

Benefits and Difficulties of Teaching Mathematics through Problem Solving

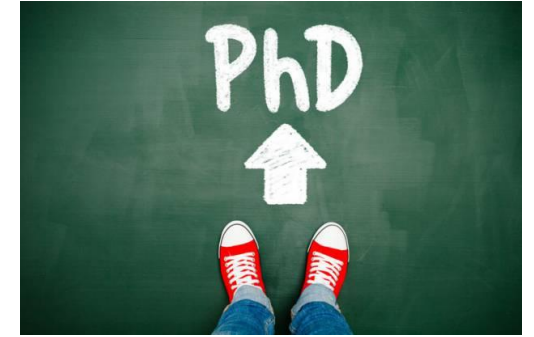


“It is not so very important for a person to learn facts. For that he does not really need a college. He can learn them from books. The value of an education is a liberal arts college is not learning of many facts but the training of the mind to think something that cannot be learned from textbooks.”

—Albert Einstein

Data modelling projects

1. Open-ended projects



2. Team work (work in small groups of 4-5 people)



3. Students are only slightly guided in the right direction



Data modelling projects

What is the best way to arrange parking?



What is the best way to arrange static solar panels?



Data modelling projects

Propose a realistic model to predict the performance of a football team in a given tournament.

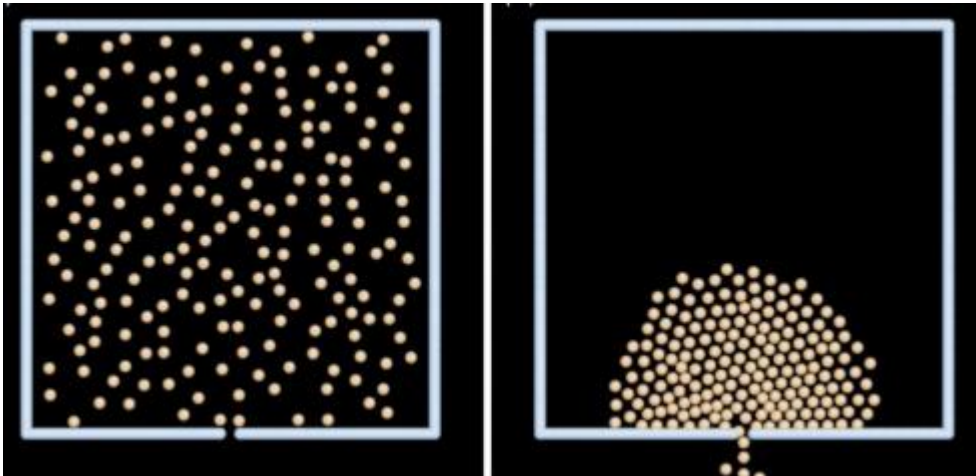


Propose a realistic model for the turnover of different types of cakes or products in the cafeteria.



Data modelling projects

Propose an evacuation schedule/algorithm in order to minimise the time taken to evacuate people.



Artificial lakes can be used to produce clean energy. Propose a differential equation to describe the amount water in a reservoir as a function of time.



Data modelling projects

Students benefit in the following ways:

- Seek out relevant knowledge and work out a strategy
- Try out both synthetic and analytical approaches
- Are prepared to take risks
- Tolerate frustration and try a completely different approach if necessary
- Present and defend their solutions
- Admit several different solutions
- Group work (the experience and social skills)

Data modelling projects

Difficulties from a lecturer's perspective

- Very time consuming
 - coming with a good problem
 - organising group sessions
 - marking
- Difficult to assess objectively
- It is NOT the same as giving a lecture
 - *'completely' open-ended projects* require knowledge across a broad range of disciplines: physics, calculus, discrete maths, AI, programming, statistics etc.
 - *open-ended project within a particular domain* require an intuitive and deep understanding of the subject

Data modelling projects

Difficulties from a student's perspective:

- Interpreting word problems
- Variety of possible solutions and approaches
- Minimal assistance is provided
- Group work is involved
- ...

Teaching maths units through problem solving

Classical disciplines in mathematics

Calculus

Theoretical Mechanics

Discrete Mathematics

Statistics

Algebra

...

...normally assessed only by exam-type questions

In the exam-based assessment students often request examples, either worked out so as to serve as templates for passing an exam.

Do students get any conceptual understanding of the classical maths subjects?

Teaching maths units through problem solving

New Applied Statistics module

- 50% exam-type questions
- 50% open-ended tasks as a coursework (e.g., investigating advantages and disadvantages of using bootstrapping methods for various data samples, using Monte Carlo simulations to perform statistical sampling experiments etc.)

I attempted to estimate the population parameter through the various bootstrap methods explored in the lectures. Overall there was a large variability in the resulting confidence intervals produced, these have been outlined below.

$$30.38 < \mu < 185.75 \quad \text{Percentile Method} \quad (6)$$

$$-113.76 < \mu < 174.35 \quad \text{Studentized Method} \quad (7)$$

$$15.76 < \mu < 178.54 \quad \text{Normal Approximated Method} \quad (8)$$

...

In this case I feel that the *percentile* method gives the more accurate result given the sample, as it does not inherently assume an underlying symmetric distribution, and can therefore lend itself better to parameter estimation when the skewness is present.

Teaching maths units through problem solving

Theoretical Mechanics (a possible approach)

- 50% exam-type questions
- 50% open-ended tasks (e.g., providing computer simulations for different types of pendulums).

