into an introduction to engineering design course,' in *Proceedings Frontiers in Education 35th Annual Conference*, IEEE, 2005, F2C–20.

[24] C. F. Goh, O. K. Tan, A. Rasli and S. L. Choi, 'Engagement in peer review, learner-content interaction and learning outcomes,' *The International Journal of Information and Learning Technology*, 2019.

[25] 'Figma.' (2023), [Online]. Available: `https://www.figma.com` (visited on 07/02/2023).

[26] 'Adminer.' (2023), [Online]. Available: https://www.adminer.org (visited on 07/02/2023).

[27] 'Draw.io.' (2023), [Online]. Available: https://app.diagrams.net (visited on 07/02/2023).

[28] 'Openstack.' (2023), [Online]. Available: https://skyhigh.iik.ntnu.no (visited on 07/03/2023).

[29] 'The most widely deployed open source cloud software in the world.' (2023), [Online]. Available: https://www.openstack.org (visited on 07/03/2023).

[30] 'Nettskjema.' (2023), [Online]. Available: https://nettskjema.no (visited on 13/02/2023).

[31] 'Chatgpt.' (2023), [Online]. Available: https://chat.openai.com (visited on 13/02/2023).

[32] 'Assignment 1: Context-sensitive university search service.' (2023), [Online]. Available: https://git.gvk.idi.ntnu.no/course/prog2005/prog2005-2023/-/wikis/Assignments/Assignment-1 (visited on 01/05/2023).

[33] 'Assignment 2.' (2023), [Online]. Available: https://git.gvk.idi.ntnu.no/course/prog2005/prog2005-2023/-/wikis/Assignments/Assignment-2 (visited on 01/05/2023).

Appendix A

Additional Material

A.1 First draft of survey questions for individual assignment

Questions about assignment

1. Did you know about peer review before this assignment?
    a. Yes
    b. No
2. Have you performed a peer review before?
    a. Yes
    b. No
3. At what development skill level would you say you are at?
    a. Beginner
    b. Intermediate
    c. Good
    d. Profesjonell
4. Have you used the Code language GO before this assignment?
    a. Yes
    b. No
5. How hard would you say that this assignment was to complete?
    a. Easy
    b. Moderate
    c. Hard
6. During this assignment did you ask other students for help?
    a. Yes
    b. No
7. During this assignment did you ask student teachers for help?
    a. Yes
    b. No
8. During this assignment did you ask the teachers for help?
    a. Yes
    b. No
9. During this assignment did you use the internet to look for help?
    a. Yes
    b. No
10. What did you think about the time given to complete this assignment? (From publish date to deadline). Choose between good, moderate or bad time duration on completing assignment.
    a. Good (To much time)
    b. Moderate (Ok time)
    c. Bad (To short time)
11. Would you say that you have learned more about developing during this assignment?
    a. Yes
    b. No
12. Would you say that you have learned more about coding in GO?
    a. Yes
    b. No

Question about peer review

13. Did you like reviewing others' assignments?
    a. Yes
    b. No
14. Did you find it hard to review others' assignments?
    a. Vert easy
    b. Easy
    c. Ok
    d. Hard
    e. Very hard
15. If you found it hard, was it because it was too complex or too messy?
    a. To hard
    b. To messy
    c. Was not hard
16. From reviewing the code, did you learn something?
    a. Yes
    b. No
17. In future projects will you use / think about the things you learn from the reviewing to advance your project?
    a. Yes
    b. No
18.

Questions about feedback

19. Have you read the feedback you received?
    a. Yes
    b. No
20. Did you like receiving feedback?
    a. Yes
    b. No
21. Did you find the feedback constructive?
    a. Yes
    b. No
22. From all the feedback you received, would you say?
    a. All were bad
    b. All were good
    c. Some good and some bad
23. Was there any feedback that you disagree with?
    a. Yes
    b. No
24. Was there any feedback that you agree with?
    a. Yes
    b. No
25. Did you find the feedback you received help full?
    a. Yes

    b. No
26. Did you learn something from the feedback you received?
    a. Yes
    b. No
27. In future projects will you use / think about the things you learn from the feedback to advance your project?
    a. Yes
    b. No

ChatGPT

1. To what extent did the peer review process help you understand the assignment better?
    a. Not at all
    b. Somewhat
    c. A lot
2. How confident do you feel about the assignment after going through the peer review process?
    a. Not confident at all
    b. Somewhat confident
    c. Very confident
3. How much did you learn from your peers during the review process?
    a. Not much
    b. Some
    A lot
4. How helpful were the comments and suggestions provided by your peers during the review process?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
5. In your opinion, did the peer review process improve the quality of the assignment?
    a. No
    b. Somewhat
    c. Yes
6. Would you like to use peer review as a part of future assignments?
    a. No
    b. Maybe
    c. Yes
7. Did participating in peer review increase your engagement with the assignment?
    a. No
    b. Somewhat
    c. Yes
8. To what extent did the peer review process improve your critical thinking skills?
    a. Not at all
    b. Somewhat
    c. A lot

9. Did the peer review process encourage you to revise your work based on feedback received?
    a. No
    b. Somewhat
    c. Yes
10. How much did the peer review process contribute to your overall understanding of the subject matter?
    a. Not much
    b. Some
    c. A lot
11. To what extent did you benefit from the peer review process in terms of your personal and academic growth?
    a. Not at all
    b. Somewhat
    c. A lot
12. Was the peer review process well-organized and effective in terms of time management and resources?
    a. Not at all
    b. Somewhat
    c. Yes
13. How helpful were your peers in finding and fixing errors in your code?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
14. Did the peer review process help you write more efficient and optimized code?
    a. No
    b. Somewhat
    c. Yes
15. To what extent did the peer review process improve your understanding of good coding practices and conventions?
    a. Not at all
    b. Somewhat
    c. A lot
16. Did participating in the peer review process help you learn new programming concepts and techniques?
    a. No
    b. Somewhat
    c. Yes
17. How confident do you feel about the quality of your code after the peer review process?
    a. Not confident at all
    b. Somewhat confident
    c. Very confident
18. Did the peer review process encourage you to consider edge cases and corner cases while writing code?
    a. No
    b. Somewhat
    c. Yes

19. How helpful were your peers in explaining the reasoning behind their feedback and suggestions for your code?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
20. Did the peer review process help you develop a better understanding of software design patterns and architecture?
    a. No
    b. Somewhat
    c. Yes
21. How helpful was the peer review process in terms of improving your debugging skills?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
22. Did the peer review process help you write more readable and maintainable code?
    a. No
    b. Somewhat
    c. Yes
23. To what extent did the peer review process help you learn about software testing and verification?
    a. Not at all
    b. Somewhat
    c. A lot
24. How helpful was the peer review process in terms of learning about code collaboration and teamwork?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
25. How clear and specific were the comments and suggestions provided by your peers during the review process?
    a. Not clear at all
    b. Somewhat clear
    c. Extremely clear
26. Did you feel that the feedback received from your peers was constructive and helpful in improving your code?
    a. No
    b. Somewhat
    c. Yes
27. How much did you agree with the feedback received from your peers during the review process?
    a. Strongly disagreed
    b. Somewhat disagreed
    c. Agreed
28. Did the feedback received from your peers during the review process align with your own understanding of the assignment and the code you wrote?
    a. No
    b. Somewhat

    c. Yes
29. How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
30. To what extent did the feedback received from your peers during the review process contribute to your overall learning experience?
    a. Not at all
    b. Somewhat
    c. A lot
31. How helpful was the feedback received from your peers in terms of learning new programming concepts and techniques?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
32. Did you feel that the feedback received from your peers was timely and relevant to the assignment at hand?
    a. No
    b. Somewhat
    c. Yes
33. To what extent did you incorporate the feedback received from your peers into your revised code?
    a. Not at all
    b. Somewhat
    c. A lot
34. How helpful was the feedback received from your peers in terms of improving your understanding of software design patterns and architecture?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
35. Did the feedback received from your peers help you write more efficient and optimized code?
    a. No
    b. Somewhat
    c. Yes
36. How much did the feedback received from your peers help you develop better debugging skills?
    a. Not at all
    b. Somewhat
    c. A lot
37. To what extent did you understand the assignment and the code you were reviewing?
    a. Not at all
    b. Somewhat
    c. Completely
38. How much time did you spend reviewing the code of your peers?
    a. Less than 30 minutes
    b. 30 minutes to 1 hour

    c. More than 1 hour
39. How helpful were the guidelines provided for performing the peer review?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
40. To what extent did you feel that the peer review process was a valuable learning experience for you?
    a. Not at all
    b. Somewhat
    c. A lot
41. How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
    a. Not confident at all
    b. Somewhat confident
    c. Extremely confident
42. How helpful was the peer review process in improving your understanding of software design patterns and architecture?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
43. To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
    a. Not at all
    b. Somewhat
    c. A lot
44. Did you feel that the peer review process was an effective way of identifying and fixing errors in your peers' code?
    a. No
    b. Somewhat
    c. Yes
45. How much did you enjoy performing the peer review for the assignment?
    a. Not at all
    b. Somewhat
    c. A lot
46. To what extent did you feel that the peer review process helped you develop better critical thinking skills in evaluating code and identifying potential problems?
    a. Not at all
    b. Somewhat
    c. A lot
47. How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
    a. Not at all
    b. Somewhat
    c. A lot
48. To what extent did you feel that the peer review process helped you develop better collaboration skills with your peers?
    a. Not at all
    b. Somewhat

    c. A lot
49. Did you feel that the peer review process was a fair way of evaluating your code and the code of your peers?
    a. No
    b. Somewhat
    c. Yes
50. How helpful was the peer review process in terms of improving the quality of your code?
    a. Not helpful at all
    b. Somewhat helpful
    c. Extremely helpful
51. Did you feel that the peer review process was an effective way of learning from the code of your peers?
    a. No
    b. Somewhat
    c. Yes
52. To what extent did you feel that the peer review process helped you develop a better understanding of software development best practices?
    a. Not at all
    b. Somewhat
    c. A lot
53. Did you feel that the peer review process was an effective way of ensuring that the code was written in a clear and concise manner?
    a. No
    b. Somewhat
    c. Yes
54. How much did you feel that the peer review process helped you develop better time management skills in completing the review and incorporating feedback into your code?
    a. Not at all
    b. Somewhat
    c. A lot
55. To what extent did you feel that the peer review process helped you develop better problem-solving skills?
    a. Not at all
    b. Somewhat
    c. A lot
56. How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
    a. Not at all
    b. Somewhat
    c. A lot
57. Did you feel that the peer review process helped you develop better coding habits?
    a. No
    b. Somewhat
    c. Yes
58. To what extent did you feel that the peer review process helped you improve your ability to write efficient and optimized code?

    a. Not at all
    b. Somewhat
    c. A lot
59. Did you feel that the peer review process was an effective way of improving the overall quality of the assignment submissions?
    a. No
    b. Somewhat
    c. Yes
60. To what extent did you feel that the peer review process helped you gain a better understanding of how to work as part of a team on a software development project?
    a. Not at all
    b. Somewhat
    c. A lot

A.2 Final version of survey questions for individual assignment

Questions for survey 1 - Individual assignment

1. What is your previous experience with peer review?
    a. No experience at all
    b. Have heard about it
    c. Have done 1 before
    d. Have done 2-3 before
    e. Have done more than 3 before

2. How effective was the peer review to reflect on the overall quality of the assignment submission?
    a. Not effective at all
    b. Slightly effective
    c. Moderately effective
    d. Very effective
    e. Extremely effective

3. To what extent did you understand the code you were reviewing?
    a. Did not understand anything
    b. Understand very little
    c. Understand a moderate amount
    d. Understand a lot
    e. Understand completely

4. How helpful was the feedback received from your peers in terms of learning new programming skills?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful
    e. Extremely helpful

5. To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
    a. Did not learn anything
    b. Learned very little
    c. Learned a moderate amount
    d. Learned a lot
    e. Learned a great deal

6. How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful

    e. Extremely helpful

7. How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful
    e. Extremely helpful

8. Did knowing about participating in peer review increase your engagement with the assignment?
    a. Did not increase engagement at all
    b. Slightly increase engagement
    c. Moderately increase engagement
    d. Very much increase engagement
    e. Greatly increase engagement

9. How much time did you spend reviewing the code of your peers?
    a. Less than 30 minutes
    b. 30 minutes to 1 hour
    c. 1 hour to 2 hours
    d. 2 hours to 3 hours
    e. More than 3 hours

10. To what extent did the peer review process improve your critical thinking?
    a. Did not improve at all
    b. Slightly improved
    c. Moderately improved
    d. Improved a lot
    e. Improved significantly

11. To what extent did you benefit from the peer review process in terms of your professional growth?
    a. Did not benefit at all
    b. Slightly benefited
    c. Moderately benefited
    d. Benefited a lot
    e. Benefited significantly

12. How much did you agree with the feedback received from your peers during the review process?
    a. Did not agree at all
    b. Slightly agreed
    c. Moderately agreed
    d. Mostly agreed
    e. Completely agree

13. How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
    a. Not confident at all
    b. Slightly confident
    c. Moderately confident
    d. Very confident
    e. Extremely confident

14. How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
    a. Did not help at all
    b. Slightly helped
    c. Moderately helped
    d. Very much helped
    e. Extremely helpful

15. Was the peer review process a fair way of evaluating your code and the code of your peers?
    a. Not at all fair
    b. Slightly fair
    c. Moderately fair
    d. Very fair
    e. Extremely fair

16. How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
    a. Did not help at all
    b. Slightly helped
    c. Moderately helped
    d. Very much helped
    e. Extremely helpful

A.3 Final version of survey questions for group assignment

Questions for survey 2 - Group assignment

1. What is your previous experience with peer review?
    a. No experience at all
    b. Have heard about it
    c. Have done 1 before
    d. Have done 2-3 before
    e. Have done more than 3 before

2. How effective was the peer review to reflect on the overall quality of the assignment submission?
    a. Not effective at all
    b. Slightly effective
    c. Moderately effective
    d. Very effective
    e. Extremely effective

3. To what extent did you understand the code you were reviewing?
    a. Did not understand anything
    b. Understand very little
    c. Understand a moderate amount
    d. Understand a lot
    e. Understand completely

4. How helpful was the feedback received from your peers in terms of learning new programming skills?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful
    e. Extremely helpful

5. To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
    a. Did not learn anything
    b. Learned very little
    c. Learned a moderate amount
    d. Learned a lot
    e. Learned a great deal

6. How helpful was the feedback received from your peers in terms of identifying and fixing errors in your group's code?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful

    e. Extremely helpful

7. How helpful were the explanations provided in the feedback your group received, in terms of clarifying the reasoning behind the suggestions and comments on your group's code?
    a. Not helpful at all
    b. Slightly helpful
    c. Moderately helpful
    d. Very helpful
    e. Extremely helpful

8. Did knowing about participating in peer review increase your engagement with the assignment?
    a. Did not increase engagement at all
    b. Slightly increase engagement
    c. Moderately increase engagement
    d. Very much increase engagement
    e. Greatly increase engagement

9. How much time did you spend reviewing the code of your peers?
    a. Less than 30 minutes
    b. 30 minutes to 1 hour
    c. 1 hour to 2 hours
    d. 2 hours to 3 hours
    e. More than 3 hours

10. To what extent did the peer review process improve your critical thinking?
    a. Did not improve at all
    b. Slightly improved
    c. Moderately improved
    d. Improved a lot
    e. Improved significantly

11. To what extent did you benefit from the peer review process in terms of your professional growth?
    a. Did not benefit at all
    b. Slightly benefited
    c. Moderately benefited
    d. Benefited a lot
    e. Benefited significantly

12. How much did you agree with the feedback received from your peers during the review process?
    a. Did not agree at all
    b. Slightly agreed
    c. Moderately agreed
    d. Mostly agreed

    e. Completely agree

13. How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
    a. Not confident at all
    b. Slightly confident
    c. Moderately confident
    d. Very confident
    e. Extremely confident

14. How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
    a. Did not help at all
    b. Slightly helped
    c. Moderately helped
    d. Very much helped
    e. Extremely helpful

15. Was the peer review process a fair way of evaluating your group's code and the code of your peers?
    a. Not at all fair
    b. Slightly fair
    c. Moderately fair
    d. Very fair
    e. Extremely fair

16. How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
    a. Did not help at all
    b. Slightly helped
    c. Moderately helped
    d. Very much helped
    e. Extremely helpful

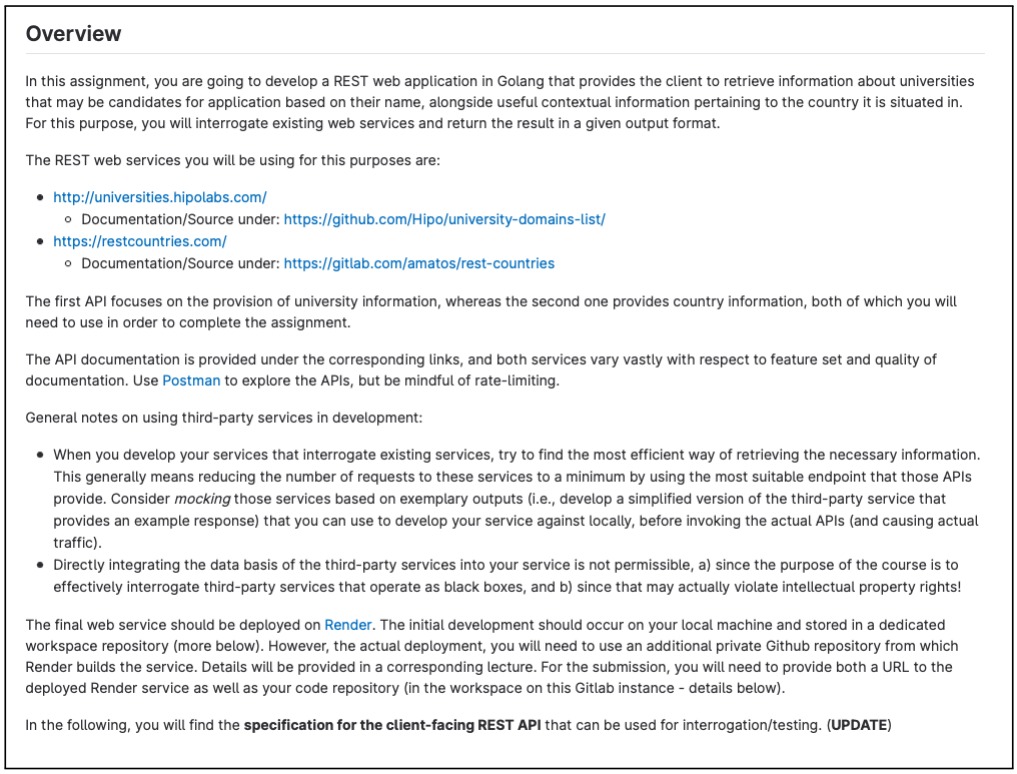
17. How would you rate your own level of participation and contribution to the group project?
    a. No contribution at all
    b. Slightly contributed
    c. Moderately contributed
    d. Very contributed
    e. Extremely contributed

18. How do you prefer to learn: by working individually or in a group?
    a. Strongly prefer working individually
    b. Somewhat prefer working individually
    c. Neutral or no preference
    d. Somewhat prefer working in a group

    e. Strongly prefer working in a group

19. How much do you feel you learn from doing an individual assignment versus a group assignment?
    a. Learn much more from individual assignments
    b. Learn somewhat more from individual assignments
    c. No difference
    d. Learn somewhat more from group assignments
    e. Learn much more from group assignments
20. To what extent do you think there were unequal contributions in your group?
    a. Contributions were completely equal among all group members
    b. Contributions were somewhat unequal, but the impact was negligible
    c. Contributions were moderately unequal, and this had some impact
    d. Contributions were significantly unequal, and this had a noticeable impact
    e. Contributions were extremely unequal, resulting in some members carrying the majority of the workload
21. Did working in a group increase your engagement with the assignment?
    a. Did not increase engagement at all
    b. Slightly increase engagement
    c. Moderately increase engagement
    d. Very much increase engagement
    e. Greatly increase engagement
22. Was there any difference in reviewing an individual assignment versus a group assignment?
    a. No difference at all
    b. Minor differences
    c. Moderate differences
    d. Significant differences
    e. Completely different
23. Was there any difference in receiving reviews for an individual assignment versus a group assignment?
    a. No difference at all
    b. Minor differences
    c. Moderate differences
    d. Significant differences
    e. Completely different
24. Do you have any comments about the new group functionality to CSAMS? Something you liked or something you did not like? (Optional to answer)
    a. Text answer

A.4 Overview assignment 1



Overview

In this assignment, you are going to develop a REST web application in Golang that provides the client to retrieve information about universities that may be candidates for application based on their name, alongside useful contextual information pertaining to the country it is situated in. For this purpose, you will interrogate existing web services and return the result in a given output format.

The REST web services you will be using for this purposes are:

- http://universities.hipolabs.com/
  - Documentation/Source under: https://github.com/Hipo/university-domains-list/
- https://restcountries.com/
  - Documentation/Source under: https://gitlab.com/amatos/rest-countries

The first API focuses on the provision of university information, whereas the second one provides country information, both of which you will need to use in order to complete the assignment.

The API documentation is provided under the corresponding links, and both services vary vastly with respect to feature set and quality of documentation. Use Postman to explore the APIs, but be mindful of rate-limiting.

General notes on using third-party services in development:

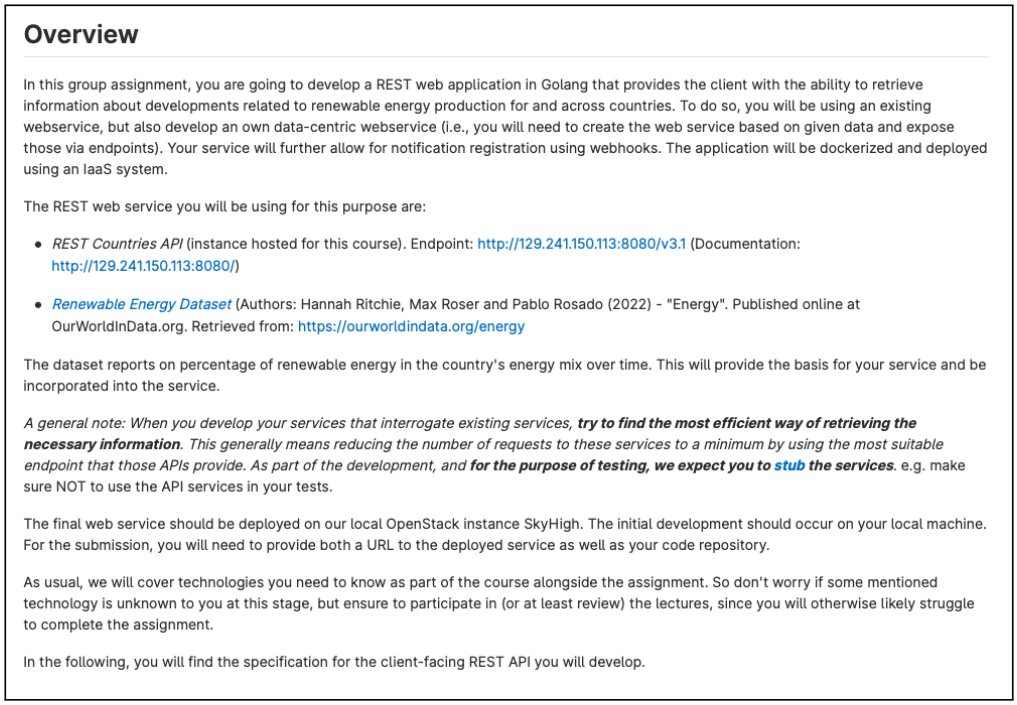
- When you develop your services that interrogate existing services, try to find the most efficient way of retrieving the necessary information. This generally means reducing the number of requests to these services to a minimum by using the most suitable endpoint that those APIs provide. Consider *mocking* those services based on exemplary outputs (i.e., develop a simplified version of the third-party service that provides an example response) that you can use to develop your service against locally, before invoking the actual APIs (and causing actual traffic).
- Directly integrating the data basis of the third-party services into your service is not permissible, a) since the purpose of the course is to effectively interrogate third-party services that operate as black boxes, and b) since that may actually violate intellectual property rights!

The final web service should be deployed on Render. The initial development should occur on your local machine and stored in a dedicated workspace repository (more below). However, the actual deployment, you will need to use an additional private Github repository from which Render builds the service. Details will be provided in a corresponding lecture. For the submission, you will need to provide both a URL to the deployed Render service as well as your code repository (in the workspace on this Gitlab instance - details below).

In the following, you will find the **specification for the client-facing REST API** that can be used for interrogation/testing. (**UPDATE**)

Figure A.1: Overview of assignment 1. Picture was taken of the assignment given to the students [32]

A.5 Overview assignment 2



Overview

In this group assignment, you are going to develop a REST web application in Golang that provides the client with the ability to retrieve information about developments related to renewable energy production for and across countries. To do so, you will be using an existing webservice, but also develop an own data-centric webservice (i.e., you will need to create the web service based on given data and expose those via endpoints). Your service will further allow for notification registration using webhooks. The application will be dockerized and deployed using an IaaS system.

The REST web service you will be using for this purpose are:

- *REST Countries API* (instance hosted for this course). Endpoint: http://129.241.150.113:8080/v3.1 (Documentation: http://129.241.150.113:8080/)
- *Renewable Energy Dataset* (Authors: Hannah Ritchie, Max Roser and Pablo Rosado (2022) - "Energy". Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/energy

The dataset reports on percentage of renewable energy in the country's energy mix over time. This will provide the basis for your service and be incorporated into the service.

A general note: When you develop your services that interrogate existing services, ***try to find the most efficient way of retrieving the necessary information****. This generally means reducing the number of requests to these services to a minimum by using the most suitable endpoint that those APIs provide. As part of the development, and* ***for the purpose of testing, we expect you to stub the services****.* e.g. make sure NOT to use the API services in your tests.

The final web service should be deployed on our local OpenStack instance SkyHigh. The initial development should occur on your local machine. For the submission, you will need to provide both a URL to the deployed service as well as your code repository.

As usual, we will cover technologies you need to know as part of the course alongside the assignment. So don't worry if some mentioned technology is unknown to you at this stage, but ensure to participate in (or at least review) the lectures, since you will otherwise likely struggle to complete the assignment.

In the following, you will find the specification for the client-facing REST API you will develop.

Figure A.2: Overview of assignment 2. Picture was taken of the assignment given to the students [33]

A.6 Results and comments from survey 1

Question: 1	What is your previous experience with peer review?
Ansvers:	
No experience at all	4
Have heard about it	4
Have done 1 before	1
Have done 2-3 before	2
Have done more than 3 before	6
Total participants:	17

Question: 2	How effective was the peer review to reflect on the overall quality of the assignment submission?
Ansvers:	
Not effective at all	0
Slightly effective	3
Moderately effective	6
Very effective	6
Extremely effective	2
Total participants:	17

Question: 3	To what extent did you understand the code you were reviewing?
Ansvers:	
Did not understand anything	0
Understand very little	1
Understand a moderate amount	2
Understand a lot	10
Understand completely	4
Total participants:	17

Question: 4	How helpful was the feedback received from your peers in terms of learning new programming skills?
Ansvers:	
Not helpful at all	2
Slightly helpful	10
Moderately helpful	4
Very helpful	1
Extremely helpful	0
Total participants:	17

Question: 5	To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
Ansvers:	
Did not learn anything	3
Learned very little	7
Learned a moderate amount	7
Learned a lot	0
Learned a great deal	0
Total participants:	17

Figure A.3: Results from survey 1. Question 1 to 5

A.7 Results and comments from survey 2

Question: 6	How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
Ansvers:	
Not helpful at all	2
Slightly helpful	6
Moderately helpful	7
Very helpful	2
Extremely helpful	0
Total participants:	17

Question: 7	How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?
Ansvers:	
Not helpful at all	2
Slightly helpful	7
Moderately helpful	5
Very helpful	3
Extremely helpful	0
Total participants:	17

Question: 8	Did knowing about participating in peer review increase your engagement with the assignment?
Ansvers:	
Did not increase engagement at all	5
Slightly increase engagement	5
Moderately increase engagement	6
Very much increase engagement	1
Greatly increase engagement	0
Total participants:	17

Question: 9	How much time did you spend reviewing the code of your peers?
Ansvers:	
Less than 30 minutes	0
30 minutes to 1 hour	4
1 hour to 2 hours	7
2 hours to 3 hours	2
More than 3 hours	4
Total participants:	17

Question: 10	To what extent did the peer review process improve your critical thinking?
Ansvers:	
Did not improve at all	4
Slightly improved	4
Moderately improved	7
Improved a lot	2
Improved significantly	0
Total participants:	17

Figure A.4: Results from survey 1. Question 6 to 10

Question: 11	To what extent did you benefit from the peer review process in terms of your professional growth?
Ansvers:	
Did not benefit at all	2
Slightly benefited	5
Moderately benefited	3
Benefited a lot	6
Benefited significantly	1
Total participants:	17

Question: 12	How much did you agree with the feedback received from your peers during the review process?
Ansvers:	
Did not agree at all	0
Slightly agreed	3
Moderately agreed	4
Mostly agreed	8
Completely agree	2
Total participants:	17

Question: 13	How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
Ansvers:	
Not confident at all	2
Slightly confident	1
Moderately confident	5
Very confident	6
Extremely confident	3
Total participants:	17

Question: 14	How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
Ansvers:	
Did not help at all	2
Slightly helped	8
Moderately helped	5
Very much helped	1
Extremely helpful	1
Total participants:	17

Question: 15	Was the peer review process a fair way of evaluating your code and the code of your peers?
Ansvers:	
Not at all fair	2
Slightly fair	3
Moderately fair	5
Very fair	5
Extremely fair	2
Total participants:	17

Figure A.5: Results from survey 1. Question 11 to 15

Question: 16	How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
Ansvers:	
Did not help at all	4
Slightly helped	5
Moderately helped	4
Very much helped	4
Extremely helpful	0
Total participants:	17

Figure A.6: Results from survey 1. Question 16

Do you want to elaborate your answer on question 1? - What is your previous experience with peer review?
Have have had peer reviews in Advanced Programming, Databases, and taken Cloud once before.
Only completed 3 this time, but I'm currently retaking the course so I have experience from last year (did them in advanced programming as well)
I had never done it formally, but I know what it is.
Done something similar in other subjects, but nothing at this scale.
Mostly from this course before and PROG2006
Never had it before Cloud Technologies.
I had done do peer reviews before assignment 1.

Do you want to elaborate your answer on question 2? - How effective was the peer review to reflect on the overall quality of the assignment submission?
I got some comments that I thought were useful, but most of them just said I had done a good job.
Being one of the lower performing students, getting feedback from peers is very useful, especially when the reviewer is significantly more experienced
Some people give good feedback, and from seeing good assignments from other people I can recognize faults with my own that I didn't think about at the time. The problem is that doing peer reviews are "forced" and since some students are either bad programmers or can't be bothered to actually read the code, they give bad or even incorrect feedback at times. You might also review incomplete assignements that that won't teach you anything.
Here, you get to see how others did things. And this is immensely helpful. Receiving a review was in my all too humble opinion not very helpful overal. Reviewing was very helpful.
Some "reviews" I got looked like the other person had not even looked at my submission. They outright lied about faults in my submission's functionality.
In my situation, I had done the assignment exactly as wanted. The feedback I had received on the peer reviews were minimal, and mostly just personal complaints.
Highly deppends on how much effort was put into the review by the other part.
The feedback I received was limited: one review said everything was mostly fine, the other pointed out obvious errors, most of which I was already aware of. In either case, I found it difficult to derive much learning from it.

Do you want to elaborate your answer on question 3? - To what extent did you understand the code you were reviewing?
Go code is usually very readable, and since the assignment is so small it leaves less room for potential spaghetti code.
I completely understand what the other students have written, but some of the functions and methods we use from external libraries are black boxes that I can't say I fully understand. (only know where to use them and what to expect, but not how they function)
I did not take the time to completely understand the code I reviewed. Enough to be able to make comments on it. And propose better ways of doing thing where I thought it could be better.
Basic things are easy to review, more in depth things require a full overview of the code and all methods used. That is too much work for me
I understood the code I was looking at a lot, and I even was impressed by some of the unique ways the assignment was solved (such as using an interface{}).
Some was a bit confusing at times, but in general i understood most of what i got.
Most of the code I reviewed was fairly similar to my own.

Do you want to elaborate your answer on question 4? - How helpful was the feedback received from your peers in terms of learning new programming skills?
There wasnt really much to teach me at this point
Feedback bringing up what I did poorly generally didn't explain why it was bad or how to do it better, which doesn't really help me get better.
The feedback I received was, in my all too humble opinion, of poor quality. It felt more like a judgement on my work. I felt good if I received good coment, bad if it was bad comments. But above all, most of the critical comments failed to propose a better alternative. And, in that sense, negative judgement is pretty much useless here. But I did receive a few suggestions.
Slightyl helpful, it did pinpoint on some aspects that need improvements.
I usually know myself what can be done better, and some reviews give such aweful feedback that I don't even know if it is correct
As noted, I had already done the assignment in a good way, so the feedback was minimal and mostly up to personal taste. My programming skills remained the same.
People don't go through every single part of someone's code to check for improvements and new things you can do. Mostly people will check if things run and work on a basic level, and that things cover the necessary requirements.
The feedback for the most part related to lacking error handling, which is not as such a programming skill, but more a consequence of limited experience with API programming. Other issues with my assignment, which I have identified later, such as modularity and scalability, were not pointed out.

Figure A.7: Comments from survey 1. Question 1 to 4

Do you want to elaborate your answer on question 5? - To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
There were solutions that had some cool tricks when solving the task that i might use in the future, but most of the solutions used the same strategy.
Learned a way to find the correct country from RESTCountries if the input name results in multiple results (like if you send a request for "china" it returns four results I think), and a way to replace empty spaces with %20 (that wasn't just a "replaceAll" or regex)
I did not learn completely new things. But I did learn different ways of doing things that I found pretty effective and that I will keep with me.
Did see some tricks, or small code that I did not think about.
Because I understood most, if not all of the code I had reviewed, I had essentially learnt nothing new.
There were some useful things to learn.
As I stated previously, both of the assignments were quite like my own.

Do you want to elaborate your answer on question 6? - How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
I only had one minor bug, and forgot to put content type json.
Didn't get any feedback on failed error handling, even though I did see some myself after the deadline
This is where it was not very helpful at all. Saying its not so good with general references to the code was not helpful. What is helpful is when you refer to precise lines of code and propose another way of doing it. Or if it's a big change, with clear explanations.
Did see some other ways to implement certain aspects of the assigment.
Mostly typos and missing comments though
Again, my code was so good that it lacked most of those.
Two of the reviews pointed out improvements related to modularity, but i knew of those allready. Again, people don't really go in depth, so as long as your code covers the bases of the assignment people won't dig for more.
Some specific mistakes in error code selection

Do you want to elaborate your answer on question 7? - How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?
To be honest they didnt have much to comment on
As I commented earlier, very little explanations provided to me in reviews.
Not so helpful because it was most of the time so general. I received one comment litteraly as such: "You should not have relied so much on ChatGPT, you can do better than that." Without pointing to a single line of code that i "could have done better".
They weren't helpful, as some of them had just written a few words, and others just pointed out personal complaints.
Sometimes I got useful feedback.
Mostly not helpfull, since most reviews just say they experienced something wrong, or that I have done something suboptimally, without describing what's wrong, or how to fix it/make it better

Do you want to elaborate your answer on question 8? - Did knowing about participating in peer review increase your engagement with the assignment?
Understanding and being able to read others code is important but can feel like a chore if you are not comfortable with the language.
Might misunderstand, know the person you're reviewing or that is can affect your grade?
Since it's an assignment that would be part of my portfolio, and its evaluation counting towards my final grade, it didn't matter to me if other students also saw my assignment after it's completion.
In the end, what I worked for was the grade, aka the review of the professor. So the motivation was already there, and the peer review did not add much more motivation. But it has a good learning value to do a peer-review. Receiving one has little value unless it is detailed. Good job or bad job helps very little in the end. But doing one has good value, no matter what the reviewer ends up writing as a review.
I comment more when I know peer review will be done
It increased the engagement simply because it was mandatory.
Because peer reviews are less instructive and authoritative than grading/teaching staff feedback, I felt, and continue to feel, that I will learn less from this assignment than one where I received feedback from a teacher.
To me it doesn't matter if other students will also see/review my code, since I already know the assignment will be evaluated and graded by the teacher, where the evaluation counts towards my final grade in the subject.

Figure A.8: Comments from survey 1. Question 5 to 8

Do you want to elaborate your answer on question 9? - How much time did you spend reviewing the code of your peers?
I did 3 reviews, and i got a review that had barely any code so i tried to help as much as possible by giving tips and potential solutions.
1-2 hours per review
A decent chunk of the time was spent figuring out how to do the review, like researching what go vet is and how to use it, rather than doing the actual review
Did the first in about 1h 15min, second in closer to 1h 30min, and 2h or a bit more on the third review i did. (got duplicate data in final review, so spent a lot of time trying to figure out why so I could give feedback on how to fix it)
First one takes the most time, then the next are quicker because you know how to do it.
I took a good amount of time, to understand the logic and the code itself. And I thought that I went quick on them and even felt a little bad for it. Then I heard in the class that some took only 30 minutes...
Spent 30min to 1h on each review
ca. 30 min per person
I had looked through the code, attempted various case situations, and reported on those.
I'm assuming this is time spent per individual review? If not, then it would be over 4 hours

Do you want to elaborate your answer on question 10? - To what extent did the peer review process improve your critical thinking?
It improved in the sense that it provided me with new ideas and new ways of going things. But did it make me better at "judging"? I don't feel like it at all. Even less to put a "grade" on the reviewed code.
I would like to say that I am a very alright individual already, and that it did not improve my critical thinking.
Again, people, including me, only covered what was required.
It made me realize vulnurabilities with my own assignment, but mostly due to things I had overlooked. I now test more diligently

Do you want to elaborate your answer on question 11? - To what extent did you benefit from the peer review process in terms of your professional growth?
I think its very important to go through this process
Reviewing other's code is very helpful. And it makes you think about better ways of doing things, and makes you think about suggestions to give on the reviewed code. It is in a way quite stimulating.
I've been through it now, so I know what to expect at least

Do you want to elaborate your answer on question 12? - How much did you agree with the feedback received from your peers during the review process?
All the feedback I got was relevant.
My first review gave good feedback that I agreed with, but my second review was by someone who misunderstood the assignment as well as what some of the questions even asked about. (e.g. saying my moderation was really bad since I had a folder structure, which makes no sense)
Some people pointed to what was a bug when it was something that I deliberately coded. And they based much of their review on that. Obviously I disagreed with them saying that my code did not work properly. So, at the core, I disagreed with all of the reviews I received. But some pointed to a genuine bug and another review offered suggestions on how I structure the code, and so that was helpful.
Yeah, most of the feedback I had gotten were saying that my code was good, and I didn't agree with some of the smaller personal complaints put forth.

Do you want to elaborate your answer on question 13? - How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
Its difficult for me to not feel slightly rude when pointing out mistakes but i try to give som encuraging words at the end.
Being one of the lower performing students, I did not feel qualified to give particularly helpful feedback
I looked through all the files of the peers I reviewed, and tested how their code worked in debugger to make sure I understood it before criticizing it
But for the second, I was warmed up, so I went deeper and offered some concrete suggestions on doing things better and I went deeper at explaining the bugs that I saw and so on. I am proud of my second review really. I think it was really helpful.
I know I can't identify everything, and when my grade might be dependent on the reviews I do, I feel like it is never good enough
I felt as though I had a proper grasp of the code and assignment in question, so I believed that my feedback was confident in pointing out problems and good sides.
This was my first peer review, and while we were supplied with an instructive and comprehensive form, it would still have been useful to see an example of a constructive peer review beforehand.
Did my best to debug the code locally to see what the problems (if any) were, and then comment on what I found out through that process.

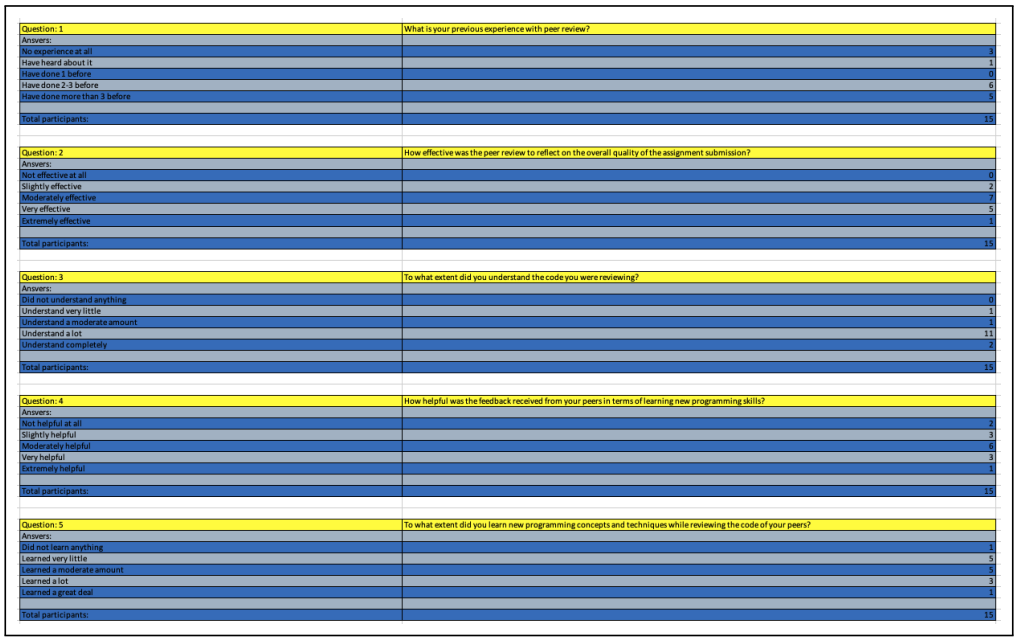
Do you want to elaborate your answer on question 14? - How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
I tried not being too mean/blunt about stuff being bad/poor, which I think slightly helped. Since we are giving feedback to other programmers on a specific task they had done, I don't think the technical concepts are that relevant.
All practice is good, but I don't feel like I became a new person after the peer review... :) But for next edition, it would be good to advise students to be precise in the feedback they give. The more precise, the better. The more vague and general, the less helpful.
I have been a TA for a while so I already do this a lot

Do you want to elaborate your answer on question 15? - Was the peer review process a fair way of evaluating your code and the code of your peers?
As long as the peer reviewer knows what they are talking about its fair.
Would be more fair if we were allowed to write a response the the review. Critique that you are unable to question, feels unfair when the critic doesn't explain themselves propperly
I don't have much more to add here. It is fair. And in the end it is something that can only be mutually beneficial, for the reviewer and the reviewed.
I do not think that students should have the last work in evuating an assigment at the higher education level. However, the opportunity for us to see others code is helpful, but should not be used for the actual evaluation of the grade in the subject.
This year it was pretty good, previously I have had some reviews that cleary didn't understand the assignment/my code
I would have to say around 80% "yes". While it is true that other students reviewing your code often provide an (at least) somewhat knowledgeable feedback on your performance, there may be situations where a peer reviewing evaluates your code, and evaluates it wrong. Given that the peers reviewing are competent, then I would feel more safe in saying it would be fair.
I truly hope the peer reviews are not the basis for our grading. Because then we are at the mercy of a good review or not.
The peer reviews feel like the blind leading the blind. I was not confident about giving authoritative feedback about a relatively new area of programming, and the feedback I received was not as comprehensive as I might have liked.
From an evaluation standpoint, it feels entirely unfair to focus on critique of what doesn't work/could be done batter, as there is minimal feedback on what is done well. Had the grade been based on peer reviews, a good grade would only be obtainable if the code is flawless

Do you want to elaborate your answer on question 16? - How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
I debugged the same way I debug my own code. There were some edge cases that i didnt think about that were helpful.
It made me more cautious of possible responses from APIs
A lot. This was the first time that I did such a task. And this was definitely good practice. It makes you look at code differently. It's hard to explain, but yeah.
I already do this a lot in group assignments and my job, so I personally haven't learned a lot
Nothing beyond what i allready knew.
I got no feedback related to debugging

Figure A.9: Comments from survey 1. Question 9 to 12

Figure A.10: Comments from survey 1. Question 13 to 16



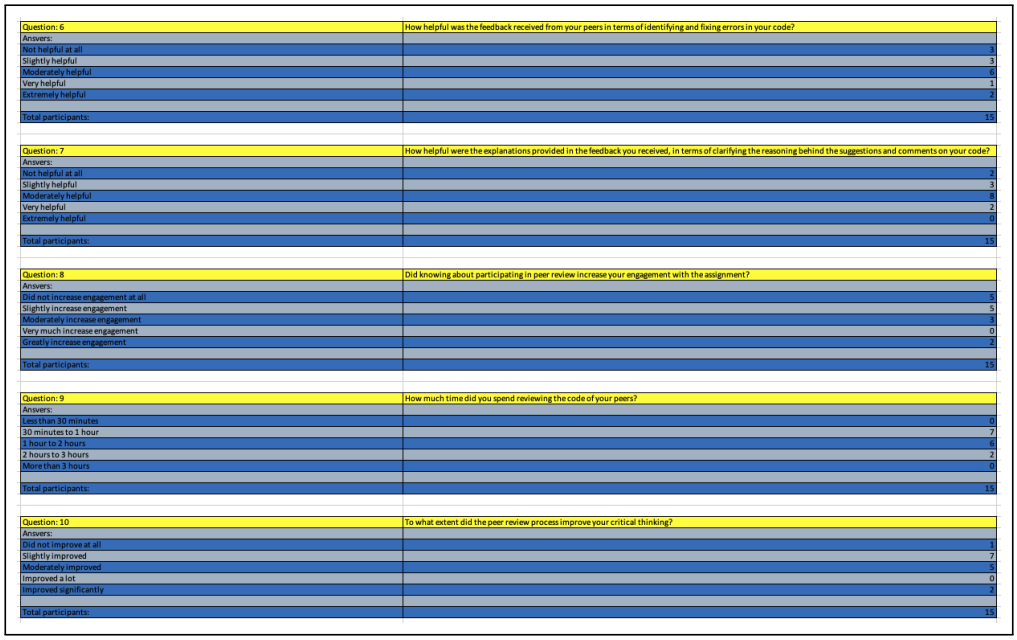
Question: 1	What is your previous experience with peer review?
Answers:	
No experience at all	3
Have heard about it	1
Have done 1 before	0
Have done 2-3 before	6
Have done more than 3 before	5
Total participants:	15

Question: 2	How effective was the peer review to reflect on the overall quality of the assignment submission?
Answers:	
Not effective at all	0
Slightly effective	2
Moderately effective	7
Very effective	5
Extremely effective	1
Total participants:	15

Question: 3	To what extent did you understand the code you were reviewing?
Answers:	
Did not understand anything	0
Understand very little	1
Understand a moderate amount	1
Understand a lot	11
Understand completely	2
Total participants:	15

Question: 4	How helpful was the feedback received from your peers in terms of learning new programming skills?
Answers:	
Not helpful at all	3
Slightly helpful	3
Moderately helpful	0
Very helpful	3
Extremely helpful	1
Total participants:	15

Question: 5	To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
Answers:	
Did not learn anything	1
Learned very little	5
Learned a moderate amount	5
Learned a lot	3
Learned a great deal	1
Total participants:	15



Question: 6	How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
Answers:	
Not helpful at all	3
Slightly helpful	3
Moderately helpful	5
Very helpful	1
Extremely helpful	3
Total participants:	15

Question: 7	How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?
Answers:	
Not helpful at all	2
Slightly helpful	3
Moderately helpful	8
Very helpful	2
Extremely helpful	0
Total participants:	15

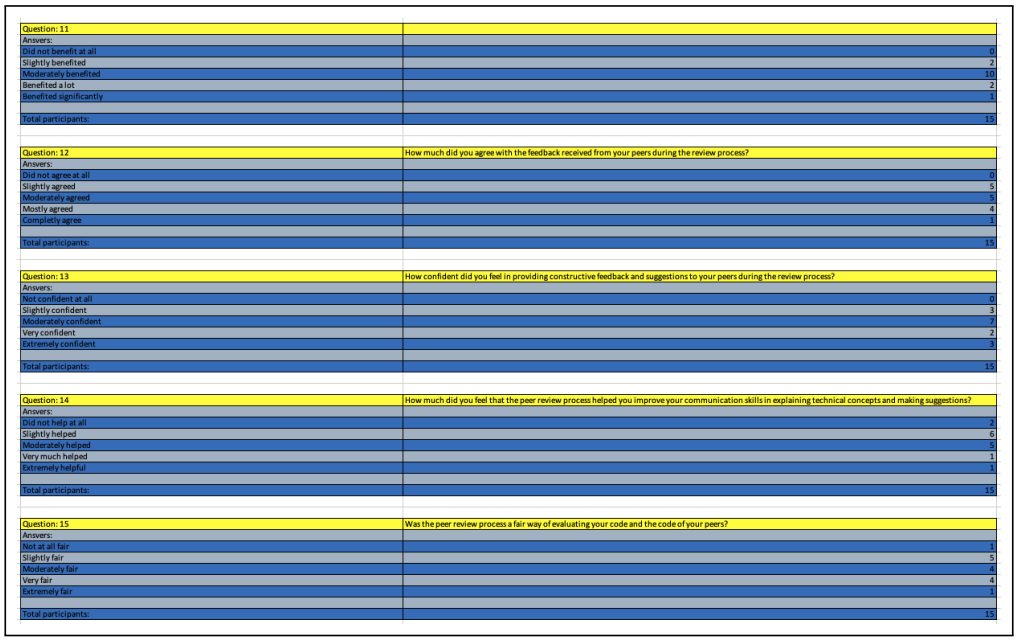
Question: 8	Did knowing about participating in peer review increase your engagement with the assignment?
Answers:	
Did not increase engagement at all	5
Slightly increase engagement	5
Moderately increase engagement	3
Very much increase engagement	0
Greatly increase engagement	2
Total participants:	15

Question: 9	How much time did you spend reviewing the code of your peers?
Answers:	
Less than 30 minutes	0
30 minutes to 1 hour	7
1 hour to 2 hours	6
2 hours to 3 hours	2
More than 3 hours	0
Total participants:	15

Question: 10	To what extent did the peer review process improve your critical thinking?
Answers:	
Did not improve at all	1
Slightly improved	7
Moderately improved	5
Improved a lot	0
Improved significantly	2
Total participants:	15

Figure A.11: Results from survey 2. Question 1 to 5

Figure A.12: Results from survey 2. Question 6 to 10



Question: 11	
Answers:	
Did not benefit at all	0
Slightly benefited	2
Moderately benefited	10
Benefited a lot	2
Benefited significantly	1
Total participants:	15

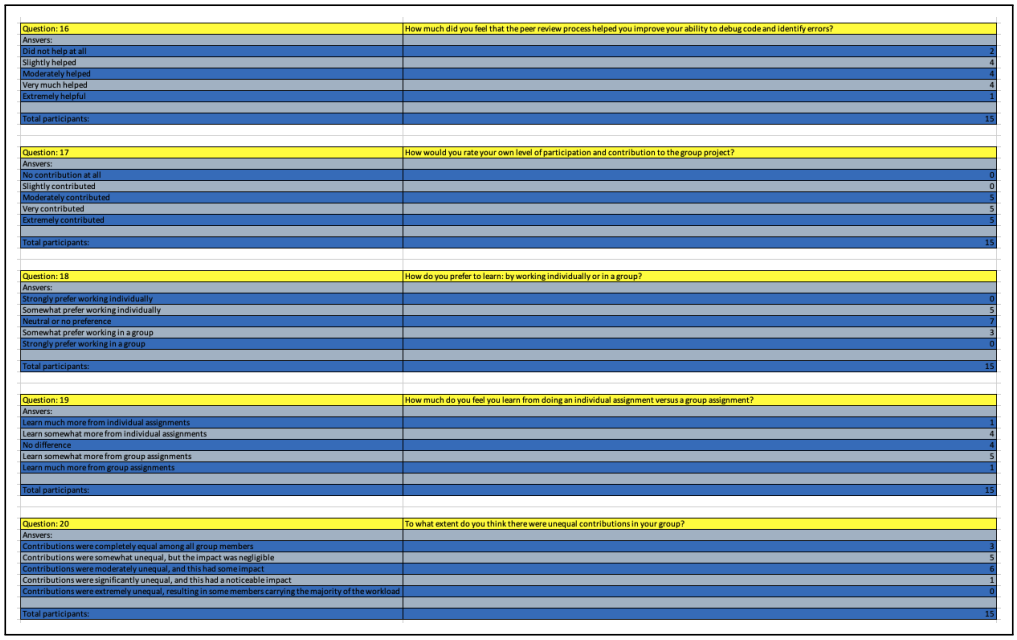
Question: 12	How much did you agree with the feedback received from your peers during the review process?
Answers:	
Did not agree at all	0
Slightly agreed	5
Moderately agreed	5
Mostly agreed	4
Completely agree	1
Total participants:	15

Question: 13	How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
Answers:	
Not confident at all	0
Slightly confident	3
Moderately confident	7
Very confident	2
Extremely confident	3
Total participants:	15

Question: 14	How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
Answers:	
Did not help at all	3
Slightly helped	6
Moderately helped	5
Very much helped	1
Extremely helpful	1
Total participants:	15

Question: 15	Was the peer review process a fair way of evaluating your code and the code of your peers?
Answers:	
Not at all fair	1
Slightly fair	5
Moderately fair	4
Very fair	4
Extremely fair	1
Total participants:	15

Figure A.13: Results from survey 2. Question 11 to 15



Question: 16	How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
Answers:	
Did not help at all	2
Slightly helped	4
Moderately helped	4
Very much helped	4
Extremely helpful	1
Total participants:	15

Question: 17	How would you rate your own level of participation and contribution to the group project?
Answers:	
No contribution at all	0
Slightly contributed	0
Moderately contributed	5
Very contributed	5
Extremely contributed	5
Total participants:	15

Question: 18	How do you prefer to learn: by working individually or in a group?
Answers:	
Strongly prefer working individually	0
Somewhat prefer working individually	5
Neutral or no preference	7
Somewhat prefer working in a group	3
Strongly prefer working in a group	0
Total participants:	15

Question: 19	How much do you feel you learn from doing an individual assignment versus a group assignment?
Answers:	
Learn much more from individual assignments	1
Learn somewhat more from individual assignments	4
No difference	4
Learn somewhat more from group assignments	5
Learn much more from group assignments	1
Total participants:	15

Question: 20	To what extent do you think there were unequal contributions in your group?
Answers:	
Contributions were completely equal among all group members	3
Contributions were somewhat unequal, but the impact was negligible	5
Contributions were moderately unequal, and this had some impact	6
Contributions were significantly unequal, and this had a noticeable impact	1
Contributions were extremely unequal, resulting in some members carrying the majority of the workload	0
Total participants:	15

Figure A.14: Results from survey 2. Question 16 to 20

Question: 21	Did working in a group increase your engagement with the assignment?
Ansvers:	
Did not increase engagement at all	3
Slightly increase engagement	3
Moderately increase engagement	3
Very much increase engagement	5
Greatly increase engagement	1
Total participants:	15

Question: 22	Was there any difference in reviewing an individual assignment versus a group assignment?
Ansvers:	
No difference at all	5
Minor differences	6
Moderate differences	1
Significant differences	3
Completely different	0
Total participants:	15

Question: 23	Was there any difference in receiving reviews for an individual assignment versus a group assignment?
Ansvers:	
No difference at all	8
Minor differences	3
Moderate differences	4
Significant differences	0
Completely different	0
Total participants:	15

Figure A.15: Results from survey 2. Question 21 to 23

Do you want to elaborate your answer on question 1? - What is your previous experience with peer review?
Before assignment 2 in Cloud, I have done 3 in another course and 2 in Cloud for assignment 1
Have done it in a school setting a few times before.
Previous school work

Do you want to elaborate your answer on question 2? - How effective was the peer review to reflect on the overall quality of the assignment submission?
Very individually, some put actually effort into it, while other don't bother
There usually are an element of forcible constraint attached to them (in such a setting as this) and that will probably skew both the outcomes and the experience for most people. In this course for example, it's tied to the grade, which makes it not that great in many regards. My personal experience is that I learned some (maybe even a lot), but I usually spent quite a lot of time on each review compared to most (all) people I've talked to about it. The feedback I or my group got was really lacking and barely scratched the surface.
Found most of the peer reviewers to be as nitpicky as possible, and some to refuse to give "top marks" to stuff the had no complaints about, and which was done exactly to standards. I blame this on the fact that we are of the understanding that what other people are rating us, affect our grade, so that people try to make other people assignment look worse so theirs look better. Would find the entire peer review part to be a lot more enjoyable if other people peer review had nothing to do with the grades, and that was stressed from the beginning. That way there is less of a motivation for people to drag other people assignment down.
The feedback mostly consisted of pointing out smaller mistakes and personal preference.
it works

Do you want to elaborate your answer on question 3? - To what extent did you understand the code you were reviewing?
Some solved things in a different way I didn't think of
Understood most parts, there were a few lines which I didn't get at first tho. There were also a good deal that didn't make sense or seemed like a convoluted way to do some tasks.
People generally think differently. Also, you could easly see that a person worked hard on a project or not.
Most of the code was similar to what I had written myself.
I understand it

Do you want to elaborate your answer on question 4? - How helpful was the feedback received from your peers in terms of learning new programming skills?
In the best case it was slightly helpful, but not really. I'm guessing that is because most people didn't review the code with the intent of providing feedback and didn't have the intent to learn something themselves, they did it to pass a hurdle on the way to getting a grade for the course.
Mostly spotting bugs in the application
Did not get that many insights for improvements, but then again maybe more valuable for less quality projects.
Again, feedback was mostly nit-picking.
meeeh
Others see the code from a different perspective
Some was very helpful, while others were more negative than actually critiquing

Figure A.16: Comments from survey 2. Question 1 to 4

Do you want to elaborate your answer on question 5? - To what extent did you learn new programming concepts and techniques while reviewing the code of your peers?
As stated previously I learned a lot, but that was because of the effort. I dived a bit deeper than most in my reviews both with the intent to provide feedback and to learn something myself.
Some of the peer reviews were prone to say that the correct standard was wrong because they misunderstood the standard themself.
Per review did not effect my coding ability
Since I was not responsible for Docker/deployment in my own assignment, the review was a nice opportunity to learn about it. Searching for bugs also provided some insight.
Different solutions to the same problem help

Do you want to elaborate your answer on question 6? - How helpful was the feedback received from your peers in terms of identifying and fixing errors in your code?
There is no point in using the feedback as it is the version handed in for peer review that will be graded.
This is where the "slightly helpful" from the previous answer comes to play. There were some errors that I/we were not aware of (tho it was minor).
Didn't have the chance to fix the code, so it didn't have a saying for the submission. But it helped make the program better, only that the person grading the assignment couldn't see that :/
Out of a total of 7 peer reviews received, I think one of them came with suggestions for code improvement.
One error was found
They saw things we didn't

Do you want to elaborate your answer on question 7? - How helpful were the explanations provided in the feedback you received, in terms of clarifying the reasoning behind the suggestions and comments on your code?
Some were very nicely detailed while some just stated what they had done with no reasoning

Do you want to elaborate your answer on question 8? - Did knowing about participating in peer review increase your engagement with the assignment?
I stive to do a good job regardless of the circumstances.
Always want to achieve the best score regardless, but was fun to do nonetheless
It motivated me to write clearer code, comments and readme file.
The options to this questions is wack, ut i knew
I was already engaged

Do you want to elaborate your answer on question 9? - How much time did you spend reviewing the code of your peers?
Some place between 2 and 4 hours for the first individual assignment. So for I have only done one for the second assignment, but that was probably 5ish hours. I plan to do a second.
Felt somewhat limited because I don't have the clearance to grade or assess them in that way, but rather spotted bugs and came up with optimalizations where I felt it was needed.
the first peer review weren't as big, and the two I did on assignment 2 was poorly done, with close to nothing done, which made the reviewing a lot faster a neither one of them had webhooks or testers to review.
Project size is a factor here, but took some time.
Very varying, some only took 30 minutes (the really good ones) and some took 2+ hours
About an hour, a bit more for the first review

Figure A.17: Comments from survey 2. Question 5 to 9

Do you want to elaborate your answer on question 10? - To what extent did the peer review process improve your critical thinking?
I gained experience.
Had to look at it from
The review did not really force me to reflect all that much, but I did gain a decent amount of practical knowledge.
I would not say it improved it too much

Do you want to elaborate your answer on question 11? - To what extent did you benefit from the peer review process in terms of your professional growth?
Good training in giving constructive feedback, instead of negative feedback. Think it is important from the teacher to stress that each review will be assessed to see how "professional" it was
This question feels VERY out of place

Do you want to elaborate your answer on question 12? - How much did you agree with the feedback received from your peers during the review process?
Some were correct, but we were aware of. Some were objectively wrong. Some were news and were internalized.
Some of the review was false (used the program wrong), for example did one review listen to port 82, while the link to the program that was given was on port 81 and then reported an error that it didn't work. Which was of course due to the wrong port
agreed on most of the basic stuff which was already known issues. Think I only received 2-4 comments that was unknown, and actual fault of the problem, and not just trying to find any reason the not give top remarks.
Some were just wrong. Technicly wrong. Not related to "general aspects"
Some good reviews, mostly just surface level things
I agreed with most of it, but again it seemed like some were trying to find flaws rather than trying to help

Do you want to elaborate your answer on question 13? - How confident did you feel in providing constructive feedback and suggestions to your peers during the review process?
Depends on what the feedback were regarding. If it was something I felt like had a good grasp on or at least had good sources on, I felt confident. If not I had to make sure I was giving correct feedback and the confidence shrunk.
Tried not to be too harsh
No issue here
A lot of it came down to personal preference since ther were few outright mistakes.

Do you want to elaborate your answer on question 14? - How much did you feel that the peer review process helped you improve your communication skills in explaining technical concepts and making suggestions?
??????I did not provide a full on essay or commentary on the code, only made comments on what was good/bad

Do you want to elaborate your answer on question 15? - Was the peer review process a fair way of evaluating your code and the code of your peers?
Really depends on whom reviewing your code
That depends entirely on if it will be used to help set the grade or not (For the group who got the review, not for the one who was doing the review).
only complaint is that it would be a little bit more fair if it was truly anonymous who you reviewed. Found some people to go "lighter" on the people they knew.
We should be allowed to respond to the feedback. It would make it less one sided, and more of a cooperative process.
Having had conversations across different groups, it seems some are FAR more critical than others, leaving an element of RNG which is unfair

Figure A.18: Comments from survey 2. Question 10 to 15

Do you want to elaborate your answer on question 16? - How much did you feel that the peer review process helped you improve your ability to debug code and identify errors?
Even more so for assignment three where we had to deploy other peoples service. The peer review itself didn't help that much as i didn't want to alter the code i was reviewing, but looking at the code and trying to figure out why it either was working or not was a good excercise. At the same time all the effort put in will probably have a marginal gain in terms of grading so i would probably rate it as "not worth".
Probably did not spend enough time trying to debug other people code.
Not used to doing it in Go until the peer reviews

Do you want to elaborate your answer on question 17? - How would you rate your own level of participation and contribution to the group project?
I spent the most time, by far. Just looking at the commits I was 50 commits over the next person. And looking at the content of the commits it was also a good portion above the next.
I did it alone

Do you want to elaborate your answer on question 18? - How do you prefer to learn: by working individually or in a group?
It really depends on what group I end up with. In some cases, it's great and preferrable to working individually, but in other cases it's not so great and I would rather work individually.
It sucks having ambitions to perform well and at the same time being dependent on the other people in the group having the same ambitions. The same is also true for skill. Being in a group with people who are stuggeling to do most things sucks for all parts. Its the same if you are the "worst" performing member of a group as then you will feel useless.
Working a group raises some proffesional aspects like how to manage work like we probably will experience in the working life which is a good lesson, but prefer individual. Optional group work is the perfect balance I believe.
Both are good in their own right. Easier to get help in a group, but easy that people stick to the things they feel comfortable with, instead of being forced to do stuff they don't know.
Both is okay. But it is hard to trust people. Specially when there is a grade on the line.
Usually prefer working in groups for larger assignments and projects.

Do you want to elaborate your answer on question 19? - How much do you feel you learn from doing an individual assignment versus a group assignment?
There are things to learn from both. I will learn regardless, what I learn will vary depending on the type of task and individual/group assignment.
Entirely depends on the type of assignment, but it is always nice to have someone to discuss with.
Hard to comment on since I did it alone, but I felt like I learned a lot since I had to know all aspects of assignment 2

Do you want to elaborate your answer on question 20? -To what extent do you think there were unequal contributions in your group?
The way we decided to split up the work resulted in some getting more work due to some of the endpoints being more work than others.
Somewhere in between moderate and significant. I did a lot of work. I don't want to try to control how other people work or how much time they spend on something or how fast they do stuff. If I'm not confident in the other peoples ability to complete a task in a reasonable amount of time I may ask if I can do it instead.
Some were more engaged than others
This field is obligatory, but I wasn't in a group

Figure A.19: Comments from survey 2. Question 16 to 20

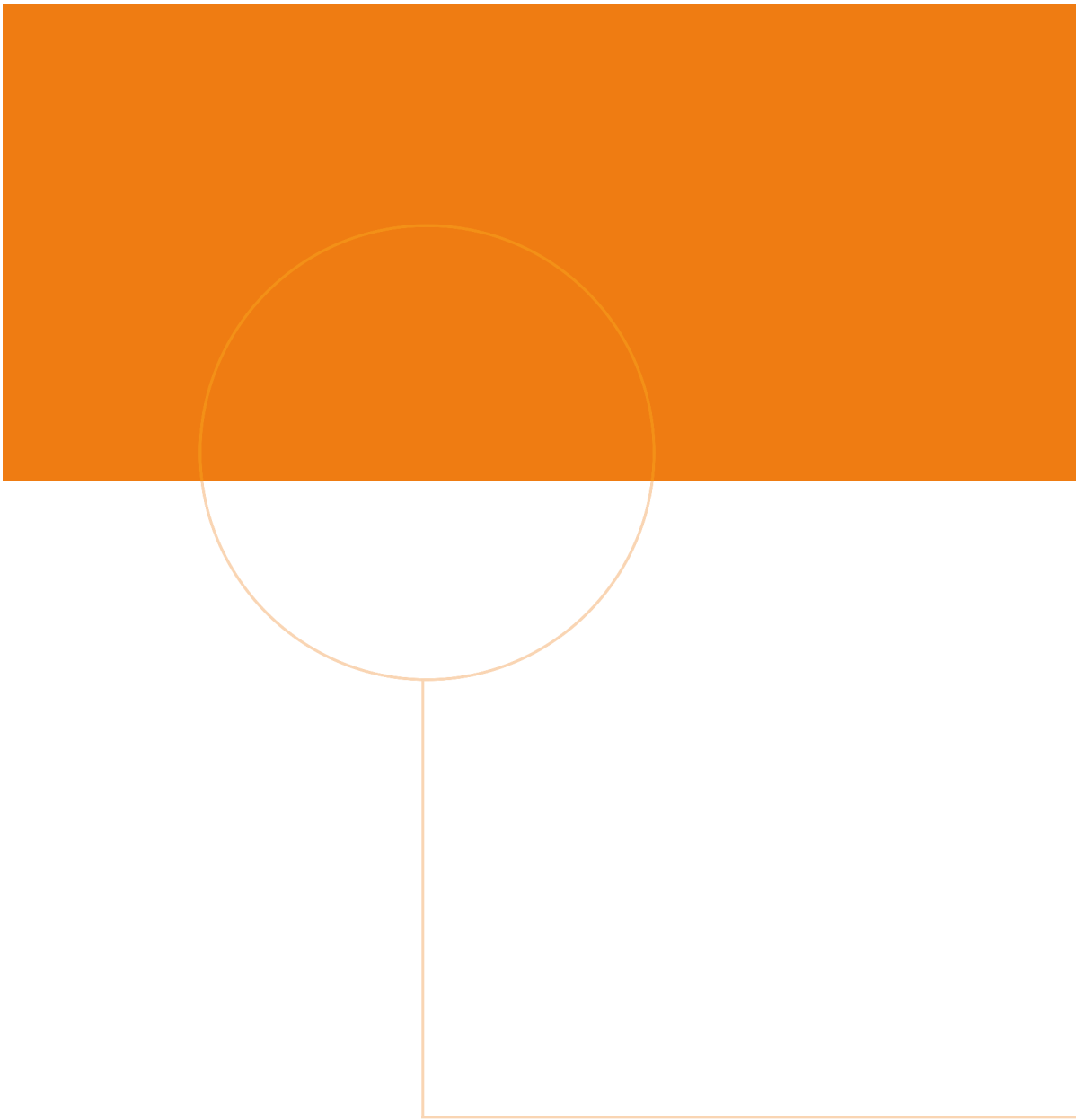
Do you want to elaborate your answer on question 21? - Did working in a group increase your engagement with the assignment?
I usually will kind of adapt. If there are people in the group who I think will do a task better than I can, I will take a step back and hope or suggest that they do it. If I feel like nobody is taking initiative or responsibility I will fill the gaps where it's needed.
I still want to achieve the same goals, working with a peer means I can talk about certain choices more which leads to better code, but the same work ethic is there.
A "good" group does the trick. A "bad" group would have the opposite effect.
You have a responsibility to the group, not only yourself
This field is obligatory, but I wasn't in a group

Do you want to elaborate your answer on question 22? - Was there any difference in reviewing an individual assignment versus a group assignment?
Larger repos, and more to review
When reviewing a group you take into account that several people worked on what's in front of you, making you a bit more critical of certain things (and less of others)
As the only review I have done for the second assignment was done solo, there has been no difference for me other than diving deeper into the whole project and being more thorough.
Both the group assignments I reviewed were done by one person, instead of a group.
Just higher quality projects in group projects. Easier to review.
More time is required to gain a proper overview of a group assignment.
Looked a bit more at commit history and structure, code style and commenting was also differing
Some aspects differed due to different people coding different parts. This made it slightly harder to understand the code.

Do you want to elaborate your answer on question 23? - Was there any difference in receiving reviews for an individual assignment versus a group assignment?
Working on a group project you have to lead some of the responsability to the team mate, so sometimes there is things you don't agree on.
The feedback was more general for the group assignment
Fewer reviews, equal exempt from that

Do you want to elaborate your answer on question 24? - Do you have any comments about the new group functionality to CSAMS? Something you liked or something you did not like?
It's nice to have a group function, in fact I might prefer it over individual work in the cloud course.
Worked great, like the UI and the design choices. A minor comment, instead of calling the button to inspect the assignment after initial delivery and before deadline "change submission" or what is was called i want a functionality to purely inspect it and see that everything is as it should. And then have the oppurtunity to change it, but think this only has to do with the button text as a experienced. Also, want to learn how to write better peer reviews, and want the chance to change the submission after the peer review but this is mostly course concerns and not about CSAMS. Cool name btw and great job creating it, I really liked it
Would be nice to have our review auto save, so that it could be done in multiple sessions, instead of the receiving person receiving a half done review.
Very cool system. Autosave is a feature that should be implemented. Talked to a lot of students that lost tons of work, because they did not save.
The admin page being open was not a good idea:))))))) Question structure was weird, in some cases misleading . Decent solution
Worked surprisingly well

Figure A.20: Comments from survey 2. Question 21 to 24



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Science and Technology