

## ADAPTIVE STATISTICAL EDUCATION TO MOTIVATE AND ENABLE A GROWING AND INCREASINGLY DIVERSE STUDENT POPULATION

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*Today we face a more heterogeneous student population in higher education than before and it should be our main objective in this respect to ensure future-oriented, creative and innovative candidates as researchers in STEM subjects, as statistics, when we today face the era of digitalization and big data. In an ongoing study at the Norwegian University of Life Science we try to adapt to this diversity in the introductory statistical course. In 2016 the course was redesigned as a flipped classroom with cooperative learning activities in class. In 2017 further adaptation were made: The students that preferred to work alone, could choose to solve problems individually and out of class. Output variables like exam scores and evaluations have been analyzed in light of the learning preferences of the students. Results show, among other, that the so-called digital and introverted students are over-represented in the group that took the course individually.*

### INTRODUCTION

The teaching of STEM subjects at the universities has traditionally been adapted to a particular cognitive mastery style among the students. This, in turn, may have led to the teaching forces also being recruited and shaped through such a pedagogical approach, and reinforced a somewhat stereotyped teaching form within the STEM subjects. However, as a larger proportion of the population is enrolled in higher education, we face a more comprehensive and diverse student population, and teaching methodologies at universities should be revised accordingly.

Historically, the introductory course in statistics at the Norwegian University of Life Sciences (NMBU) has been lecture based. A previous study (Sæbø et al., 2015) at NMBU concluded that the course structure apparently disfavored certain cognitive student types. Several studies have shown that flipped classroom and cooperative learning has a positive additive effect on learning outcomes (e.g. Schultz et al., 2014; Foldnes, 2016). Therefore, the introductory course in statistics was restructured into a student active learning course using flipped classroom in the autumn of 2016.

Unpublished, preliminary results indicated that the flipped classroom approach may have a positive effect for some students, but that additional course adaptations may be necessary to reach an even wider group of the heterogeneous student mass. From 2017 the students in the introductory course in statistics were therefore offered two alternative course formats; they could either choose (i) to participate in mandatory, weekly colloquium work in a supervised class setting, or (ii) to do the colloquium assignments individually and out of class. The mandatory weekly assignments also included a set of multiple-choice questions. In addition, students were encouraged to solve weekly sets of additional exercises.

In the present study, we present some results from an ongoing study, in which we explore these course options, that is, the “colloquium type” course format versus the “individual type” course format. In the analyses, output variables like exam scores, course format and student evaluations were compared with cognitive information from the students. The latter was collected as an online assessment provided by the National Centre for Science Recruitment in Norway.

### DATA COLLECTION

The cognitive assessment provided by the National Center for Science Recruitment (Brovold, 2014) is based on a multi-factor type inventory, which includes factors similar to Myers-Briggs four-factor models (Myers & Myers, 1980). The online test contains a simple personality screening, where each student is measured according to four dichotomous traits, based on the model of Walter Lowen (1982) and on the traits proposed by Carl Gustav Jung (1921). The traits are; Introverted/Extroverted, Feeling/Thinking, Sensing/Intuitive and Digital/Contextual. The students are encouraged to respond to the cognitive assessment at the beginning of the first term, and to have this in mind when they choose

their preferred course format. Results will be presented for 211 students who took the course during one of the terms autumn 2017 or autumn 2018.

At midterm the students evaluate the course through an online assessment. Information include which course format was chosen, the students' perceived learning outcome, whether they would have chosen the same course format again, and, for those choosing the individual course format, questions regarding their choice. In the autumn term 2018, 102 students out of 220 responded to the evaluation.

The course exam consists of three parts; Assignment 1, Assignment 2 and a set of multiple-choice questions. In Assignment 1, the students are asked to write a short report based on the output from a given context and a given statistical analysis. This open question is formulated to correspond to the weekly colloquium assignments (which they solved individually or in colloquium groups), and the task measures the students' ability to contemplate freely about a statistical analysis. The questions in Assignment 2 are formulated to reflect the optional weekly questions. The multiple-choice part of the exam corresponds to the weekly, mandatory multiple-choice assignments. The three parts of the exam account for 25%, 25% and 50% of the total exam score, respectively. Variables used in the following analysis include the scores from the three parts of the exam (range 0-10 for each part), the four dichotomous cognitive traits, and course format, for 72 students during the autumn term 2018.

## RESULTS

### *Choice of course format according to cognitive traits*

It was mandatory to join a colloquium group and meet in class twice a week the first two terms after the course was flipped. Feedback from the course showed that some students found the situation uncomfortable and that for some students, the perceived learning outcome by participating in colloquium groups was next to nothing. In 2017 we therefore let students who preferred to study alone, choose the individual course format. The first semester, 42 students out of 231 (a proportion of 0.18) chose this alternative. In spring 2018, autumn 2018 and spring 2019 the proportions of students choosing the individual course format were 0.30, 0.26 and 0.35, respectively. Table 1 shows the distribution of the different cognitive traits within the two course formats, for the autumn terms 2017 and 2018.

Table 1. Course formats (Colloquium or Individual) versus cognitive traits for students taking the course during the autumn terms in 2017 and 2018

	Colloquium	Individual
Digital	87	31
Contextual	79	14
Introvert	100	34
Extrovert	66	11
Sensing	135	36
Intuitive	31	9
Feeling	101	24
Thinking	65	21

Four Chi-square tests were conducted to compare the chosen course format (Colloquium or Individual) with the four different cognitive traits (Introverted/Extroverted, Feeling/Thinking, Sensing/Intuitive and Digital/Contextual). The digitally oriented and the Introverted students were slightly over-represented among those who chose an individual course format (p-values 0.05 and 0.06, respectively), whereas there were no associations between the course format choice and the cognitive traits Sensing/Intuitive or Feeling/Thinking (p-values 0.84 and 0.36, respectively).

### *Midterm evaluations*

In total 46 % of the students responded to the anonymous midterm evaluation in the autumn term in 2018. Of these, 18 of the 75 students (24 %) who followed the in-class colloquium groups reported that they should rather have chosen the individual course format, and 7 of the 27 students (26

%) who followed the individual course format would rather have attended in-class colloquium groups. On a scale from 1 to 5, where 1 is the lowest and 5 the highest, the 27 students following the individual course format had a mean score of 3.33 on “the perceived learning outcome” and 3.46 on “how easy it is to follow the teaching plan when you never have to attend class”.

#### *Associations between course format and exam results*

Of the 72 students who signed the declaration of consent to gather information about cognitive types and exam scores from the autumn term 2018, 56 students followed the colloquium course format, and 16 students followed the individual course format. We found no significant difference in the total exam score between the two groups (two-sample t-test p-value 0.18).

The correlations between scores on Assignment 1 (the report) and Assignment 2 (regular exercises) was 0.43. The correlation between the exam scores for the multiple-choice questions, and Assessment 1 (the report) and Assessment 2 (regular exercises), were 0.63 and 0.51, respectively. A principal component analysis (PCA) of the corresponding covariance matrix was conducted. The first principal component explained 70 % of the total variation in exam sub scores, and Assignment 2 (regular exercises) had the highest loading for this component. The second principal component explained 23 % of the variation and could be regarded as a contrast between Assignment 1 (the report) and Assignment 2 (regular exercises).

No differences in correlations were found between the course format groups.

To see if the student differs in how they answered the Assignment 1 (the report) with respect to course format, we fitted a linear model to the data. Score of Assignment 1 was response and the explanatory variables were respectively which course format they had, scores on Assignment 2 and scores on the multiple choice with interactions up to second order. There appears to be no significant main effects other than the multiple-choice. The interaction between teaching arrangement and Assignment 2 came out barely significant (p-value 0,048). Figure 1 shows a scatterplot with Assignment 1 on the y-axis and Assignment 2 on the x-axis. The least square lines for the different teaching arrangements are visualized.

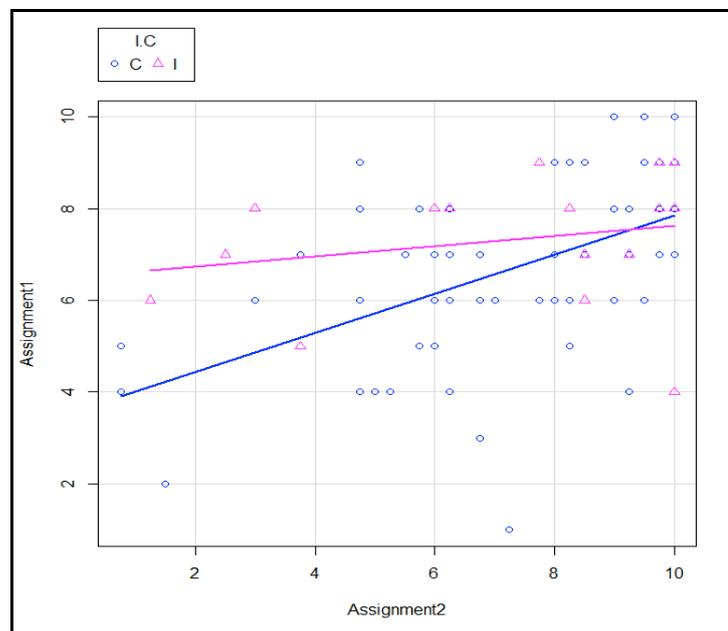


Figure 1. Scatterplot with Assignment 1 score (0-10) on the y-axis and Assignment 2 score (0-10) on the x-axis. The least square lines for individually (I) is pink and colloquium (C) is blue.

## DISCUSSION AND CONCLUSION

### *Choice of course format according to cognitive traits*

The assumption that different students learn differently is so basic and so important for teachers that it is considered a well-known fact. Still, few research results have explored or confirmed

this fact in higher education. Our main goal with the adaptive course is to provide the students with options, so that they can choose the course format that enables them to obtain the best learning outcome. By assessing cognitive information and using this as a part of the background for their choice, we hope to promote more metacognitive thinking and increase the students' motivation for statistics.

The proportion of students that carry out the course individually seem to increase. In the spring of 2019 the proportion was 0.35 compared with 0.18 in the first semester. They receive the same information in the beginning of the course and a clear advice to choose the in-class colloquium since the course emphasizes discussion and interpretation of results. Our main goal is that the student, based on some metacognitive insight, choose the course format by which they maximize their learning outcome. Unfortunately, we have noticed that an increasing amount of students, who choose to do the course individually, base their choice on other facts like overbooked schedules, either with other mandatory courses or work outside the university, they follow the statistic course from other parts of Norway or they want to create their own study group outside class with people they know.

The results in Table 1 show that digital and introverted (I) students dominate in the group of students choosing the individual study format. This is in accordance with Sæbø et al. (2015) who found that these cognitive types also did best in introductory courses characterized by lectures, individual reading and exercise training and minimal use of dialogue with or among students. This learning format suits these student types well. Introverted students prefer individual work, thinking and reflecting at their own pace. Many of these students also become uncomfortable in group settings where they need to speak up to be heard. As shown by Brovold (2014), being extrovert is stronger associated with cognitive traits/interests like being social, human orientation and service minded, which explains why these students prefer working and learning in groups. Furthermore, Brovold (2014) also found positive association between being digital (D) and traits like being structured and self-administrative, which also explain why the digital type dominates among the students who choose individual study.

#### *Midterm evaluations*

From the midterm evaluation we can see that the majority of students would have chosen the same teaching arrangement if they were to take the choice over again. The numbers are higher for the individualists than for the colloquium group attendees. One reason for student wanting to swap from colloquium to individual format may be that the group dynamics did not work. The groups are divided randomly, and this may be a problem if the group members do not meet on equal terms (eg. background, ambitions for the course, speed to solve problems). The individualists reported that the weekly mandatory assignments were not adapted to do individually and that it took too much time to solve alone.

#### *Associations between course format and exam results*

It would be an interesting result if the students, with respect to course format, differs in performance on the different parts of the exam. The correlation for the different assignments for all students is low, which can indicate that the three parts of the exam tests different skillset. The results from the PCA pointed out Assignment 2 as the most crucial assignment. Assignment 2 in the autumn term 2018 was a probability assignment and the structure on the exercises differed from earlier exam sets. From the linear model with Assignment 1 as response, we got a barely significant effect on the interaction between teaching arrangement and Assignment 2, shown in Figure 1. One possible reason for such an interaction is that the individual students all over are better at finding strategies to solve unfamiliar assignments, while the academic weak students, who have been part of a colloquium group, do not have trained the "how to face new challenges alone"-mindset and therefore have problems when faced with a not so familiar layout on the final exam.

#### *Conclusion*

We did not find important differences in learning outcome with respect to the exam scores, for students from different course formats, in the data collected from the autumn term 2018. Still, the students are eager to discuss the project with different course formats. They reflect around their own learning process with each other and the lectures, before they take their choices, and after the course

has ended. We also found that digital (D) and introverted (I) students dominate in the group of students choosing the individual study format, as expected. We believe that reflection like this and the fact that the students have a positive learning experience in a theoretical subject as statistics is important. We will continue the process of collecting more data and investigating similar results over several semesters.

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