A technique for delivering individualised formative problems and examples

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Challenges of teaching STEM

• Diverse students
  – Background knowledge
  – Ability
  – Interest and engagement!

• Learning has to take place outside of the lecture which introduces the techniques.
Active learning

• Mathematics and Statistics particularly benefit from **active learning**.

• Students need to **do** maths and stats in order to
  – improve memory of problem solving techniques
  – develop expertise in identifying and applying techniques and interpreting results
  – gain confidence

• Regular formative problems are important.
The problem(s) with problems!

• How to pitch them at the right level?
  – Easy problems to help those who are struggling – but the better students switch off
  – Harder problems to challenge the better students – but the weaker ones give up trying

• We would like to provide an appropriate series of problems that get progressively harder for each topic ... and automate the decision regarding which level of difficulty is currently appropriate.
A possible solution … autoQs

• autoQs – a system (in Excel) for delivering problems in sequence *tailored* to a student’s level
  – Struggling? Try an easier question (with hints)
  – Doing well? Try more challenging questions
  – Build confidence and expertise until the topic is mastered to a sufficient level

• The level of the question to show is chosen by the program (depending on results so far).
The methodology behind autoQs

• A variation of the ‘3+3’ dose escalation procedure used in clinical trials.

• For us ... first...
  – Assign each question or example a difficulty level (a ‘dose’)
  – Each level needs at least 6 questions
  – Create up to five files containing relevant support material (general or question specific)
Our intra-student $3+3+1 \times k$ dose escalation design

- On first visit to difficulty (‘dose’) level $i$, deliver 3 questions
  - If 3 are sufficiently understood, escalate to level $i+1$
  - If 0 or 1 are sufficiently understood, de-escalate to level $i-1$
  - Else deliver 3 more questions for level $i$
Our intra-student $3+3+1 \times k$ dose escalation design

- After 6 questions have been attempted for difficulty level $i$
  - If 5 are sufficiently understood, escalate to level $i+1$
  - If 2 or 3 are sufficiently understood, de-escalate to level $i-1$
  - Else deliver 1 more question for level $i$ and re-evaluate (continue until user-defined de/escalation rule is passed)
Application 1 – statistics service course

- Second year module on “Statistics and Epidemiology for the Life Sciences”

- 80 questions on the chi-squared test of independence were produced – all with medical/health/nutrition focus

- 8 batches of 10 questions with different levels of difficulty
  - With expected values, with formulae, with hints, or no help and no table!
A demonstration ... 

- What the lecturer sees is a spreadsheet to enter filenames of pre-prepared materials.

- What the student sees is an Excel form which is the interface for delivering the questions and materials (depending on ability level).

- Let’s see ...
Application 2 – geometry option

- First year module on “Geometry”.
- Several revision questions on loci, parabolas, ellipses, hyperbolas.
- Focus here is not on bypassing questions through escalation of level, but on delivering every question per section ...
  ... and releasing support files in a sequential way.
- This requires a modification of the program.
A demonstration

• The student now has a “Hint” button to press, to enable the next support button in the list
  – Figure illustrating the problem (PDF)
  – Statement of the final answer (PDF)
  – Geogebra interactive file showing answer (GGB/HTML)
  – Partial solution (to act as a hint if stuck; PDF)
  – Full solution (PDF)

• Let’s see ...
Possible future directions

• The system is generic
  – Any image can be displayed on the left
  – Any five files (or fewer) can be accessed from the right

• To incorporate marking of questions, can use an existing system e.g. Maple TA
  – Image can display an ID code for one of several “mini-tests” in Maple TA
  – Support files on the right
  – “Percentage understanding” becomes “Record your mark”
In conclusion

• We believe that individualised sequences of formative problems will help guide students through their learning.

(We are awaiting feedback from students!)

• Although developed for mathematics and statistics, the Excel file can be used by anyone for any subject.

• Free to download from http://www.personal.reading.ac.uk/~sns99kla/
Thank you for listening

• Any questions?

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