A Case Study of Blended Learning for Mathematically-Intensive Topics in a Large Engineering Class

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Background facts and introduction

Blended learning environment implemented in a year 2 Data Analysis course for biomedical engineers. Approximately 100 students

- Video Lectures
- Online interactive database of practice questions

Attempts at measuring impacts on learning
Design of the learning environment

Weekly cycle (one per topic)

- Video Lecture (mathematical theory)
- Weekly lecture (discussion on an application of the theory)
- Tutorial (hands-on implementation)
Design of the learning environment: example

Topic of the week: Linear Regression

Linear regression: finding values of the parameters

\[
\beta_1 = \frac{m \sum x_i y_i - \sum x_i \sum y_i}{m \sum x_i^2 - (\sum x_i)^2}
\]

\[
\beta_0 = \frac{\sum_{i=1}^{m} y_i - \sum_{i=1}^{m} \beta_1 x_i}{m}
\]

Proof (start from the right):

\[
\sum_{i=1}^{m} (y_i - \beta_0 - \beta_1 x_i) = 0
\]

Multiply by \(m\):

\[
\sum_{i=1}^{m} (y_i \beta_0 - \beta_1 x_i) = 0
\]

Linear regression: minimisation of the SSE

\[
SSE = \sum_{i=1}^{m} (y_i - \beta_0 - \beta_1 x_i)^2
\]

To find the minimum:

\[
\frac{\partial}{\partial \beta_0} SSE(\beta_0, \beta_1) = 0
\]

\[
\frac{\partial}{\partial \beta_1} SSE = -2 \sum_{i=1}^{m} (y_i - \beta_0 - \beta_1 x_i) = 0
\]

BN2102: Bioengineering Data Analysis

Linear Regression: introduction

Lecturer: Dr Alberto Corrias

All the theory into the video lecture
Design of the learning environment: example

Topic of the week: Linear Regression

In class: “Today we talk about ski jumping…”
Classroom discussion and hands-on tutorial are an application of linear regression in a realistic case.

- Real application
- Real data to analyse
- Real scenario
Design of the learning environment

Traditional Framework vs. Technology-enhanced Authentic Framework

- **Weekly Contact Time**
  - **Theory content (lectures)**
    - Theory content
    - Illustrative examples

- **Students solve small problems at home to reinforce content covered in class**
  - **Presentation of a realistic application. Discussion of typical issues**
    - Practical implementation by the students
Objectives

● Improving students’ learning experience compared to traditional framework

● Lightening up content during face-to-face classroom session

● Increase students’ participation
Critical Issue

Students should come to class with at least a rough knowledge of the theory (content of the video lecture)
Addressing the critical issue: basic awareness

**Week 9: 13 Oct-17 Oct**

The topic of week 9 is the general case of linear regression. The video lecture covers the most theoretical aspects of this analysis.

1. [Workbin linear_regression_general_case-PRINTER.pdf](#) - Slides of the video lecture on the general case of linear regression...
2. [Workbin linear_regression_general_case.pdf](#) - Slides of the video lecture on the general case of linear regression
3. [Multimedia Week 9. Linear regression - general case](#)

**Lecture: Lecture (Dr Alberto Corrias)**

Monday, 13-Oct-2014 11:00 AM - 01:00 PM

**Duration:** 2 hour 0 min  **Location:** LT4

In this lecture, we will see a case study that applies the concept of the general case of linear regression in the field of micro-mechanics: we will try to determine the optimal length at which muscle cells are able to generate maximal force.

1. [Workbin case_study_week_9.pdf](#) - Case study for week 9
2. [Workbin case_study_week_9-PRINTER.pdf](#) - Case study for week 9, printer friendly version

**Tutorial: Tutorial Group 1**

Tuesday, 14-Oct-2014 10:00 AM - 12:00 PM

**Duration:** 2 hour 0 min  **Location:** E2-03-07 (PC4)

1. [Workbin tutorial_week_9.pdf](#) - Tutorial exercise for week 9
2. [Workbin week_9_data_problem_1.dot](#) - Data file for problem 1 (week 9)
3. [Workbin week_9_data_problem_2.txt](#) - Data file for problem 2 (week 9)

**Tutorial: Tutorial Group 2**
Addressing the critical issue: basic awareness

Video lecture reminder:

Dear EN2102 students,

Just a gentle reminder that part II of EN2102 will begin on Monday, September 29th. We will start at 11 am sharp.

Please do not forget to watch the video lecture before coming to class. You can find it on VLE or by clicking here.

There will be one specific topic for each week. For each topic, there will be a video lecture with the theory details and a case study of a practical application that will be discussed in class (every Monday with the exception of week 9). You are encouraged to refer to the Lesson Plan on VLE for the corresponding teaching material.

FYI, I am attaching again (see below) a schematic view and explanations of the resources that are available each week and accessible through the Lesson Plan.

Have a great weekend ahead.
Best wishes,
Alberto

Video Lecture covering the theory part for the week (video + corresponding slides)

Application of the theory will be discussed in class as a case study

The tutorial exercise will be conducted in the computer room. The same material is used by all the groups.

Week 11 arrangements

Dear EN2102 students,

The topic of next week (week 11) is non-linear regression with more than one variable. We will see a practical application by discussing a case study in our lecture on Monday in the field of the analysis of biomarkers. As usual, the theory is covered in the video lecture that you can find on VLE. Please find some time to watch the video lecture before attending the class on Monday.

I have also made available a non-graded Moodle self-assessment test that you can take at any time (from now to the end of the course) to test your understanding of the topics of week 11. You are allowed unlimited number of attempts.

Please let me know if anything is unclear.

Have a great weekend ahead.
Best wishes,
Alberto
Addressing the critical issue: (small) rewards system
Addressing the critical issue: formative assessment questions

Database of 50 questions:

- Divided by topics
- Made available weekly
- Non-graded, auto-marked by IVLE
- Unlimited number of attempts

**Problem 1:**
Given the equation
\[
\frac{dC}{dt} = a + bt
\]
Find \(a\) and \(b\) that best approximate the experimental data.

**Problem 2:**
Given the equation
\[
\frac{dC}{dt} = aC + b \log C
\]
Find \(a\) and \(b\) that best approximate the experimental data.

**Problem 3:**
Given the equation
\[
\frac{d^2C}{dt^2} = aC
\]
Find \(a\) that best approximate the experimental data.

**Solution with explanation**

Problem 1:
The ODE can easily be solved analytically.

\[
\frac{dC}{dt} = a \frac{t^3}{3} + b \frac{t^2}{2} + 1
\]

This is an equation that is linear in \(a\) and \(b\), hence linear regression can be used.

Problem 2:
Monitoring and measuring outcomes: survey

Total number of students: 97
Respondents: 70
Monitoring and measuring outcomes: survey

Total number of students: 97
Respondents: 70

Average Score

- Video Lectures Useful: 4.4
- Better than traditional framework: 4.2
- Self assessment quiz is useful: 4.0
- Self assessment helped in difficult topics: 4.0
- Rewards system enjoyable: 4.4
- Rewards system useful: 3.8

5 (strongly agree)
1 (strongly disagree)
Monitoring and measuring outcomes: did they watch the video lectures?

**Total number of students:** 97

**Estimated Average Class Attendance:** ~ 70%
Monitoring and measuring outcomes: possible impacts on learning*

Total number of students: 97
Monitoring and measuring outcomes: did they take the formative tests?

Formative Assessment

- Any time
- Before classroom session

% of students with at least one complete try

Total number of students: 97
Monitoring and measuring outcomes: possible impacts on learning*

**Raw exam marks for 3 questions**

- **Q6**
  - Students who took the self-assessment test: [bar chart data]
  - Students who did not take the self-assessment test: [bar chart data]
  - p = 0.010

- **Q7**
  - Students who took the self-assessment test: [bar chart data]
  - Students who did not take the self-assessment test: [bar chart data]
  - p < 1e-7

- **Q8**
  - Students who took the self-assessment test: [bar chart data]
  - Students who did not take the self-assessment test: [bar chart data]
  - p < 1e-3

*Average mark (% of total marks available for the question)*

Total number of students: 97
Monitoring and measuring outcomes: key issues

- Very difficult to measure impacts on learning with a reasonable degree of certainty
- Students who watched videos and took self-assessment tests are more diligent and would probably have performed better regardless
Final considerations

- Presence of video lectures and self-assessment questions overall positive

- Open issue: is the actual utility of blended learning overestimated? Are we helping students who would learn well anyway?

- Learning Analytics may play an important role moving towards evaluating impacts on learning and decision-making
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