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Project Supervisors' Views of a Group Based Project Exam for Engineering Students in a Problem-Based Learning Curriculum

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Introduction

Exams are part of any university education program, and it is vital that the exams are perceived as valid and reliable by for instance the employers who receive the graduates. When designing exams, researchers argue for the importance of constructively aligning the assessment to the officially stated learning objectives and the teaching methods [1]. In other words, the exam methods should fit the learning objectives of the particular course or program, which also means that the examination method influences what is measured and noticed. Furthermore, a future exam is a well-documented factor in the students' motivation for the course, and it influences what the students learn [2,3]. It is, therefore, vital, that the exam method is considered carefully in order to support the teaching methods and the intended learning objectives.

This paper focuses on the assessment of engineering students' collaborate project work and uses the project supervisors' perceptions to understand how essential skills such as collaboration and communication can be assessed effectively as well as assessing the students' deeper understanding. These skills, like problem-solving skills, are essential to engineers; however, the interpersonal skills are difficult to assess. Their effective assessment will enhance learning; anticipation of an exam affects student behavior and aligning a curriculum to the assessment method promotes the attainment of learning objectives.

Problem-based learning and the group exam

Engineering students at Aalborg University (AAU) in Denmark spend half their time each semester working on group projects. The groups usually consist of 3-8 students and to aid the students' work; each group is assigned to a supervisor who acts as their facilitator and meets regularly with the group during the semester. The group produces a joint written report of around 100 pages where all group members are accountable for all the content. The other half of a semester is spent on more traditional courses. These courses are sometimes general mathematics courses in, for instance, linear algebra or courses that provide a theoretical background to the projects. The course structure changes as the semester progresses. The first half of the semester is full of courses with a few empty slots in the schedule for project work. Then, a little after halfway through the semester, the course load gets smaller, and towards the end of the semester, there are no more lectures so that the students have time for their projects. The courses are assessed in separate individual oral or written exams. The student projects are within a problem-based learning (PBL) curriculum which involves problem analysis and problem-solving. The projects apply theory to solve an engineering problem from society. The students are responsible for their learning including project planning. The AAU PBL model is, therefore, a student-driven and motivated method working with exemplary problems that are typical for the engineering profession in question. A project could, for instance, be about energy systems and the pros and cons of different types of investments or it could be an analysis of electric heat pumps in solar thermal district heating. The structure is usually that students find an initiating problem in society within the given thematic framework of a semester, then they analyze the problem in its context, formulate a more specific problem statement, and finally, embark on a problem solution.

In earlier semesters, students are to some degree being given the problems in project catalogs as their level of subject knowledge is often not high enough to be able to formulate relevant problems from scratch by themselves. The projects furthermore need to be doable within one semester and neither too hard nor too easy [4,5,6,7].

The group exam

The projects are assessed through group exams lasting around four hours after which each student receives an individual grade. It is not uncommon that students within a group obtain different grades and some might even fail while others pass. AAU had held group exams since its start in 1974, except during 2007-2013 when national law mandated individual exams. The individual project exams at AAU usually lasted 20-30 minutes per student. When the group exam was reintroduced, questionnaires were created for both students and supervisors to analyze the reimplementation. At the exam, alongside the supervisor who now acts as an internal examiner, there is usually an external academic or industry examiner. A 2007 survey showed that supervisors preferred the group exam as it appeared to be more aligned with PBL principles. However, the new group exam differs from the former; it now includes an individual phase in which each student is questioned directly but where the other group members are still present. Overall the new group exam consists of three phases: (a) Students jointly present their project which usually lasts around one hour. (b) A joint phase usually lasting up to two hours where the examiners ask questions to the group and where each group member can volunteer to answer the question or add something to what another group member has stated, and (c) an individual phase where each student directly gets a specific question. Sometimes the students draw the question from a poll of questions at random, at other times the students are being asked something within an area of the project report that the students did not previously say something about. Before the reintroduction of the new group exam, the Faculty of Engineering and Science had held several workshops and produced online material to support the faculty in administering the new exam.

Research questions

This paper reports the supervisors' views of (1) The new group exam in comparison with the individual exam, (2) The individual phase of the new group exam, (3) The distribution of grades and quality of assessment. Also, responses of tenured and untenured faculty were analyzed for differences. The reason for comparing these two groups is that in countries like Denmark, it is mandatory for faculty to have received a teaching certificate aimed at higher education before obtaining a tenured position. One of the arguments for having this requirement is that to be a good teacher in higher education; it is not enough for be a good researcher, one also needs educational training. This includes being a competent examiner. Experience is likely to have an impact on how one handles being an examiner, and it is important to learn where untenured faculty may find this type of exam difficult to administer.

Methodology

The questionnaire was distributed just after the summer exams in 2013 via emails to all supervisors at the Faculty of Engineering and Science. The questionnaire was based on the 2007 survey and revised after a pilot in February 2013. Questionnaires were also created and

distributed to all the students at the Faculty of Engineering and Science [8,9,10]. A total of 1,402 people received the questionnaire and 208 answered which gives a rather low response rate of 15%. It is not unusual for online surveys to receive low response rates [11] but in this case, we subsequently learned that the file with email addresses we had received from the administration by mistake had also included emails to technical and administration staff as well as faculty purely doing research. The response rate of the February survey was 36% [8]. This means that although conclusions can still be drawn, they should be drawn with caution. In the analysis of the answers, the level of significance is set to .05. The questions were formulated as opinion statements to which the supervisors on a 5-point Likert scale could answer from 'agree' to 'disagree.'

Results and discussions

The new group exam in comparison with the individual exam and the individual phase of the new group exam

Fifty-two percent of the respondent were tenured faculty (full or associate professors) while the rest had untenured positions. A minority of supervisors (15%) preferred to have an individual exam, and the difference between tenured and untenured faculty was almost significant ($p = .072$) with the untenured faculty being more in favor of the individual exam. In comparison, the analysis of the February survey [8] taken place right after the first time the group exam was reintroduced and where a great number of faculty had never tried it before, showed that when comparing faculty who had never tried the group exam to faculty who had tried it before (either at AAU in the past or elsewhere) the difference was significant ($p < .001$). Inexperienced faculty members were strongly in favor of the individual exam.

Sixty percent agreed that the individual and the group part of the group exam each assess different competencies, but there was not a significant difference between tenured and untenured faculty. Another question asked if the time spent on the individual part was better spent on a longer joint part. Here a minority of 35% agreed, and there was a significant difference between tenured and untenured faculty ($p = .032$) where tenured faculty agreed more to the question.

In relation to the question of alignment, the supervisors were also asked if they found the group exam to be a good mirror of the way the students work in their groups. 84% agreed, and there was almost a significant difference ($p = .085$) with the tenured staff tending to agree the most. A related question asked if it is important that the students are good at participating in a discussion. 86% agreed, and there was not any significant difference. Another question relating to the appropriateness of a group exam asked if shy students suffer. Here a majority agreed (53%), and there was a significant difference between tenured and untenured staff ($p = .035$) with untenured agreeing more. A question asked how well the supervisors felt they were able to chair the exam. Twenty two percent found it difficult and there was a significant difference ($p = .013$) between tenured and untenured faculty with untenured agreeing more. Almost all (96%) the supervisors found that they had been well-prepared to administer the exams that there was not a significant difference between the faculty. Below is an overview of how the supervisors answered those questions.

Question	Percent agree	p-value for difference tenured-untentured	If significant, who agreed the most
Prefer individual exam	15%	.072	NA (untentured)
Individual and group exam each test different competencies	60%	.230	NA
Time spent on individual better spent on a longer joint part	35%	.032	Tenured
A group exam is a good mirror of how they work in the groups	84%	.085	NA (tenured)
The students need to learn to participate in a discussion	86%	.890	NA
Shy students suffer in a group exam	53%	.035	Untentured
It was difficult to be the chair of the exam	22%	.013	Untentured
Were you well-prepared to administer the new group exam	96%	.252	NA

Table 1: Overview of responses to questions about attitudes to the group exam.

From the answers to these questions, it appears that overall, the supervisors preferred the group exam and they also support the introduction of an individual part within the group exam. It also appears that some major arguments in favor of the group exam are that it is a good mirror of how students have worked in the group and the students also need to learn to participate in a discussion. However, it also appears that the picture is not only positive as shy students seem to suffer in the group exam. One may argue that it is not a surprise as the exam is designed to reward students who can handle the joint part in which they need to interact with not only the examiners but also the other students. But one may argue that this is something they need to learn to be able to do. In line with [12], it can thus be argued that in engineering, innovation and design are social processes involving several individuals which mean that it is essential that students learn to be socially competent during their study.

There are many places where tenured, and untentured faculty answered significantly different, or nearly significantly different (then noted in brackets in the table who were most in agreement with the statement). At all places, the untentured faculty members are the least in favor of the group exam. It also appears that the untentured faculty members are the ones who find it most difficult to handle the group exam, but all faculty members find that they are properly prepared to administer the exam. One might form the hypothesis that when someone finds it hard to handle a certain type of exam, they become more skeptical of this type of exam. Or perhaps it is the other way around – they are skeptical of the validity of the exam. Hence they find it difficult to maintain examination fidelity. Either way, it appears that experience impacts the views of the group exam.

The distribution of grades and quality of assessment

A minority (29%) found that the individual part of the new group exam was not necessary to determine the individual student's grade. There was almost a significant difference here ($p = .056$). Only 24% preferred that the students should sit alone with the examiners during the

individual part. During the individual part of the group exam, it is customary that the rest of the group members remain in the room, but they are required to be passive. There was almost a significant difference ($p = .064$) between tenured and untenured faculty on this question. Almost half the supervisors (40%) found that the assessment was made difficult by the fact that one cannot ask the same question to more than one student in a group but there was not a significant difference here. It may be unexpected that on the one hand, almost half the supervisors find it difficult that the examiner cannot ask the same question twice but only a minority find that it would be better to have the student one by one in the individual part, which to some extent would solve the problem. A reason might be that the problem is not perceived to be that big or there are other benefits of having all students present all the time during the exam which outweighs the negative element.

There was also a question that asked the supervisors if it had been difficult to make the assessment of the individual student and another asking if they found that an individual exam might have given a more diverse range of grades. A minority agreed to these questions, and for both of them, there was a significant difference between tenured and untenured faculty with untenured agreeing the most. Only a small minority (13%) found that there had not been time enough for proper student assessment and there was not any significant difference between tenured and untenured staff.

In relation to the question if it was easier to differentiate between the students when assessed in groups than when assessed one after one in individual exams, a big minority of 38% had agreed. Here particularly the assistant professors agreed (68%) while the associate professors had disagreed (57%). The answers in each category differ more than on other questions, and we see significant differences between some of the subcategories, e.g., full and associate professors versus assistant professors ($p = .004$). When postdocs are also included, the p-value becomes .009, but other untenured faculty members such as Ph.D. students and adjunct faculty makes the difference not significant. The question is interesting since from one perspective one may argue that it is challenging to keep track of up to eight students during a group exam and remember who said what. The preparation before the reintroduction of the group exam had given the supervisors various tools to aid the note taking which might explain it to some extent. Furthermore, informal talks with supervisors revealed that the fact that having a group of students at the same time made it easy to compare since examiners took several breaks during the exam to compare notes and discuss the students against the grading criteria and comparing them to each other. It is not uncommon to have discussions in the breaks where one examiner, for instance, says that if Student X appears to deserve grade B, then Student Y should also get B since so and so and then a debate begins about where the border between grades should be. Often this leads to examiners agreeing to ask certain students about this or that after the break and then notice how they respond. One may argue that although the grading (in Denmark) is done using a criterion-referenced grading scale, the actual grading uses elements of norm-referenced assessment, in this case, a kind of comparative judgment ranking the students within a group [13]. Below is an overview of how the supervisors answered those questions.

Question	Percent agree	p-value for difference tenured-untenured	If significant, who agreed the most
The individual part was not necessary to determine the grade	29%	.056	NA (tenured)
Assessment is difficult since one cannot ask the same question twice	40%	.340	NA
Prefer to have students one by one in the individual part	24%	.064	NA (untenured)
It was difficult to make an individual assessment	16%	.021	Untenured
An individual exam would have given more diverse grades	27%	.017	Untenured
There was not enough time to make a proper assessment	13%	.771	NA
It is easier to differentiate between the students when assessed in groups than if assessed one by one	38%	.305	NA

Table 2: Overview of answers to questions regarding the quality of grading.

Overall we see that the individual part is essential in securing a fair grade. It also appears that overall the supervisors feel well-prepared and that they have enough time to assess. The places with a significant difference between the tenured and untenured faculty, reveals that the untenured were the ones who found it the most difficult to grade. The untenured faculty appeared to believe more that the individual exam would have resulted in more different grades being given to the students. At the same time, they also appear to prefer an individual assessment which indicates that they may find the individual grades given during a group exam less valid; the grades ought to have been more spread across the grading scale. One may argue that since the tenured faculty had another viewpoint here, it indicates that more training of untenured faculty is needed in order to properly assess the students in a group exam. It might also indicate that more experienced faculty can assess the students also in a more complicated exam – or at least they believe so themselves. In favor of the viewpoint supporting the validity of a group exam is that when the group exam was made forbidden in 2007, a survey [14] showed that 87% of the external examiners preferred a group exam instead of an individual exam. However, this should be taken with caution as external examiners have agreed to be examiners. In cases where AAU asked someone from outside AAU to become an external examiner, and this person did not believe in the validity of group exam or PBL, this person would most likely not agree to become an external examiner; hence would not have been part of answering the questionnaire about the group exam in 2007. The same argument can be used in relation to tenured and untenured faculty as the latter would likely seek employment elsewhere before becoming tenured.

Besides these questions, the supervisors were asked to compare the former individual project exam to the new group exam and state to what extent they found that the group exam have a better, similar or worse opportunity to obtain a fair grade. 45% stated it was the same, 35% that it was better and 13% that it was worse. There was not significant differences between the answers, also when taking positions of tenured and untenured into account. However, when considering the following components, more than half the supervisors stated that the group exam was better:

1) opportunity to ask relevant questions, 2) give feedback to the scientific content, 3) cover the material, 4) give feedback to project management, 5) give the students new knowledge as part of the exam, 6) ask questions relating to the students' deeper understanding, 7) argue for and against a solution, 8) apply knowledge from the project to other contexts, 9) communicate knowledge, 10) be part of a dialogue and collaborate, 11) supplement other students' answers and 12) be part of a team. Only in questions about the students' ability to answer quickly as well as explain concepts and definitions, more than half stated that it was the same. In general, the tenured and untenured faculty were either not significantly different, or the untenured faculty agreed less.

Conclusions

Overall, the study shows that the group exam is an aligned and suitable practice to assess students' learning outcomes in a PBL curriculum but that an individual phase is also important. The group exam can assess skills of collaboration and problem-solving essential for engineers. It appears that experience has an impact on how supervisors experience the grading. This is similar to the study from 2013 [8]. However, in the 2013 study, some of the inexperienced faculty in relation to administering the group exam were tenured faculty. However, the picture is the same as the younger/less experienced faculty are, the less in favor of the group exam, and they are also the ones more critical about the possibility of given fair grades.

Good preparation of faculty is necessary to secure a fair assessment. Faculty preparation also has an impact on the issue of the validity of the exam. In theory, if we follow the line of reasoning of constructive alignment, one can argue in favor of the group exams since they, as also seen above, give room for the possibility of students to be assessed on collaboration competencies which are aligned with both PBL and the requirement of modern engineers. On the other hand, it appears that untenured faculty members find it comparably harder to administer these exams compared to the tenured faculty. In fact often the untenured faculty answer more in favor of more individual exams. This means that one can argue that group exams administered by tenured faculty are more valid than the ones administered by untenured faculty. One may argue that a solution might be to give more intensive training to untenured faculty before they are allowed to examine or to move towards the individual exam as tenured faculty can be assumed to also be able to administer these exams. Then, one would for sure avoid issues of shy students and the problem of not being able to ask the same question more than one time. However, when taking alignment to PBL and the future profession into account, it might be more advisable to continue to train the untenured staff. Also, it may be wise to train more shy students, so they are more able to behave well at the group exam, not just for the sake of the exam but also since it will help them in their future profession.

When the study was done in 2013, students and many of the faculty (particularly the newer faculty) were against the reintroduction of the group exam. For that reason, the Faculty of Engineering and Science paid the center where the author works to do an evaluation of the reintroduction to learn how the reintroduction was received. A report of the February survey of both the supervisors' and the students' views of the group exam was used internally at AAU to learn how the reimplementation went and if there were places where rules or practice needed to be changed. From another perspective, the report and subsequent papers of both the students' and

the supervisors' views are used in the discussion of what to include in the teacher training for university teachers as well as in more general discussions about the group exam. For instance, the result above stated that a majority of supervisors (and students) find the individual part useful is used in the discussion since there is not agreement across the university faculty about the benefit of having this part being inserted into the old group exam. Some argue that it is better to have a longer joint part. In this way, the results are indirectly influential for the students' learning experience.

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