Interdisciplinary education through active learning. Introducing Economics and Econometrics into engineering education; hands-on learning using real data

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1 Background and objective

This project concerns the interdisciplinary master course Housing markets and Strategies (Faculty of the Built Environment, chair Real Estate Management and Development).

The course teaches engineering students to apply theories and empirical methods from economics and especially econometrics to solve real world problems. This in the context of the housing markets and making use of big data. Examples of such problems are: figure out how much people are willing to pay for dwellings with solar panels or for a location with little traffic nuisance, predict future housing demand in a location, etc. Understanding what clients want and how markets work is crucial for a successful engineer of the future. Economics and econometrics offer tools and concepts to do this using real world data.

The **goal** of the project was to augment the classical teaching in this course with active learning activities based on hands-on real world assignments.

The main **innovation** was to design active learning in such a way as to make the material appealing to engineering students who had not been acquainted with economics/econometrics yet.

2 Design of the active learning

To achieve the project goal, we have designed the following structure for the course.

Weekly meetings of this course were divided into two parts. In the first hour (lecture), new material was taught in a classical way like before, with the teacher taking the lead.

In the second hour (tutorial) the classroom was flipped and active learning took place. Active learning was of several kinds:

(i) Active learning by analysing others' work (weeks 2 to 4 and 6 to 8).
- In each tutorial two teams of students would present to the class high quality empirical articles in which the theory and methodology of the previous week was applied to solving real world problems.
- Students who were not part of the presenting teams, had to read the articles in question in advance and formulate questions on them. After the presentation, students would ask their questions to the presenting team. The teacher acted as a moderator leading this peer-to-peer discussion.

(ii) Active learning by doing yourself.
- During week 5, students had to make a hands-on real data assignment. In this assignment they used real data on housing sales that we managed to collect. The goal of the assignment was to perform a number of econometric analyses using methodologies learnt during the lectures and tutorials. After the assignment was handed in, it was discussed during the tutorial. In this way students got feedback on what they did right or wrong.

3 Project realisation and challenges solved

To realise the design, several steps had to been taken:

General

1. Choosing didactic methods

- First, theoretical research was done on the didactic methods most suitable to organise the active learning activities (see Section References for the literature consulted). We eventually combined insights from different methods: (a) flipping-the-classroom; (b) problem-based education; (c) team-based learning. None of these methods was adopted fully however. For instance, we flipped the classroom during the tutorial as in (a), but did not switch to a video lecture instead of a classical lecture. Also, students had to solve real problems in groups as in (b) and (c), but they did not need to search themselves for information about possible methods as this information was provided during the lecture.

Activities (i)

2. Selecting high quality research articles.

- We selected some 20 articles that would offer material for active learning (i). To make the assignments 'real' and thus attractive for the students, we searched for high quality research articles that tackle relevant social or company problems. An important challenge we faced is that the articles had to be interdisciplinary: come from economics journals, but have a subject that is interesting for real estate/architecture/built environment students.
- The number of the articles was higher than the number of presentations. To help students prepare the presentations, we gave examples of how these presentations should look like. We did this by discussing a number of articles during the lectures.

3. Ensuring that the presenting team understands the article and can explain it to the peers.

- We developed a question list that student teams had to answer in their presentations and a rubric to evaluate the presentations. The question list was based on the expected learning outcomes. Presenting teams had to show that they master the knowledge and skills we expect them to. We communicated the question list to all students in advance and showed them several times during the lectures how this list can be applied when discussing an article.
- Because the economics/econometrics theories and methods are new for most students, we offered presenting teams a possibility to pre-discuss their presentation with the teacher. All the teams made use of this small-group teaching activity. We helped the teams with structuring their presentations and also with the issues they did not understand. With this we wanted to make sure that the teams can take the lead during the tutorial and act as a teacher/tutor for the rest of the class.

4. Ensuring that the rest of the class comes prepared and takes part in the discussion.

- A considerable challenge was to activate the students who did not have to give a presentation. Experience from the previous year had shown that students – unfortunately - lack intrinsic motivation to prepare for the class and read the articles. We solved this by introducing an extrinsic motivation. We asked students to formulate two questions about articles due each week and send them in before each tutorial. Points could be earned for sending in questions. A selection from these questions was discussed in class each week, so each of the students could be asked to read out his/her question, state it to the presenting team and reflect on their answer. In this way most students came prepared.
- Next year we might add small graded quizzes on each of the articles, at the beginning of each tutorial, to activate the students further.

5. Collecting the data.
- To develop the hands-on data assignment, real data had to be collected. This was a challenge as individual data connected to the housing market (sale and rent transactions etc.) are not readily available from the open sources. We solved this challenge by developing a computer algorithm that collected information on individual houses listed on listing sites (Jaap, Funda). We managed to gather some 900 records, out of which 560 turned out to be suitable for our purposes. The data were cleaned, processed and augmented with additional information from open sources.

6. Analysing the data and making the assignment.
- We wanted the assignment to generate interesting tractable insights, e.g. about how much people are willing to pay for various characteristics of a dwelling such as: larger size, presence of a garden, presence of a parking space, etc. As the data were real, it was not clear in advance which insights can be obtained. We needed to analyse the data ourselves first, in order to formulate the assignment in a way that students would become enthusiastic.

7. Supporting students in the use of the programming software.
- Programming software R was chosen for this assignment. Reasons for this were: the software is widely used in practice, so students would get a valuable skill; the software is free. However, it was not familiar for students. We had to include a training module in the assignment, in which the main commands of R were discussed. Furthermore, we organised walk-in hours in which a student-assistant was available to answer the questions.

4 Evaluation of the course

The course as a whole got a high evaluation from the students. On average, the scores were 0.5 points higher than in the previous year.
Especially the parts concerning active learning (educational setup, interim tests, variation in teaching methods) got high scores. One of the students commented: "The assignment of presenting and asking questions really helps to think about the subject matter, and thus helps you to understand the subject matter."
- overall score: 7.5/10
- relevancy: 4/5
- educational setup: 4/5
- organisation of the course: 3.9/5
- study material: 3.6/5
- interim tests (this concerned the data assignment): 4/5
- content, interaction, variation in teaching methods: 4.1/5
- enjoyment from the course: 4.2/5

Furthermore, Rachelle Kamp from TEACH visited one of the tutorials to evaluate our experience with active learning and help with suggestions for further improvements. She complimented us on the set up and the realisation, especially on the fact that all the students in the class actively participated in the discussion. She made some suggestions on how to use blended learning possibilities (online quizzes etc.) to activate students even more; we will try them out next year.

5 Dissemination and sustainability

The following dissemination activities were executed:

- Presentation at a 4TU session of the 4TU.CEE
- We have taken a video of one of the tutorials and are working on an inspirational film about active learning in interdisciplinary education
- Publication of the experiences within the TU/e community.

The active learning activities developed this year will be applied in the next year course as well. Furthermore, we are thinking about transferring some elements to other courses of the curriculum and about introducing programming software R in data assignments in other courses.

6 Conclusions

The goals set in the project proposal have been realised and the innovation worked out. We augmented the classical teaching in course Housing markets and strategies with active learning activities based on hands-on real world assignments. The result was positively evaluated by both, students and a professional expert from TEACH.

We expect that our approach is readily transferrable to other courses. There are two main challenges teachers have to take care of. First, designing active learning assignments that are based on real world problems and are attractive for engineering students is quite time-consuming. One of the reasons is that real world data are not readily available. Second, it may take considerable effort to ensure that all the students actively participate in each tutorial. Combining different existing active learning approaches (flipping-the-classroom, team-based learning, problem-based learning, etc.) helps here.

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