Imperial College London

Automated feedback on maths homework: Rich, timely, personalised support

Peter Johnson, Phil Ramsden, Rob Chatley

Teachers of large classes cannot give adequate one-to-one tuition.

Technology can automate some ‘low-level’ teaching functions so that **contact time is quality time**.

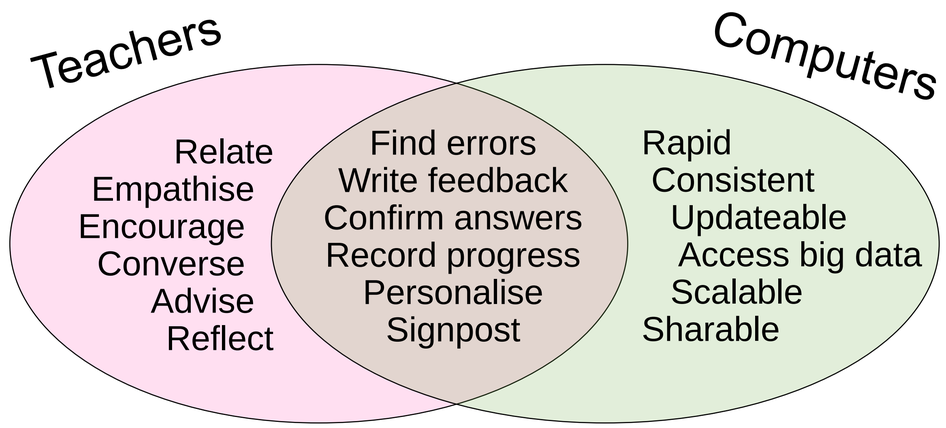
This project, funded by the College Digital Innovation Fund (DiF), is developing a software platform for automated feedback.

The long term goal is rich, personalised formative feedback at the time of doing homework.

What is good automated feedback?

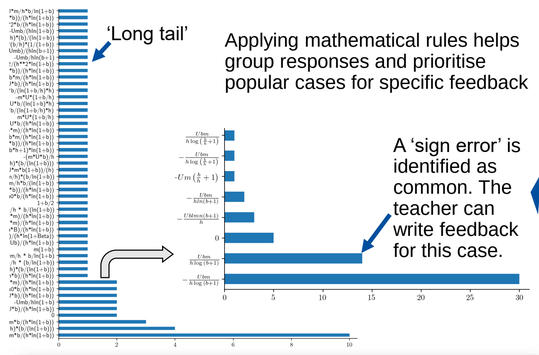
If a computer gives feedback to a student, the parameters are different to when a teacher gives feedback. We need to develop the art of constructive feedback when it is automated:

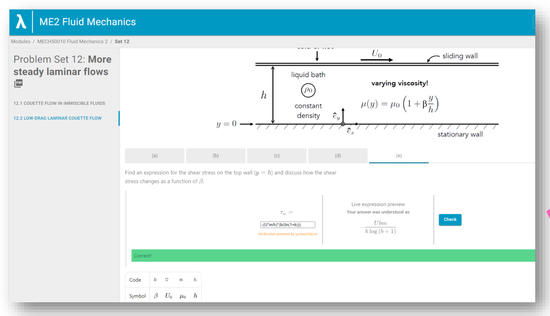
- is saying ‘good try’ an effective message if it’s automatic?
- when is it ethical to give advice automatically or even make a decision on behalf of a teacher (e.g. which exercise to do)?
- when should feedback include ‘hints’ or reveal other information that may, or may not, compromise the learning experience?
- how do people respond to mathematical and/or informal feedback when we know it was automated?
- what risks and opportunities are there to make automated feedback a force for bad/good? For example encouraging good *thinking* habits; being *inclusive*; building a community; achieving the graduate attributes.



Data-driven

Teachers develop feedback based on student responses, which often initially look very diverse.





Who decides?

Students and staff are providing input throughout the design of the software. This engagement helps prioritise. For example, autonomy is important. Content and feedback is curated by the teacher according to their pedagogy; students are in control of their experience according to their study preferences.

Software architecture

Data analytics

Data-driven development of automated feedback

Back end & database

Cloud native, secure, scalable, upgradable

Nest.js, GraphQL, AWS, PostgreSQL

Front end

Modern UI developed with student and staff partners

Next.js, typescript.

Evaluation functions

Independent, open source algorithms to evaluate student responses and provide rich, personalised, timely feedback.

Can be written in any computing language.

Rapid execution using ‘lambda’ functions.

Project timeline

2022 **Minimum Viable Product (MVP) deployed in January with 200 student users. Alpha product to be deployed in October with nine ‘pioneer’ academics.**

2023 **Deploy Beta product available across College.**

2024 **Deploy v1.0 across College and beyond.**

Prototypical problem

Factorise: $x^3 - 2x + 1$

How can an ‘evaluation function’ process a student response? This is partly a question of **specificity and sensitivity:** accurately identifying correctness or incorrectness of the student response.

This problem is more subtle than mathematical equivalence. For example, in the question given here, we could use the following computation to determine the correctness of a student response:

student_response == teacher_answer

The Boolean outcome (‘true’ or ‘false’) can be delivered to the student. However, this approach fails in at least two ways:

- if the student inputs the question itself (the unfactorised expression) – inaccurately evaluated as ‘correct’.
- If the student enters an answer which is essentially correct but contains a syntax error – inaccurately evaluated as ‘incorrect’

The evaluation function therefore requires a more sophisticated mathematical and computational approach.

Future developments

The platform will be a catalyst to develop positive and inclusive online communities of students and teachers. For example:

- students sharing their work, questions and answers
- feedback benefitting from large scale data and algorithms
- teachers sharing content, using it ‘a la carte’ in their teaching

Pioneer academics 2022:: J. Fenton (Physics), M. Ribera Vicent (Aero), M. Parkes (BioEng), M. van Reeuwijk, (Civil Eng), S. Cooke (Life Sciences), Idris Mohammed (Mech Eng), P. Ramsden (Maths), Peter Johnson (Mech Eng). Sam Cooper and Freddie Page (Dyson). The project is called ‘Lambda Feedback’ and is supported by ICT, FoE Ed Tech lab, EDU, and the Digital Innovation Fund (DiF). Contact: Peter Johnson peter.johnson@ic.ac.uk.