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Mathematics students' attitudes to group-based project exams compared to students in science and engineering

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At Aalborg University, science, engineering, and mathematics students spent half the time each semester working in groups on projects within a problem based learning (PBL) curriculum. They are assessed through group exams. A survey showed that overall, the students are positive towards the group exam but there are significant differences between engineering, science, and mathematics students. Within this collectivistic student culture, some engineering students are very positive towards group exams, while mathematics, science, and other engineering students are less positive. In terms of the opportunity to obtain a fair grade in a group exam, the mathematics students are moderate positive, with different engineering students being more or less positive. All students agree that a group exam gives less differentiation of grades compared to an individual exam.

Keywords: attitudes; project exam; group exam

Introduction

At Aalborg University (AAU) in Denmark, science, engineering, and mathematics students work half the time each semester in groups of four to eight students on a project in a problem based learning (PBL) curriculum. PBL is student-centred and self-directed learning in teams with problem analysis and problem solving (Barge, 2010). The project is documented as a joint written report with an oral group exam lasting around four hours. This exam has traditionally consisted of two phases: First the group presents the project, then the external examiner and the supervisor examine the group. Each student is awarded a grade that may not be the same as the others. From 2006–2012 the Danish government banned group exams, but during this time AAU students still worked in PBL groups but the exam became an individual oral exam of around half an hour per student. This situation led to research on assessment methods in PBL, and Kolmos and Holgaard (2007) concluded that the students, the academic staff, and the external examiners preferred the group exam. One argument was that the students were not able to interact with each other during an individual exam, hence it was not possible to test PBL process competencies such as collaboration and teamwork. Since Danish law states that a grade solely depends on the student's performance at the exam (they cannot earn partial credits during the semester), this created a misalignment between PBL teaching and the assessment methods. In 2013 the group exam was reintroduced in Denmark and at AAU. The Faculty of Engineering and Science (FES) now added an individual phase into the previous group exam, where each student is questioned without interference from the group. Dahl and Kolmos (2015) found that the students overall were in favour of the reintroduction of the group-based project exam, but that students from two different engineering programmes were not equally positive, partly owing to their previous experience with the individual project exam and partly owing to professional cultures of individualism or collaboration influencing their attitudes. Maull and Berry (2000) and Bingolbali et al. (2007) showed that mathematics and engineering students are different in terms of their learning of mathematics, so one might ask whether a similar division

between engineering and mathematics students is seen in relation to which type of exam is perceived appropriate. This paper therefore compares students from eight programmes in science, engineering, and mathematics in relation to how they perceive the new group exam, the new individual phase as well as the opportunity to obtain a fair grade.

Theoretical background

Alignment and exams

Biggs and Tang (2011) argue that in order for students to learn the intended learning outcomes (ILOs), teaching should be constructively aligned with the ILOs and the exam. This theory fits other studies stating that an upcoming exam is a key factor for students' motivation and learning (Boud & Falchikov, 2006); i.e. the 'backwash effect' of exams. Hence, one can argue that in a PBL curriculum, the exam method should be aligned with the team-based and collaborative teaching method and the ILOs on PBL process competencies. Romberg (1995) argues that a group exam is able to test "reflection on one's own thinking, reasoning and reflection, communication, production, cooperation, arguing, negotiating" (p. 165). One can thus argue that a group exam assesses PBL competencies of communication and cooperation. However, each programme also prepares the students for a professional life after the university so the problems that the students address vary and AAU's PBL model is developed "on the basis of both professional and educational argumentation" (Kolmos et al., 2004, p. 9). One might anticipate that professional culture influences the students' views of the group exam, particularly master students.

Cultural differences in engineering, science, and mathematics

Murzi et al. (2015) studied how students perceived their discipline culture using Hofstede's dimensions. One dimension measures individualism versus collectivism. Overall, students had a high individualistic score. Mathematics, computer engineering, and electronic engineering students were among the *less individualist* students. This fits the study by Burton (2004) where a majority of professional mathematicians worked co-operatively. Murzi et al. (2015) further argued that they had expected industrial design students to be more collectivistic as they rely on collective work in team projects but the results were opposite. Architect students' scores fell between mathematics and industrial design. Dahl and Kolmos (2015) also found significant differences between the engineering programmes Architecture and Design (AD) and Software Engineering (SE) at AAU. SE students were significantly more positive toward the group exam than those of AD. AD combines architecture with civil engineering and students here expect a more individual-oriented programme whereas SE is a system-oriented approach and a collaborative profession.

Research questions

How do the students from the eight programmes view the group-based project exam compared to the individual project exam and the individual phase of the new group exam? How do they experience the grading? What does this tell us about mathematics assessment in PBL?

Methodology

The questionnaire was piloted after the January 2013 exams and the revised questionnaire consisted of 20 questions of which most had several sub-questions. After the June 2013 exams, all 4,588 FES students received a link to this questionnaire and 1,136 responded. The response rate was relatively low (25%), which unfortunately is not uncommon for online surveys, but the level is still reasonable (Nulty, 2008). The response rate for each study programme cannot be determined separately but the number of student responses were as follows: Computer Science (CS: 40), Energy (EnE: 50), Mechanics and Production (MP: 39), Physics and Nano science (PN: 27), Architecture and Design (AD: 79), Mathematics (M: 28), Software (SE: 51), and Electronic (EIE: 48). In this paper, all questions are translated from Danish by the author. The programmes compared all had a relative large number of students who responded. The engineering programmes are civil engineering.

Results

Views of individual versus group-based project exam

Of all FES students, 34% preferred the individual exam and 57% the group exam, but students in different programmes were not equally positive towards the group exam (see Figure 1).

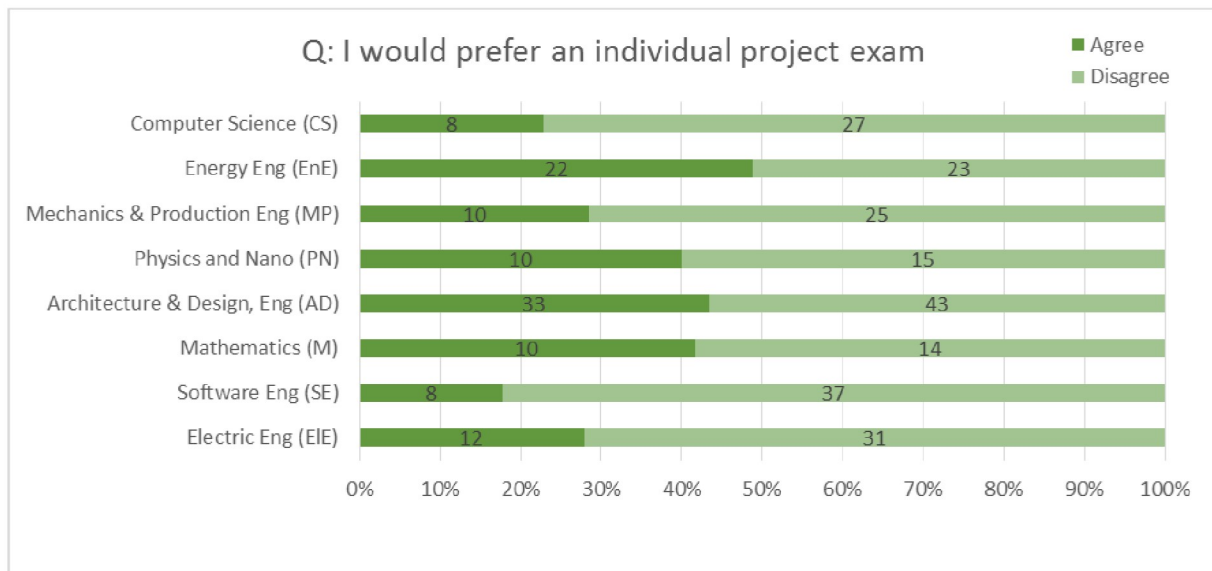


Figure 1: "I would prefer an individual project exam"

EnE students were the least positive towards the group exam while SE students were the most positive. Table 1 shows the programmes that were significantly different.

	EnE	AD	PN	M
CS	.047	.037		
EIE	.043			
SE	.002	.004	.041	.031

Table 1: Significant differences in answers to the question if they preferred the individual exam

SE and EnE are at opposite ends of the group-individual preference and they are each significantly different from many programmes. SE, CS and EIE are the most collective while EnE, AD, PN, M are the more individualistic, although M appears to be more moderately individual. MP are not significantly different from any. Master students are significantly more positive towards the individual exam than bachelor students ($p = .001$). Almost half the master students preferred the individual exam while only a third of the bachelor students did. Comparing bachelor and master students in each programme, there is only a significant difference for EIE ($p = .002$).

The survey asked a related question: “The time spent on the individual part is better spent on a longer joint part?” Of all FES students, 34% agreed, 50% disagreed, and 15% did not know. The students do not differ except MP, which is significantly different from AD ($p = .005$) and M ($p = .030$) (see Figure 2). Overall the students are positive towards the individual phase, particularly M. There is not significant difference ($p = .114$) between bachelor and master students for all FES. When comparing students in each programme, MP bachelor and master students are significantly different ($p = .024$) but here the master students are the more positive toward the group exam.

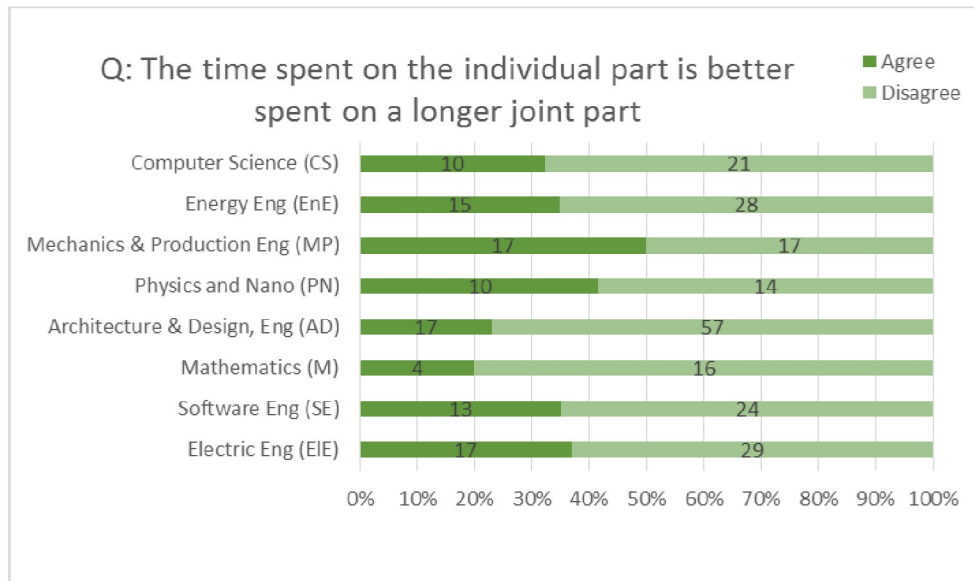


Figure 2: “The time spent on the individual part is better spent on a longer joint part”

How did the students experience the opportunity to obtain a fair grade?

A question asked if the students were satisfied with their own grade. Overall, 83% agreed and there was not a significant difference between the eight programmes. Another question asked whether they found that all their group members had received a fair grade. Here only 66% agreed. In all groups, a majority of students had agreed but EnE (61%) and AD (59%) agreed significantly less than SE (76%) and PN (85%). EnE was different from SE ($p = .046$) and PN ($p = .037$) while AD was ($p = .019$) different from SE and PN. When comparing each programme, most had given significantly different answers to the two questions except EIE ($p = .064$), PN ($p = .324$), and SE ($p = .760$).

The survey also asked the students who had tried the individual exam whether the new group exam gave a better or a worse opportunity to obtain a fair grade. The views differ greatly (see Figure 3).

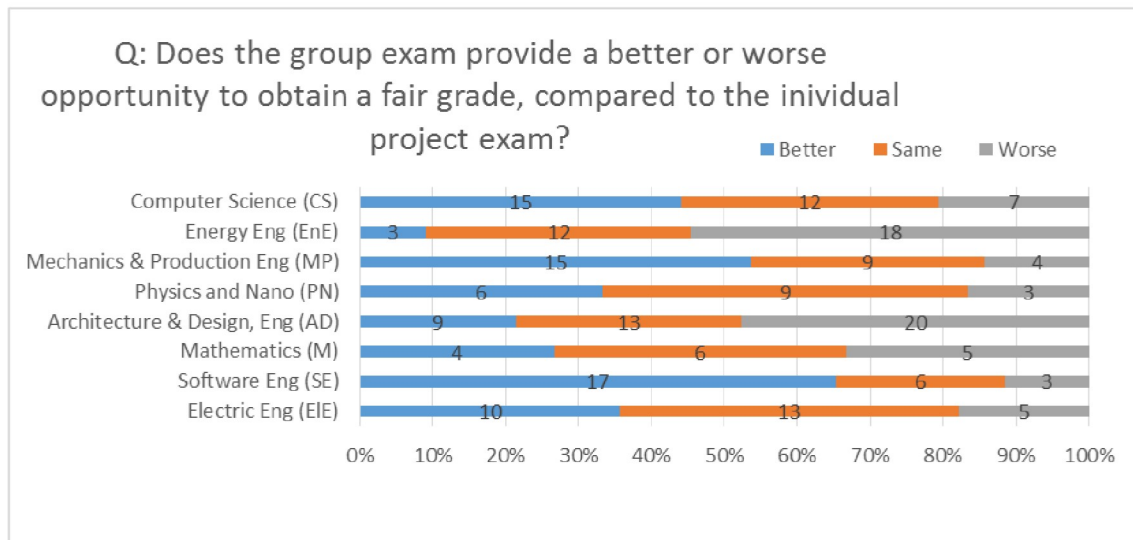


Figure 3: “Does the group exam provide a better or worse opportunity to obtain a fair grade...?”

When comparing the programmes, one sees that only M is not significantly different from any of the others while students from several of the engineering programmes answer significantly differently from each other (see Table 2). M therefore appears to be quite moderate in their views of whether or not the group exam gives a better or worse opportunity to obtain a fair grade. CS, EIE, SE, MP and to some extent PN are more positive towards the group exam as giving them a fair grade, while AD and EnE in general state that it provides them a worse opportunity to obtain a fair grade, compared with the individual exam. The students answering this question were all from the second **year** or older, as these were the only ones who had experienced both types of exams.

	CS	EIE	SE	MP	PN
EnE	.001	.004	< .001	< .001	.015
AD	.030	.039	< .001	.005	

Table 2: Significant differences in answers to the question if the group exam provided a better or worse opportunity to obtain a fair grade

The survey also asked the students whether there was a larger differentiation of grades in the group exam compared to the individual exam. The Danish grade scale has five passing grades (2, 4, 7, 10, 12) and two failing grades (-3, 0). This question relates to an internal discussion at both AAU and in Denmark debating if the group exam uses less of the grade scale as it is harder to give a precise individual grade and weaker students can hide and good students are not rewarded. Only a minority of the students confirmed that the group exam resulted in more differentiated grades. The lowest was EIE, where 7% said that the group exam resulted in more differentiated grades to some or to a higher extent, while the highest was M with 29%. This difference was not significant ($p = .069$).

Conclusions

Individual versus group exam and the individual part of a group exam

The students were in general very positive towards the group exam but there are significant differences. Murzi et al. (2015) found that mathematics, computer engineering, and electronic engineering were among the *least* individualistic within a very individualistic student culture. One might argue that in general the AAU students are used to working in PBL and thus have a more collectivistic culture since, overall, the majority of students were in favour of the group exam when asked to compare it to an individual exam. This study of AAU students shows that in agreement with Murzi et al. (2015), CS and EIE were among the most collectivistic students as they were among the most positive towards the group exams. However, this is stated within the frames of a collectivistic AAU culture. Murzi et al. (2015) found mathematics students to also be among the least individualist, however at AAU, M appeared to be among the more individualistic students, even though AD and EnE appeared to be even more individualistic. Architect students in Murzi et al. (2015) were not among the individualist groups. In relation to their attitudes to the time spent on the individual part of the group exam, M were the most positive toward the individual part. M was again close to AD but quite different from MP. PN students were closer to the M students.

Master students were generally more positive toward an individual exam than bachelor students, especially EIE. However MP master students appeared very positive toward having a longer joint part in the new group exam. One might argue that this is related to the fact that the master students have been used to the individual exam prior to 2013, or perhaps to how they perceive their future professional life (wrongly or rightly) might have an impact.

Fairness of grades

The students were overall satisfied with their own grade but relatively less satisfied with the grades given to their peers. Given the relatively low response rate, it could make sense that students answer this question significantly differently. The question in the questionnaire did not explicitly ask if their peers were over/under-graded, but it appears that seeing how their peers behave at the exam, perhaps with reference to their work during the semester and then experiencing what grade they received, often left the other students feeling some degree of unfairness. More research is needed here in order to determine why. The students also differed when they compared the group and the individual exam in relation to the opportunity to receive a fair grade. Here, M was more or less in the middle, not being significantly different from any of the other programmes. In general one sees that the same programmes as above show ‘collectivist’ preferences (CS, EIE, SE, MP) and ‘individualistic’ preferences (AD, EnE), which to some extent validate the results shown above and show that the students are consistent in their answers. However, one also needs to discuss to what extent their experience of receiving a fair grade is correct. Do students always know which grade they deserve? Furthermore, the perception – rightly or wrongly – of not being awarded a fair grade, might negatively influence their view of the exam. Students are occupied by fairness in grading and their perception of justice is significantly affected by the assessment method (Burger, 2016).

Students appear to obtain more similar grades when they are assessed as a group than if they are assessed individually. The question is then – which is the right grade? One might argue that in a group exam of up to eight students, it might be difficult to make a distinction between each group member, which to some extent might explain the different opinions about own grade and the grade of the group members, and the same question can only be asked once. On the other hand, one might also argue that since a group exam to some extent is able to test PBL process competencies, which an individual exam cannot, the grades given in a group exam are the more accurate.

Summing up and impact for mathematics assessment

It appears that mathematics students are not distinct from engineering or science students on the issue of preference for individual or group exams. The eight groups were mixed; ergo mathematics students were more similar to some engineering students but different from others. This is different from what is known from how the learning of mathematics takes place when comparing mathematics and engineering students. For instance Bingolbali et al. (2007) found that engineering students see mathematics as a tool and therefore wish to see the application side. In science, engineering, and mathematics PBL projects, mathematics is applied to solve problems, but in a mathematics project, the body of mathematical theorems used to solve a problem usually takes up a considerable part of the project work and the report. Thus, the role of mathematics is different in the PBL projects in each programme. Assuming that the group exam is the best fit to PBL, it is unexpected that the students are not more in agreement with each other about the group exam. An obvious answer is that the group exam does not fit each programme equally well. The more moderate views of the mathematics students could indicate that it is a reasonably good fit when there is an individual phase as this is a way to serve both the individual and collaborative aspects of mathematics.

The question of individualistic or collective attitudes may also depend on the overall student culture. Murzi et al. (2015) found that mathematics students were among the *least individualistic* within an individualistic culture, while this study found the mathematics students to be among the *most individualist* students within a collectivist culture. With caution, one might argue that the most individual student cultures were AD and EnE, with M and PN also being individualistic but not as much. The most collectivist student cultures were SE and CS, with EIE and MP also being collectivistic but not as much.

However, the above conclusions should be treated with caution as the students base their attitudes about the group exam on the ‘learnt’ curriculum (Bauersfeld, 1979), which is not necessarily the same as the intended curriculum. The group exams were intended to be the same throughout the FES and prior to the reimplementation, workshops had prepared the supervisors for this type of exam. It is, however, unlikely that all group exams were identical as students, supervisors, and external examiners were different. One should therefore hesitate to draw too strong conclusions, particularly also taking into account the relatively small response rate. The results are *indications* of how students in different programmes at a Danish PBL university perceive a group exam and therefore which attitudes curriculum planners might expect from students if other universities wish to implement a type of project work or group exams. Curriculum planners need to consider what is the general ‘culture’ of collaboration both at the university and in the future profession, they need to

consider how the exam has a backwash effect on how the students work, and that bachelor and master students might not perceive such an exam in the same way. The group exam might also be a better fit for some groups than others, but in terms of mathematics, it neither appears to be an obvious fit, since mathematics students might lean more towards the individualistic culture, nor does it appear to be a bad choice since the students in general are positive. This might reflect the mathematics culture as being both individual and collectivistic. In terms of grading, curriculum planners need to consider that group exams might result in a smaller distribution of grades.

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