Enhancing learning of fluid mechanics using automated feedback and by engaging students as partners

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Agenda

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The FLUIDS project

Feedback for Learning Using Independent Directed Study

Funded by a Santander 100 teaching and learning scholarship

“There are known knowns; there are things we know that we know. There are known unknowns; that is to say there are things that, we now know we don't know. But there are also unknown unknowns – there are things we do not know we don't know”

Donald Rumsfelft 2002
A thirteenth-century Persian poet, Ibn Yamin said there are four types of men:

1. One who knows and knows that he knows... His horse of wisdom will reach the skies.
2. One who knows, but doesn't know that he knows... He is fast asleep, so you should wake him up!
3. One who doesn't know, but knows that he doesn't know... His limping mule will eventually get him home.
4. One who doesn't know and doesn't know that he doesn't know... He will be eternally lost in his hopeless oblivion!

How do we make sure our students are not number 4

In any new field of study, we cannot know what is out there to be known, so we have no way of understanding what threshold concepts might be important.

Fluid mechanics is a topic that has not been covered on any A-level syllabus and contains new threshold concepts.

A way needs to be found to start to improve student’s self knowledge – is this the main role of Feedback?

With many questions, and many students, automated feedback using the VLE is the only real option.
Much of the real learning will take place outside of class time

Self-Evaluation and Reflection are vital

This project aims to give students tools for self reflection

To start to understand what they do and do not know
3 Phases of Implementation

1. Benchmarking Fluid Mechanics Teaching
   • Web-based research and Staff interviews
   • To determine custom and practice for independent learning activities

2. Creating new independent learning activities with students as partners
   • A range of activities including automated prompts and feedback

3. Implementation in a level 4 module
   • Activities provided using the VLE
   • Evaluation of module performance and student experience
Online benchmarking undertaken to see how fluid mechanics is covered on other Mechanical Engineering degrees.

Mechanical Engineering at Ulster has a similar balance to courses at Sunderland, Dundee and Edinburgh Napier, but has fewer credits of mechanical science than Strathclyde or Huddersfield.

In terms of Fluid mechanics specifically, Mechanical Engineering at Ulster is at the lower end of sampled degrees in terms of the number of credits studied.
Phase 1: Benchmarking

- Interviews were carried out with staff at Strathclyde and Edinburgh Napier Universities. Both use traditional weekly tutorial activities or extension notes for independent study. Both reported that students did not always fully engage with these activities.

Strategies to improve engagement:

1. Build tutorial activities into a coursework project.
2. Use timetabled sessions for completion of tutorial activities.
Independent learning activities

1. Multiple Choice Quizzes (MCQs)
   Each week, students answer 3 or 4 concept questions, based on what they have learned to date
   Attempting the MCQs allows them to access next week’s VLE resources

2. Richer Independent Study Activities
   Engagement with traditional tutorial sheets is inconsistent
   By delivering online automated feedback, it was hoped that improved learning and engagement would result.
   These activities were prepared using students as partners

3. Tutorial Sheets
   Students still have weekly tutorial sheets that allow them to practice questions in class sessions
Phase 2: Students as Partners

- Student volunteers prepared new learning activities for a level 4 module
  - Four students from level 5 and four from level 6
  - Two different types of activities,
    1. Elaborative Interrogation (EI)
    2. Practice Questions (PQ)
- Elaborative Interrogation
  - The student reads a passage and is prompted to ask “why” questions.
- Practice Questions
  - These questions reinforce the week’s topic and give some automated feedback.
Elaborative Interrogation

What is the most effective way to teach learners scientific concepts? Much of what we know about this issue is based on research that focuses on acquisition of factual information (e.g., Martin & Pressley, 1991). Certainly this is one aspect of learning about scientific concepts, but it is by no means the only aspect of acquiring scientific concepts. As many educational psychologists have noted, a main objective in learning is to be able to go beyond the particular facts stated and use the conceptual information in new ways and in new contexts. That is, it is important to teach about the scientific concept in such a way as to facilitate inferential thinking (e.g., Mayer & Gallini, 1990). (Indeed, it may be that this kind of deep understanding of concepts is a pre-requisite for creative thinking; see Donnelly, 1995.) In this article, one of our main objectives is to explore and identify learning techniques that foster inferential thinking with newly acquired scientific concepts.

McDaniel and Donnelly, 1996
Partner student feedback

“Students can steer the lecturer in the right direction”
“I found (elaborative interrogation) very beneficial and use it in my own studies”
“I like the stop start approach, checking your own answers”

Results:
Year 2 student partners fluid mechanics marks increased from 50% in year 1 to 62% in year 2. The average for all students went from 54% to 47%
Year 4 student partners fluid mechanics marks increased from 59% to 86% (class average increased from 46% to 71%)
Multiple choice quizzes

Consider two identical spherical balls submerged in water at different depths. Which of the following statements is TRUE

- The buoyant force on both balls will be the same
- The buoyant force will be higher for the ball nearest the surface
- The buoyant force will be highest for the ball submerged deepest
- It is impossible to tell without further information

Selected Answer: ✗ The buoyant force will be higher for the ball nearest the surface
Correct Answer: ✓ The buoyant force will be highest for the ball submerged deepest
Elaborative Interrogation

Students read a given short text (~1 page)

1.4.1 Density

The *density* of a fluid, designated by the Greek symbol \( \rho \) (rho), is defined as its mass per unit volume. Density is typically used to characterize the mass of a fluid system. In the BG system, \( \rho \) has units of slugs/ft\(^3\) and in SI the units are kg/m\(^3\).

The value of density can vary widely between different fluids, but for liquids, variations in pressure and temperature generally have only a small effect on the value of \( \rho \). The

Promoted with 3 or 4 “why” questions

**Why does the density of liquid water vary very little with an increase in temperature?**

After an answer is given, a “correct” answer is shown

In a liquid, water molecules are free to move around, but not to the same extent as in a gas. The kinetic energy increases as they are heated, but they remain close together, since the attractive forces in a liquid remain strong. It takes a very large amount of energy to get the molecules to move far enough apart to make a significant change in the density, and this is the transition between liquid and gas.
Practice Questions

These are very like traditional tutorial questions

Consider a 70 kg woman who has a total foot area of 400 cm$^2$. She wishes to walk on snow but the snow cannot withstand a pressure greater than 0.5 kPa. Determine the minimum size of the snowshoes needed (The area per shoe) to enable her to walk on the snow without sinking. Report your answer in cm$^2$

After an answer is given, a “correct” answer, or a prompt is shown

The weight of the walker is 70 kg x 9.81 m/s$^2$, this gives the force in Newtons. The area should then be calculated to ensure that the pressure (Force/Area) is 500 N/m$^2$. 
Results: Engagement

- MCQs had the highest engagement rates, each student using them an average of 5 times
- Elaborative interrogations were used 1.4 times
- Practice questions were used 1.0 times
Results: Module performance

- Engagement with online material is a better gauge of “engagement” than attendance
  Better predictor of module performance
- Mean module mark was 51.3%
Effect on performance

- Those who used MCQs 4 or fewer times averaged 42.5%, while those who used them 9 or more times averaged 64.8%. Those who used them between 5 and 8 times averaged 53.0%.

- Those who used EI activities at least 3 times averaged 54.8%, while those who used them fewer times averaged 50.8%.

- Those who used practice tests at least twice averaged 58.2%, compared with 49.2% for those who did not.
Linear regression model

Best model to predict the final mark includes:

• Mean semester 1 mark
• Engagement with MCQs,
• Engagement with EI activities
• Engagement with PQs activities

Adjusted $R^2$ of 0.56

$$Mark = -8.97 + 2.3(MCQ) + 0.88(PQ) + 0.95(EI) + 0.70(Avg\_Mark)$$
Students generally found the online independent study activities to be helpful

This module was rated as having the most helpful independent study activities by 57% of responders, compared with 26% for the next best module

Students would prefer personal feedback to automated feedback
Results: Experience

“It is clear what should be learned. EI technique is interesting and I believe it will be useful in helping me learn and connect different aspects of the course”

“The MCQ are in my opinion the most useful aspect of learning in this course”

“The MCQs were done very well, allowing me to attempt to answer them correctly. If I did not, this made me question why I went for the answers I did.”

“The EI activities are not to my taste”

“Remove the tests that allow you to access the content. They are annoying and failed to load for me sometimes”
Findings

The students who helped prepare resources all benefitted significantly, especially those who had just completed the level 4 module.

MCQs had much higher engagement than EI or PQ activities. These had an element of compulsion built in using conditional release of material.

Online engagement was a better predictor of module outcome than attendance.

Students liked the online activities, but would prefer personal feedback.
Three Deeper Questions

Engagement seems to be driven by assessment. How can we best engage students with deep understanding of core conceptual material?

Students prefer personal feedback to automated feedback. What variety of feedback is best for the development of self-reflection that defines independent learners?

Partner students benefitted more than any others in this project. How can we incorporate more “learning by teaching” type activities?
Thanks for Listening