GROUP WORK IN ENGINEERING EDUCATION: INSIGHTS AND ISSUES

Anette HEIMDAL
University of Agder, Norway

ABSTRACT
We are usually focused on the product produced when evaluating students' work. As evaluators, we look at the academic language, the description and choice of methods, the depth of the literature review, and the work and originality the engineering students have put into the project. What if we take a more human-centred approach to the education we offer and explore the challenges students encounter in developing soft skills throughout their studies?
This study examines second year and third-year students, and graduates from the University of Agder. The purpose of this study is to investigate how students choose their team members, their experiences on group work and how the universities should include teamwork in the curriculum. This study found that the majority of the students have experienced free riders, different levels of ambitions and skills, and disagreements between group members. Students prefer group members based on peers they have previously worked well with, friends, and classmates they perceive as competent. A suggestion for a fair assessment of students could be group work, but also with individual evaluation. To engage all group members from the start, a sprint at the beginning of the project could help include everyone.

Keywords: Teamwork, engineering education, group projects, assessment methods

1 INTRODUCTION
Today's engineers are highly dependent on working in organised teams or in informal collaboration with others [1]. Civil engineers must collaborate with multiple stakeholders in almost every project. According to Trevelyan [2] one of the key skills of an engineer is being able to work with others. Therefore, the civil engineering programme at the University of Agder (UiA) places a strong emphasis on students working in groups throughout their studies. The purpose of this is for students to learn to work in groups and for the programme to provide a preview of professional life. One of the lowest scoring subjects in “Studiebarometeret” [3] is connections to working life. However, this relates to information about work life and connections with the industry and does not take soft skills into account. One of the main focus areas that the University of Agder strives for is making students feel part of their study environment. Pedler et al. [4] concludes higher achievements, higher motivation and higher academic engagement amongst students with a greater sense of belonging. All new students at the Faculty of Engineering and Science at UiA, are divided into groups by the university at the start of their first semester [5]. This is done at a faculty level and is called First Year Study Environment (FYSE). All new students at the Faculty of Engineering and Science are also offered a mentor [6]. Most study programmes within the faculty employ a start-up project the first week for new students, using the pre-assigned groups. This project helps over 80% of the students get to know their group members and make new friends [7]. Starting in the second semester, the students form their own groups in most subjects.
However, students are not taught group work, and it seems like this is something they are expected to learn on their own. 97% of the students at Civil Engineering at the University of Agder have experienced project work during their study [8]. Project work was rated 4.03 on a scale from 1 to 5, 1 meaning highly irrelevant and 5 meaning highly relevant, when discussing work relevance. Therefore, the students seem to acknowledge project work as work relevant. It is however, not specified if they meant the subjects of the project work or working in groups specifically.
Every year, we see several groups that do not function well, and many groups have so-called "free riders." This becomes even more apparent in larger projects, where students must collaborate over a longer period of time. Previous research has shown that a satisfaction score and grade were significantly higher when working in groups with friends [9]. The same study also showed that low ability students

performed better when working in groups with friends than randomly assigned groups with no acquaintances. We must, however, be cautious that the stronger students do not end up doing most of the group work, while the weaker students get a free ride to better grades. We are usually focused on the product produced when evaluating students' work and not evaluating the soft skills. This study will have a more human-centred approach, and try to answer the following questions:

- What types of challenges have students experienced with group work?
- How do the students choose their groups, and how do they manage the group dynamic?
- How should the universities include teamwork in the curriculum?

2 CASES

This study will consider third- and second-year students in the Civil Engineering programme, as well as Civil Engineering graduates (alumni) from the University of Agder. The respondents were selected based on their progression in the study programme. First-year students were excluded, as they had only experienced mandatory group work during their first semester. Alumni were also invited to participate, limited to those who had maintained contact with the university. The students on their third year are currently writing their bachelor thesis in groups of two to four members. If the students do not have a group they will be assigned one by the course leader. The students in the second year are currently working in groups in several subjects this semester. The graduates have had the same structure during their study years at the University of Agder. Table 1 shows an overview of the study plan for bachelor students at the University of Agder. The subjects in bold show the subjects where group work is mandatory, and a part of their assessment method. This shows that 13 out of the 23 subjects have group work, and that 112.5 out of their 180 ECTS are accomplished through group work. Starting in their 2nd semester, the students are allowed to choose their own group members. The second-year students are on their 4th semester and the third-year students are on their 6th semester. Table 1 also shows that they are all currently working with group projects, respectively 15 and 30 ECTS.

Table 1. An overview of the study plan for the bachelor programme

1st semester	**Technical Design 7.5 ECTS**	**Construction Management 5 ECTS**	Technology, Environment and Sustainability 5 ECTS	**Programming and ICT Security 5 ECTS**	**Mathematics 1 7.5 ECTS**
2nd semester	**Physics 7.5 ECTS**	Mathematics 2 7.5 ECTS		**Building Materials 7.5 ECTS**	Structural Mechanics 1 7.5 ECTS
3rd semester	**Statistics 7.5 ECTS**	Applied Building Physics 5 ECTS	**Building Design 5 ECTS**	Mathematics 3 5 ECTS	Structural Mechanics 2 7.5 ECTS
4th semester	**Digital Building Process 1 7.5 ECTS**	Geotechnical Engineering 1 7.5 ECTS		**Architecture/Road Design 7.5 ECTS**	Loads and Structures/Structural Mechanics 3 7.5 ECTS
5th semester	**Project Management/Areal Planning 7.5 ECTS**	**Water and Wastewater/Pavement Technology 7.5 ECTS**		Structural Design Concrete/-Steel 7.5 ECTS	Structural Design Wood/Concrete Rehabilitation 7.5 ECTS
6th semester	**Bachelor Thesis 30 ECTS**				

3 METHODOLOGIES

The methods used in this study are three different surveys: one survey for each case group. The surveys were conducted with the survey programme *SurveyXact*. For the students in their second and third year, the survey was distributed on the learning platform used by the University of Agder. For the graduates, the survey was sent out via email. All the surveys have questions concerning their previous experience at the University of Agder, but also questions about the situation that they are currently in.

The third-year students had a lecture on group work in the beginning of the semester, encouraging them to do a SWOT-analysis and to write a group contract. The students were given a template on a group contract, but it was optional to use this and to write a group contract at all. A group contract establishes clear expectations and consequences, enabling university staff to mediate conflicts effectively. Without such a contract, disputes often devolve into word-against-word situations, limiting staff intervention. The survey to the third-years students will do a follow-up on group contract and the lecture given to investigate whether this had an effect or has influenced the group dynamics. The survey sent to the graduates will investigate what they learned at the University of Agder regarding teamwork, whether they are using this knowledge now, and the extent to which they are required to engage in group work

at their workplace. The surveys were available for a period of 7 to 9 days. Table 2 gives an overview of total number of recipients and respondents of the surveys.

Table 2. Overview of participants in the study and the number of questions on the surveys. The number in parentheses represents the number of free text questions

Case group	Number of questions	Total number of recipients	Total number of respondents
Second-year students	12 (3)	54	18
Third-year students	18 (5)	47	21
Alumni	8 (3)	19	12

4 RESULTS AND DISCUSSION

Figure 1 compares the answers between the second-year students, the third-year students and alumni. All participants were asked the same question: "What types of challenges have you ever experienced with group work at UiA?". On this question the participants were asked to select all the options they had experienced. It is apparent from this figure that most of the participants in the alumni group have experienced most of the challenges listed regarding group work.

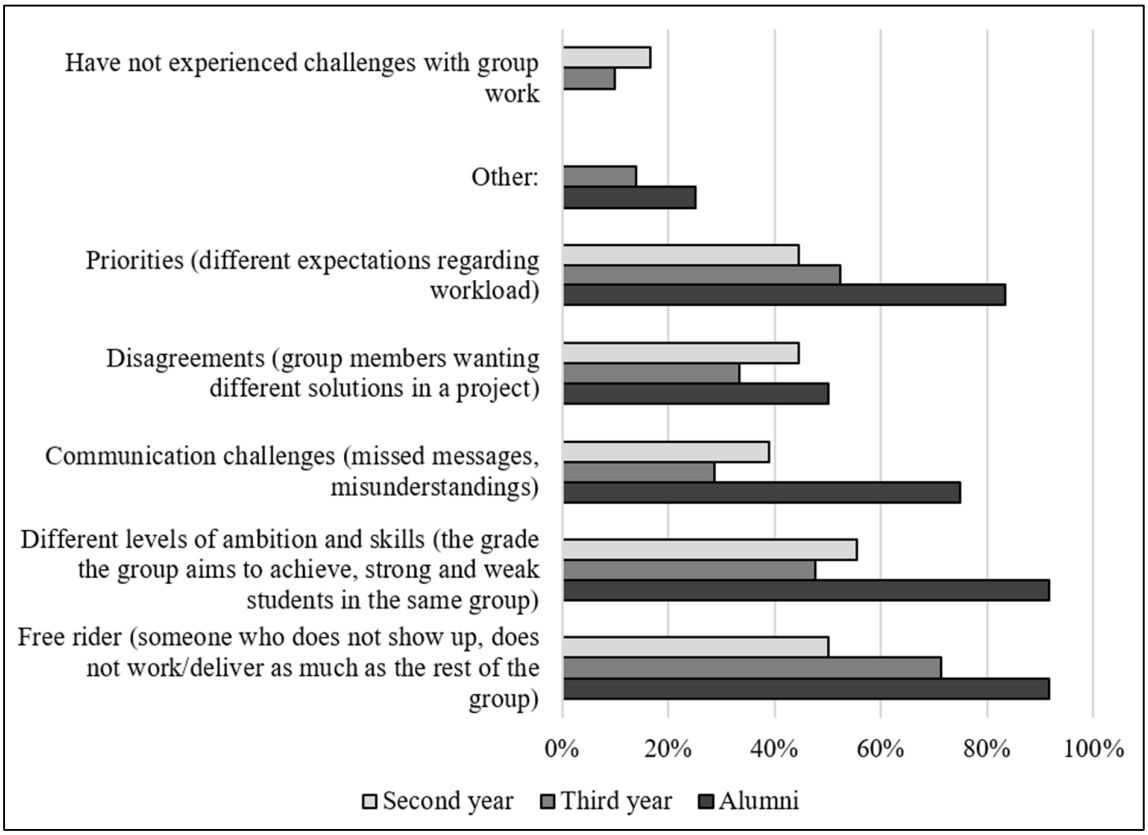

Figure 1. Results from the question "What types of challenges have you ever experienced with group work at UiA?"

One of the most frequent challenges reported by the participants was the presence of free riders. This finding is consistent with that of Wilson et al. [10], who mentioned free riders and uneven workload as the most commonly reported problem in group work. They also mention a challenge that was not addressed in this study; the final product can become a result solely based on individual parts rather than a cohesive whole. What may resemble this could be the challenge "Disagreements". Many respondents also reported experiencing this challenge; 44% of the second-year students, 52% of the third-year students and 83% of the alumni. These disagreements may lead to the final product becoming a blend of unconnected individual parts, rather than a meaningful "whole". Surprisingly, communication difficulties seem to be the least prevalent challenge. This is a valuable finding, since this skill is more individual based. The other challenges mentioned can largely be mitigated or avoided by dividing

students into appropriate groups according to academic skills and priorities. Nevertheless, we must be cautious with this approach. As mentioned earlier by Mahenthiran et al. [9], there is a clear correlation between being in a group with friends and achieving better grades. If we focus too much on forming groups based on individuals' skills and different problem-solving approaches, it may come at the expense of the final result, even though it could lead to better group dynamics. It can also be argued that encountering group work related challenges provide students with more experiences and tools that they can take with them into the workplace.

One of the questions in the survey distributed to alumni was “How much do you collaborate with others in your current job?”. 25% said that they usually work with others, and 50% state that they work as much independently as they do collaboratively. 83% said that they learned something or a lot about working in groups at the University of Agder. Since many of the alumni respondents report to have experienced several challenges one could argue that this has better prepared them for work life. Upon closer examination of some of the textual responses, there seems to be a consensus on the amount of group work at the University of Agder. 75% agree that the amount of group work is just right, and 17% wish there was even more. However, they would still prefer more randomly assigned groups but with individual assessment. Students depend on their grades for their future careers. Therefore, it may be unfair to experiment on them with skills they are not formally assessed on by placing them in groups to enhance soft skills. While this approach mirrors real-world workplace dynamics, a potential solution could be group work combined with individual assessments. One way to do this is explained by Lingard et al. [11], introducing a sprint in the beginning of a team project. This would include all the members of the group in an early stage of the project, but also equally divide the work in the beginning, not relying on one student to initiate group work. Johnson et al. [12] point out that there is an increase in responsibility forces when individual accountability is accounted for in group work. We observe a trend, at least at the University of Agder, where several assessment methods are shifting from written school exams to group projects combined with individual oral exams. In this way, it better resembles what it will be like in the workforce. They do not have just one day to demonstrate their skills and knowledge acquired over an entire semester, but they get to work on a larger and more complex project together with other students. The students’ feedback is consistent with the findings in “Different Assessment Methods in a Civil Engineering Course” [13]. Working on a group project but also be individually assessed can result in a fairer grade for the students. Another reason for the individual component of the assessment method is to verify that the students actually understand the product they have submitted and have not, for example, used artificial intelligence to complete the entire assignment.

One of the questions in the surveys was how the students select their group members. This was only included in the surveys for the second year and the third-year students. As we can see in Figure 3, there are four categories that most students base their selection of group members on. It appears that students prefer to join forces with previous group members with whom they have collaborated well, friends, and fellow students they thought were competent. Based on the findings from Pedler et al. [4] mentioned earlier, these choices can lead to better academic achievement and increased motivation in studies. It is clear from the active students that they strongly desire to choose their own group members, while alumni encourage more random collaboration. This may be because students are currently very focused on results in the form of grades, whereas in the workforce, they see more value in soft skills. Several, both active students and alumni, urge the university to provide students with tools for handling challenges in group work. Currently, only third-year students receive an introduction to SWOT-analysis and group contracts. However, only 14% have created a group contract and 19% have conducted a SWOT-analysis. It can be debated whether this should be introduced earlier in the study programme, as we see more dissatisfaction among students earlier in their studies. Some of the responses from both second and third-year students indicate that they try to solve challenges through dialogue. Several mention that this still does not help, and they end up doing more or all of the work alone. They learn from these experiences and do not work with the same group again. A positive aspect highlighted by the respondents is the assigned groups in the first year (FYSE). Through this, they find out who they can and cannot collaborate with. Several courses in the first semester have oral presentations of projects in front of the rest of the cohort, allowing them to see potential new group members they want to work with. Regardless, when second and third-year students were asked if they currently work in a group with someone from FYSE, 72% and 57% respectively answered yes. Although fewer students *base* their choice of group members from FYSE, as shown in Figure 3, responses indicate they still work with someone from FYSE.

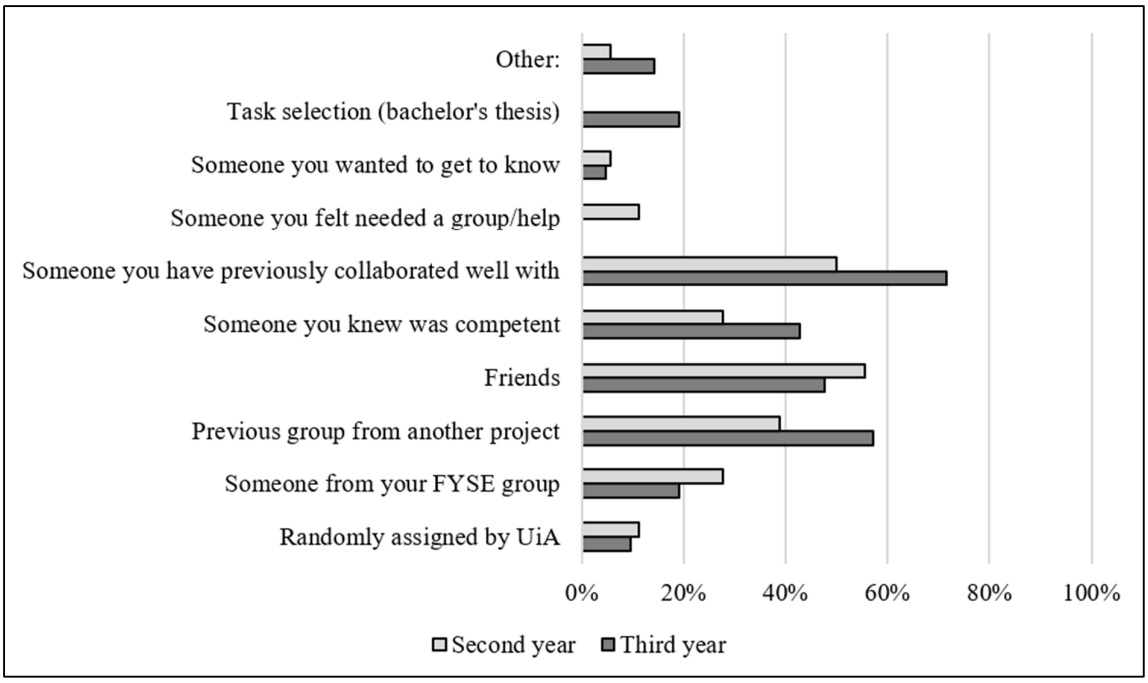

Figure 2. Results from the question "What is the background for the selection of group members?"

We see a trend that students become more and more satisfied with their group members and group dynamics throughout their studies. 85% of third-year students say they are somewhat or very satisfied with the group members they currently work with, while 72% say the same in the second year. The question we can then ask is whether students learn to work in groups over time, or do they find the groups they want to work with? It is challenging to find the balance between teaching students to work in groups while at the same time meeting their desire for self-organising and maintaining their academic performance. When asked if they felt the previous grade on a group project was fair for their group members, 50% of second-year students felt the grade was fair, while 77% of third-year students felt the same. This indicates a presence of free riders and/or key contributors. As a university, we want the grades on students' diplomas to reflect their true abilities. If too many students are affected by free riders and/or key contributors, their academic results might be inaccurate. Another threat with group projects is that group work can lead to a flatter grade distribution. It can be difficult to identify the superior and inferior students. Groups with so-called *team heroes* [11] will solely finish a group work and give all the members of the group good grades. This brings us back to the findings of Johnson et al. [12]. It is important to incorporate individualisation in group projects. Students seem to be more satisfied with their grades when they are also assessed individually. If a written product is submitted, students could perhaps be evaluated on the different parts they have completed as well as an overall assessment of the product produced by the group. This would likely result in additional work for the universities, but it might lead to a fairer evaluation of the students' work.

5 CONCLUSIONS

What types of challenges have students experienced with group work?

This study found that the majority of the students have experienced free riders, different levels of ambitions and skills, and disagreements between group members. We observe that the further along students are in their studies, the more challenges they have experienced related to group work.

How do the students choose their groups, and how do they manage the group dynamic?

Students prefer group members based on peers they have previously worked well with, friends, and classmates they perceive as competent. Unfortunately, it seems that several students address challenges in group work by simply doing the job alone and selecting different group members for the next project. This survey also highlights the importance of our FYSE programme. Most students continue to work in groups with the peers they were randomly assigned to in their first year, even though this does not

emerge as a criterion for selecting group members. It is also helpful for students to gain insight into the work of other classmates so that they can identify potential group members for future projects.

How should the universities include teamwork in the curriculum?

When examining the results from alumni, it becomes clear that there is a desire for group work in the study programme. They wish for more random assignment of group members to learn more soft skills. However, we see that active students in their second and third years have a strong desire to choose their own groups. We know that grades are affected by whether students work with friends or not, so this is a somewhat difficult dilemma. A suggestion for a fair assessment of students could be group work, but also with individual evaluation. To engage all group members from the start, a sprint at the beginning of the project could help include everyone. There is also a desire for a group contract and more tools to handle group dynamics. This survey indicates that providing these tools to third-year students is too late and should therefore be introduced much earlier in the study programme.

Further studies need to be carried out in order to validate the results. Typically, it is the most motivated, conscientious, and perhaps high-achieving students who respond to surveys—along with alumni who were high-performing during their studies. This may have influenced the results. One of the aspects that needs to be examined more closely is *when* the various challenges in group work arise and whether the way groups are formed has an impact on the occurrence of challenges. Since this is a relatively small study, it should also be investigated whether these findings are recurring over several years.

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