18

Promoting Active Participation in Computer Science Lectures

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Introduction

The B.Sc. course "Data Analysis" ("Dataanalyse"), Department of Computer Science, University of Copenhagen, aims at enabling students to solve data analysis problems using methods from signal processing, statistics and machine learning. The focus on problem solving skills is reflected in the intended learning objectives (ILOs), and the students solve actual data analysis problems during the course in written assignments. However, in the lectures, the learning activities have mainly consisted of traditional one-way lecturer-to-student communication.

Several problems with classical lectures limit the learning outcome, including the fact that students are mainly passive listeners and that the amount of interaction between students and lecturer is low. In addition, as previously identified (Sommer 2013), the learning activities in the lectures in "Data Analysis" are not in alignment with the ILOs and the assessment criteria; the lectures do not focus on enabling the students to actually solve data analysis problems.

Problem Statement

In this project, I will investigate ways of promoting active participation in the lectures in "Data Analysis" in order to both align the learning activities with the ILOs and the assessment criteria, and to increase the learning outcome among the students. I will in particular focus on ways of making the students perform data analysis tasks in the lectures and on how the results

of these tasks can be used for initiating discussions. The effect of changing the learning activities will be evaluated and discussed based on written feedback from students attending the lectures.

Lectures and Student Activation

The inherent problems with traditional lectures are described thoroughly in the literature, see e.g. (Gibbs 1981) and (Rienecker et al. 2013, chap. 4.1). Among the major issues is the one-way communication from teacher to student that results in the students passively listening to a presentation instead of actively working with the content. It is very hard for the lecturer to target the teaching for the actual students, both because the students will have very different prerequisites (Rienecker et al. 2013, chap. 1.1) and because feedback from students to lecturer is at best sparse. The high involvement of students that is the focus of problem based teaching and problem based learning (Rienecker et al. 2013, chap. 4.3-4) is almost contrary to the classical lecture.

In the course “Data Analysis”, the above issues are complemented by the fact that the lectures do not teach the students what they should learn; actually solving data analysis problems (see course description page in appendix A). A very concrete reflection of the problems with the previous structure of the lectures and learning activities is the fact that less than half the students of the course attend the lectures.

Promoting student activation in lectures is the subject of texts such as (Mazur 1997). Here it is proposed to structure the lecture around problems that students are asked to solve and discuss in pairs during the lecture. Following this, answers can be discussed between lecturer and students. This approach has several benefits, including that students are actively working with the material, that the lecturer receives feedback from the solutions to questions, and that discussions following the questions can address the parts of the subject that students actually find hard. In traditional lectures, the presentation in the textbook is often repeated in the lecture. With the structure proposed by (Mazur 1997), this problem is alleviated by involving the students in both solving problems and, using the repeated feedback, targeting the presentation towards the student’s needs.

Case: Datanalyse 2014

In order to increase student participation and align the lectures with the course ILOs, I will use the lectures "Classification 1" and "Classification 2", both 2 x 45 minutes, as the case for testing and evaluating a teaching method inspired by (Mazur 1997). The intend is to design the lectures to have a greater focus on student participation and discussions. The outcome of the changed teaching approach will be evaluated with written evaluation following the second lecture.

In order to best address the learning objectives, the students should participate in formulating, executing, and discussing steps in solving a data analysis problem. The fixed 2 x 45 min. lecture format does not allow time for both defining a problem in its entirety, implementing computer code for the analysis, and discussing the results. Instead, I wish to give the students experience with handling the different steps of the analysis process within the time-frame by focusing on subparts of the problem solution process. As a general rule, the intend is that each part contain a question for the students, that the students have time to think of an answer and discuss in pairs (3 min.), and that this is followed by a discussion of the answers between students and lecturer and related to additional theory. The structure implies shift from the lecturer covering a large topic in detail to a focus on fewer, selected parts of the material.

Example Lecture: Data Analysis Classification 1

Below is an outline of the first of the two redesigned lectures. The lecture starts with a discussion with the students of the ILOs and their relevance. The lecture ends with a discussion on to which degree the ILOs have been addressed in order to guide the students in their study after the lecture. Both parts are introduced to established a "didactical contract" with the students.

Part 1 (45 min.)

0-2 min. Welcome: Todays lecture, structure and content.
3-7 min. Discussion of ILOs and relevance.
8-11 min. Discussion of examples of classification tasks.
12-14 min. 3 min. question: structure of a classification problem.
15-26 min. Discussion of answers and summary on blackboard.
27-34 min. Examples in MATLAB and discussion of visualization.

35-37 min. 3 min. question: geometric examples of classification.
38-45 min. Discussion of answers and summary on blackboard.

Part 2 (45 min.)

0-2 min. 3 min. question: qualitative and quantitative measures of performance of classification functions.
3-14 min. Discussion of answers and summary on blackboard.
15-17 min. 3 min. question: training and test of classification functions.
18-29 min. Discussion of answers and summary on blackboard.
30-32 min. 3 min. question: pseudocode for cross-validation algorithm.
33-40 min. Discussion of answers and summary on blackboard.
41-45 min. Summary and discussion of ILOs.

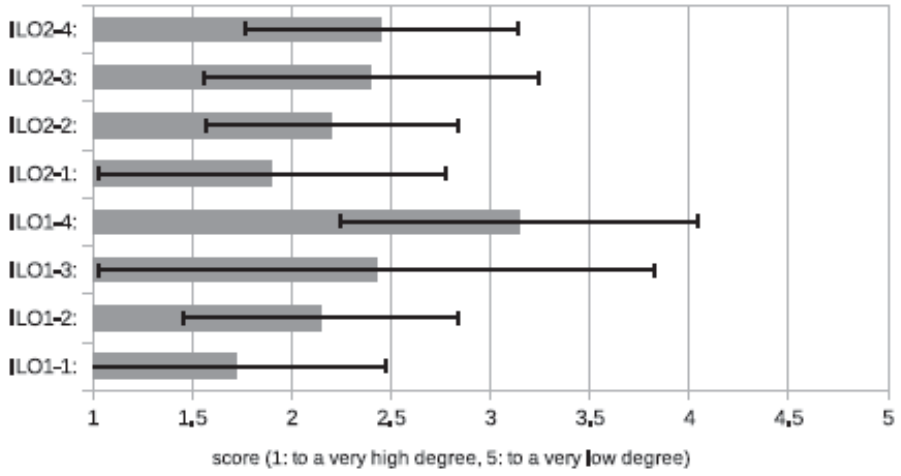

Fig. 18.1. Student responses: To which degree did the lectures make you able to meet the ILOs 1-1 to 1-4 (lecture 1) and ILOs 2-1 to 2-4 (lecture 2).

Note that the general structure is a sequence of questions that the students have 3 minutes to answer and discuss in pairs. Following each question, we discussed the answers together and students came to the blackboard to illustrate their solutions. We summarized the discussions and related them to the rest of the theory by treating smaller questions and by structuring the answers on the blackboard.

Evaluation and Results

In addition to the continuous feedback I received from discussing with the students during the lectures, the students were asked to evaluate the learning activities in a questionnaire at the end of the second lecture, see appendix B. The questionnaire focused on evaluating to which degree the changed teaching style helped the students in meeting the ILOs (Figure 18.1). In addition, the students were asked to evaluate the new learning activities in comparison with the previously taught traditional lectures (Figure 18.2).

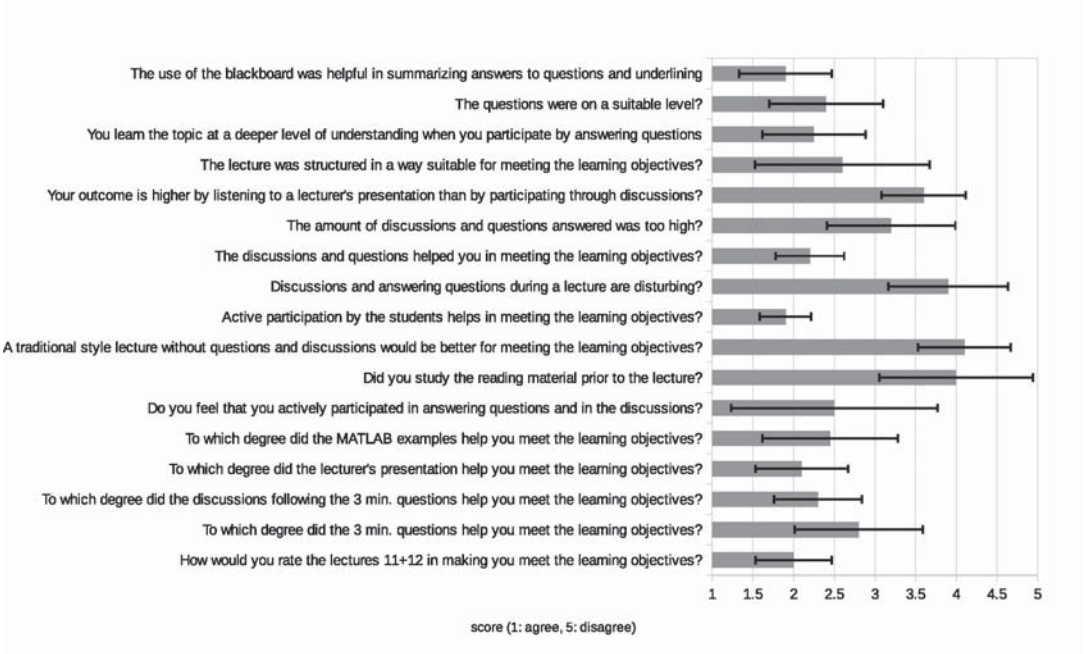

Fig. 18.2. Student evaluation of the change in teaching method and of involving students in the lecture trough questions and discussions. The responses indicate that students generally feel their learning outcome is higher with the question/discussion based lectures.

The ten students present at the second lecture answered the questionnaire. The student's own perception of to which degree the lectures helped them meeting the learning objectives is moderately positive.

The student's evaluation of the changed learning activities indicate that they find that their learning outcome has increased. Responses to questions such as "Active participation by the students helps in meeting the learning objectives?" are positive (mean < 2 on the 1-5 scale). The students in addition answer that they feel they obtain a deeper level of understanding

by actively participating in the lecture. To a high degree, they favour the changed lecturing style for meeting the learning objectives.

There is a more positive rating of the learning outcome from the lecturer's presentation than from the questions and discussions though none of the factors are rated negatively.

Some students indicated in their comments that they felt the amount of questions and discussions where too high though the general response to the question "The amount of discussions and questions answered was too high?" is neutral.

Discussion

The evaluation was performed by a small fraction of students on the course. Though the ten students are not representative of all students of the course, the responses represent the evaluation by students actually participating in the lectures. Had the lower number of attendees been known prior to the planning of the project, an interview based or oral evaluation would likely have been more informative. The low attendance at both lectures and exercise sessions is a general problem for the computer science bachelor courses. It can be speculated that an improved learning outcome with the more interactive lectures will make the lectures more relevant for the students and thus increase attendance. This can be tested if the changed teaching style is applied to all lectures next time the course is taught.

Though the students generally respond positively to the degree by the which the lectures have enabled them to meet the ILOs, lacking similar responses from lectures with the traditional teaching style, it is hard to conclude on any effect of the changed structure. It should be noted that "novelty-effects" can be the cause of the positive responses to the changed structure.

The fact that there is a more positive rating of the learning outcome from the lecturer's presentation than from the questions and discussions can be linked to the presentations being improved by the continuous feedback provided by the questions and discussions. I generally felt that the continuous feedback helped me greatly in targeting the presentation and use of the blackboard to address parts of the subjects where the students needed more elaboration. The communication where two-ways throughout both lectures which I felt made the presentation work much better.

The students where very active in the discussions and in answering questions that other students asked. The atmosphere were in general less formal than the previous lectures, and the students seemed more open to asking questions. These questions clearly revealed areas that needed more elaboration, and the questions therefore served as guidance for where I should focus. I experimented with having other students in the class answering questions. The students were able to explain the material in different words, and the combination between my explanations and that of other students seemed to work very well in making hard parts clear.

The continuous feedback was challenging to handle as it forced me to change my plan for the lecture several times during the lecture. My planning served more as a rough idea of what the lecture could focus on which I then used to shape the content as needed.

It is my impression that the discussions of the ILOs in the beginning and end of each lecture worked well in aligning expectations with the students of how the ILOs could best be achieved (the "didactical contract"). In particular, it took focus away from what I as a teacher should provide the students and instead emphasized what the students should do in order to meet the ILOs. In addition, we discussed the importance of the ILOs thus making the relevance of the material clear early in the lecture.

Conclusion

There is a general consensus in the literature that the classical lecture does not result in optimal learning outcome. In addition, the lectures in "Data Analysis" have previously been found not to be in alignment with the ILOs. To address these issues, a changed lecture structures based on (Mazur 1997) was designed where the teaching activities were build around questions that students answer during the lecture followed by discussions of their answers.

Based on written evaluation in the form of a questionnaire, the student's responses to the changed teaching method is positive. They are positive towards the increased amount of participation and indicate that it results in increased learning outcome.

Though it was a challenge planning the interactive lectures, I believe based on the evaluation and from the continuous feedback during the lectures that they improved the learning outcome significantly. I will employ a variation of this format in all my future lectures.

A Course description of "Dataanalyse"

Courses

NDA13002U Dataanalyse (DA) **Årgang 2013/2014**

Engelsk titel
Data Analysis (DA)

Kursusinformation

Sprog	Dansk
Point	7,5 ECTS
Niveau	Bachelor Kandidat
Varighed	1 blok
Placering	Blok 4
Skemagruppe	C
Kursuskapacitet	Ingen begrænsning

Efter- og videreuddannelse

Studienævn Studienævn for Matematik og Datalogi

Udbydende institut
- Datalogisk Institut

Kursusansvarlig
- Aasa Feragen (aasa@diku.dk)

Undervisere
Sami Sebastian Brandt og Stefan Sommer
Gemt den 08-11-2013

Uddannelse
Bacheloruddannelsen i datalogi

Kursusindhold
Formålet med kurset er at give en grundlæggende og bred introduktion til repræsentation, analyse og behandling af samplet data; at introducere den studerende til simple statistiske analyser af eksperimentel data samt data visualisering. Eksempler tages fra den virkelige verden såsom målinger af internettrafik, aktiemarkedsdata eller forbrugerdata, digital lyd og billede, osv. Endvidere gives en introduktion til programmeringsværktøjer til dataanalyse.

Kurset vil indeholde:

- Introduktion til databehandling og -filtrering.
- Sampling, samplet data frekvensrepræsentation.
- Sandsynlighedsregning og statistik, Bayesisk inferens.
- Parameterestimering, mindste kvadraters metode, lineær regression, matematisk modellering.
- Multivariat statistik, principalkomponentanalyse.
- Præsentation af analyseresultater inklusive visualisering med simpel plotting.
- Introduktion til MATLAB.

Målbeskrivelser
Viden

Den studerende vil have kendskab til dataanalysemetoder omfattende datarepræsentation, filtrering, modellering og estimering samt visualisering.

Færdigheder

Den studerende vil være i stand til at:

- Vælge en passende datarepræsentation og transformere mellem rum/tid- og frekvensdomæner, filtrere i både rum/tids- og frekvensdomæner.
- Anvende sandsynlighedsteori og statistik til problemer med skalar- og vektorværdier.
- Anvende mindste kvadraters metode til lineær modellering og estimering.
- Analysere samplet data med passende matematiske modelleringsværktøjer.
- Beskrive udvalgte multivariatmetoder og deres anvendelse, specifikt principalkomponentanalyse (PCA) og

dennes brug i dimensionsreduktion.
- Visualisere lav- og højdimensionel data med simple plot og billeder.
- Implementere simple dataanalyse og -modelleringsmetoder.
- Udføre analyse af eksperimentel data med brug af de i kurset lærte metoder og evaluere resultaterne deraf.

Kompetencer

Den studerende vil være i stand til at udføre grundlæggende dataanalyseopgaver omfattende modellering, visualisering og fortolkning af resultater samt vurdere metodernes begrænsninger.

Undervisningsmateriale

Se Absalonsiden.

Undervisningsform

Forelæsninger, praktiske øvelser og obligatoriske opgaver.

Faglige forudsætninger

DIMS eller MatIntro, LinAlg, OOPD og SS.

Tilmelding

Via STADS selvbetjening

Eksamen

Point	7,5 ECTS
Prøveform	Løbende bedømmelse Eksamen består af en løbende bedømmelse af 4-6 hjemmeopgaver. Opgaverne vægtes lige.
Hjælpemidler	Alle hjælpemidler tilladt
Bedømmelsesform	7-trins skala
Censurform	Ingen ekstern censur Flere interne bedømmere
Reeksamen	20 minutters mundtlig eksamen uden forberedelse men med hjælpemidler.

Kriterier for bedømmelse
Se målbeskrivelsen

Arbejdsbelastning

Kategori	Timer
Forelæsninger	32
Teoretiske øvelser	72
Praktiske øvelser	72
Forberedelse	30
I alt	206

Gemt den 08-11-2013

B Evaluation of lectures 11+12 (Classification 1+2), Datanalyse 2014

Intended Learning Objectives:

Scale: 1 (to a very high degree), 3 (neutral), 5 (to a very low degree):

Did lecture 11 (Classification 1) make you able to ...

- formulate a classification problem

  1 2 3 4 5

- apply classification algorithms to concrete data

  1 2 3 4 5

- explain errors in terms of geometric properties of the applied algorithms

  1 2 3 4 5

- make a quantitative assessment of results using cross validation

  1 2 3 4 5

Did lecture 11 (Classification 2) make you able to ...

- evaluate if the learning algorithm is overfitting or underfitting

  1 2 3 4 5

- tune a classification algorithm using nested cross validation

  1 2 3 4 5

- identify relevant parameters for main classifications algorithms

  1 2 3 4 5

- select appropriate algorithms for datasets with different properties

  1 2 3 4 5

Outcome of Lectures:

How would you rate the lectures 11+12 in making you meet the learning objectives?

Very good Good Neutral Bad Very bad

To which degree did the 3 min. questions help you meet the learning objectives?

Very high degree High degree Neutral Low degree Very low degree

To which degree did the discussions following the 3 min. questions help you meet the learning objectives?

Very high degree High degree Neutral Low degree Very low degree

To which degree did the lecturer's presentation help you meet the learning objectives?

Very high degree High degree Neutral Low degree Very low degree

To which degree did the MATLAB examples help you meet the learning objectives?

Very high degree High degree Neutral Low degree Very low degree

Do you feel that you actively participated in answering questions and in the discussions?

Very high degree High degree Neutral Low degree Very low degree

Did you study the reading material prior to the lecture?

Very high degree High degree Neutral Low degree Very low degree

Do you agree that ...

... a traditional style lecture without questions and discussions would be better for meeting the learning objectives?

Fully agree Agree Neutral Disagree Fully disagree

... active participation by the students helps in meeting the learning objectives?

Fully agree Agree Neutral Disagree Fully disagree

... discussions and answering questions during a lecture are disturbing?

Fully agree Agree Neutral Disagree Fully disagree

... the discussions and questions helped you in meeting the learning objectives?

Fully agree Agree Neutral Disagree Fully disagree

... the amount of discussions and questions answered was too high?

Fully agree Agree Neutral Disagree Fully disagree

… your outcome is higher by listening to a lecturer's presentation than by participating through discussions?

Fully agree Agree Neutral Disagree Fully disagree

… the lecture was structured in a way suitable for meeting the learning objectives?

Fully agree Agree Neutral Disagree Fully disagree

… you learn the topic at a deeper level of understanding when you participate by answering questions and by taking part in the discussions?

Fully agree Agree Neutral Disagree Fully disagree

... the questions were on a suitable level?

Fully agree Agree Neutral Disagree Fully disagree

… the use of the blackboard was helpful in summarizing answers to questions and underlining important concepts?

Fully agree Agree Neutral Disagree Fully disagree

What do you like about the lectures 11+12:

_____

_____

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_____

What do you dislike about the lectures 11+12:

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_____

_____

Why do you think that only less than half the students of the course attend the lectures:

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All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2014-7/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/

kapitler/2014_vol7_nr1-2_bibliography.pdf/