Diversity Matters!
Proceedings of the European Distance and E-Learning Network 2017 Annual Conference
Jönköping, 13-16 June, 2017
ISBN 978-615-5511-18-9
ISSN: 2707-2819
doi: https://doi.org/10.38069/edenconf-2017-ac-0011

ADAPTIVE LEARNING AS A TOOL FOR SUPPORTING DIVERSE STUDENTS WITH THRESHOLD CONCEPTS AT A DISTANCE

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Overview

A key aspect of the learning experience for students is the need to consolidate and absorb what they are learning. To do so, they need space and time in their learning, and additional support to overcome any aspects of their learning that they find particularly challenging. A number of researchers have identified the idea that 'threshold concepts' exist across many subject areas which require students to make a transformative, irreversible and integrative step in their learning (Land & Meyer, 2010).

This paper concentrates on an example of a first level undergraduate engineering module and the challenges of teaching the key mathematical concepts needed to a diverse audience of engineering students with varying levels of mathematical ability.

The paper outlines how the project team went about identifying the threshold concept, planning an adaptive learning approach to supporting students and then talks about the findings from this initial work. We then go on to discuss how we are considering developing the approach for future cohorts of students.

Identifying the threshold concept

The diversity of mathematics skills in enrolling engineering students has been the focus of several studies (Bahr, 2011; Tolley et al., 2012).The academic team have supported students on a previous engineering module at The Open University meaning that they already had some good evidence on the areas of study that students struggled with, and undertook some additional analysis work with the tutors from this module to confirm these. As a result of this work, the team identified several areas of mathematical anxiety for engineering students that may represent threshold concepts including:

- rearranging equations;
- vectors;
- trigonometry;
- algebra;
- calculus.

Evidenced by poor understanding and performance during their second level study, as well as perceptions of tutors teaching at higher levels, it became clear that 'rearranging equations' was a key threshold concept that some students had never surmounted. In reviewing the findings,

the team settled on the concept of rearranging equations as being the key barrier for many level 1 engineering students.

Planning the support

Having identified the threshold concept, the team worked with the Technology Enhanced Learning department in the university to design paper prototype solutions that could support students with getting through this threshold.

The module design was already building in regular formative self-assessment opportunities for students to test and practice their maths knowledge and the teaching activities around this particular concept were again to be based on the use of three such formative online quizzes. Core to the approach was devising a hand-holding, supported design that enabled struggling students to draw on additional resources at key points to help with their understanding. This involved presenting resources that described and outlined the concepts using various types of approach, including visual on-screen tutorial clips. As these students are part-time distance learners, the design also sought to include the tutors at a key point to help any students who simply couldn't grasp the concept, despite having engaged with all of the supporting resources.

This process went through several iterations on paper to ensure that what was ultimately built was going to be practical for the students and tutors but also technically possible within the VLE systems available to the university.

The design

Having identified a workable solution, the next step taken was to produce a working prototype and to test this with real students. Two groups were invited in and provided with instructions to help them step through the quizzes.

Core to the design at this stage was a sequence of online quizzes consisting of 5-6 linear algebraic equations for the students to solve. The first quiz included straightforward equations based subject areas the students have already covered, and the subsequent quizzes carefully built up the complexity for the students; introducing powers and algebraic fractions. The aim being to (a) gently guide students through the process and build their confidence, and (b) to enable any support from a tutor to identify precisely which aspects of the concept the students struggled with.

Testing revealed that the fundamental approach to the design worked. Some of the testers were able to complete all three quizzes unaided, whilst 2-3 struggled at specific points in the quiz. What was also evident was that having three attempts at each question enabled them to work out where they had made a mistake and to correct it.

The challenge for the team at this point was to support the students with the 'syntax' required for answering the questions, and a decision was needed as to whether this would be a viable option in the live module. Supporting two small cohorts of testers with the syntax is

ISBN 978-615-5511-18-9

manageable, whereas supporting 1000+ students on a live module is a very different and more costly matter.

Final design

In resolving the student issues, the final product consisted of three multiple choice online quizzes with conditionality attached to prevent the students from moving onto the next quiz until they successfully completed the previous quiz. This basic model is outlined in Figure 1 below.

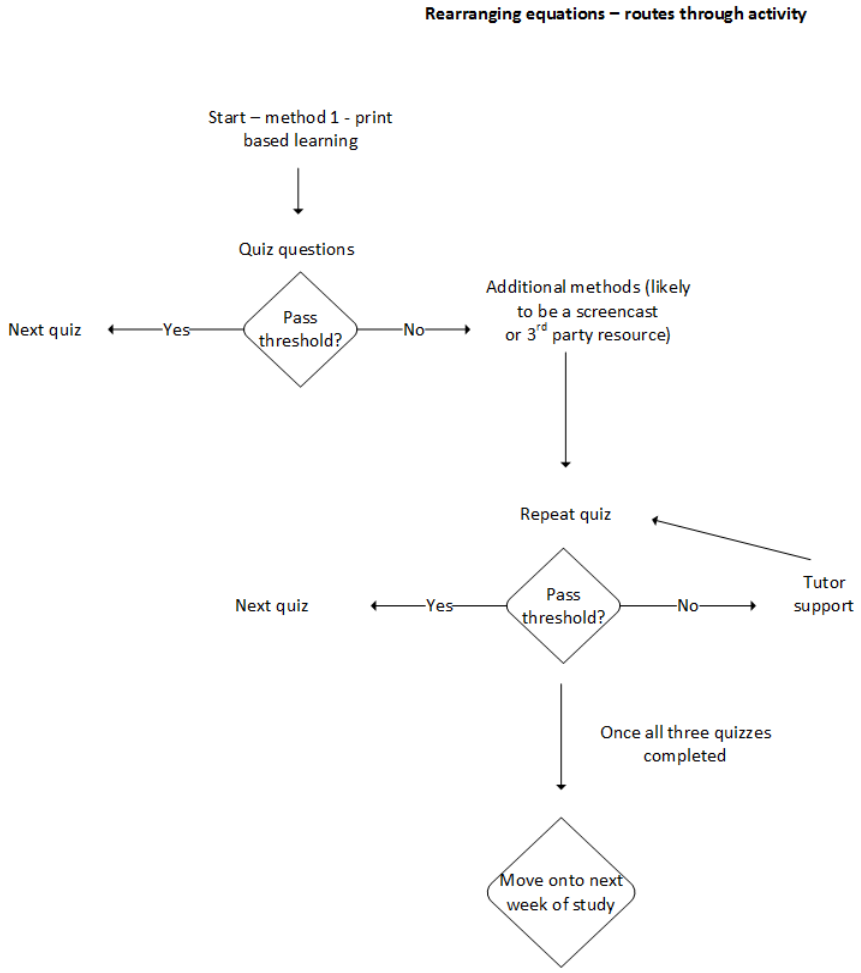

Figure 1. Pathway for adaptive learning content around rearranging equations

Students have three attempts to complete the quiz (with single attempts at each question), and after each attempt the system assesses their results. If they've passed they can move onto the next quiz, if they haven't they are steered to the relevant content for that attempt. So after attempts 1 and 2 this provides additional resources. Whereas after attempt 3 they are guided to the tutor to get additional support. The student's behaviour and performance is monitored by tutors during the process.

An example of the type of feedback provided to students is highlighted in Figure 2.

ISBN 978-615-5511-18-9

Where next? - 1st attempt

As you got less than four of the questions right on this quiz you need to look back over some of the materials provided earlier in the module.

Try looking back through section 3.2 of the Part 1 book and Study session 3.2 'Scientific models' and watch the tutorial clip on 'Rearranging equations in the form of a = b × c.' in week 3. There is also a video clip in the additional resources area of week 3.

Re-visit questions 1-8 of Week 3 Practice quiz and ensure you can work out each answer and the method used to do so.

Figure 2. Example of quiz feedback

Findings and reflections

This system worked and catered for the 1000 students on this cohort with no apparent technical problems, so the solution is a scalable one that we can apply and develop at scale. In total, we found that 500+ students attempted the quizzes, and the quiz was followed by an intervention from their tutor to discuss performance and give, when required, additional focused support.

The next steps

Having successfully delivered this model for the first presentation of the module, we are keen to see another cohort go through it in this year before reviewing all of the data and anecdotal evidence ahead of making changes for the next year of study which starts in October 2017. These are likely to include a wider range of equations being available in the quiz.

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ISBN 978-615-5511-18-9