PTAS Project Report (for REGULAR PROJECT GRANTS)

Project Title: Supporting transition to university mathematics with blended learning

Project type (delete as appropriate) :
A Research Project (research focus on particular dimension of teaching, learning, assessment)

Principal Investigator : Richard Gratwick
Schools/department : Mathematics

Team members (including Schools and Departments) : Toby Bailey, Ruth Forrester, George Kinnear, Grace Sansom, (all School of Mathematics) Anna Wood (Moray House/School of Physics)

For further details, please contact: Richard Gratwick

Project teams must submit a report within 4 months of the conclusion of their project.
Copies of dissemination material (eg journals/newsletter articles, conference papers, posters should be listed and attached (separate to the word count). The brief report will be published on the IAD web pages.

Report (maximum 1500 words)

What did you do?

We used both qualitative and quantitative methods to investigate the impact of an online course in introductory university mathematics, “Fundamentals of Algebra and Calculus” (FAC), which was first delivered in 2018-2019. The course was introduced to provide better support for incoming students with a range of mathematical backgrounds, in particular those students with entry qualifications below those of most of their peers (e.g. without qualifications in Advanced Higher Mathematics or A-Level Further Mathematics). The availability of the course is relevant to the University Widening Participation Strategy in two ways. First, it enables access to university mathematics for a wider range of incoming students – due to contextual admissions, students from a Widening Participation background may be admitted with lower entry grades than their peers. Second, the course provides additional academic skills support to students with skills gaps on entry.

We considered what impact the course had on students’ performance in mathematics, and on students’ attitudes to and perceptions of mathematics. We also investigated students’ experiences of and responses to various aspects of the course design. The course is delivered (almost) entirely online, with short blocks of expository text, worked examples, interactive diagrams, and concise video clips embedded within a sequence of exercises and questions. The course design draws on a variety of ideas and evidence from cognitive science and education research.

We examined the possible impact on performance in two ways. First we compared students’ scores on a pre- and post-test, the School of Mathematics Diagnostic Test. This was administered

before the start of semester 1 (the semester in which FAC is delivered), and then again at the beginning of semester 2. Second, we considered results in two other first-year mathematics courses, on which were enrolled both students who took FAC and students who did not.

We implemented another pre- and post-test, the Mathematics Attitudes and Perceptions Survey (MAPS), to investigate quantitatively what effect FAC had on students' beliefs about and attitudes to mathematics. This measures how close respondents' answers are to a consensus of "expert-like" opinions about mathematics.

Finally we conducted group and individual interviews with FAC students, a number of which were identified as being in a Widening Participation category, with two purposes: to pursue in greater depth questions raised in MAPS, and to gather responses from students about the design of the course. Students were asked about their study approach, their experiences of studying online, their interactions with others during the course, and the design of the course including the feedback and assessment regime. These sessions were recorded, transcribed, and subjected to thematic analysis.

What did you find out?

The most striking result is that FAC seems to eliminate an apparent attainment gap. The 2018-2019 FAC cohort performed on average 14 percentage points lower than their peers not enrolled on FAC on the first Diagnostic Test (a natural consequence of FAC students typically comprising those with lower entry qualifications). In the second Diagnostic Test, this discrepancy had been eradicated, and FAC and non-FAC students performed alike. There is no apparent difference in outcomes between FAC and non-FAC students in the other two first-year mathematics courses that we considered.

While full analysis of the MAPS data remains underway, initial results indicate little evidence of any impact of FAC on attitudes to and perceptions of mathematics. Moreover the whole cohort underwent little change in most categories across the first semester, except for slight negative changes (i.e. moves away from expert-like opinions) in the general categories of interest and confidence in the subject. The interview data indicate, however, that FAC had beneficial consequences for students' persistence with and confidence in mathematics, both within the course and beyond, in other courses at university.

The interviews also provided rich data about students' experience of the course. Most students interviewed found the course beneficial and would recommend it to others. Some, however, raised difficulties related to the design of the course. First, students perceived the course to have a high workload – but this may indeed be largely a matter of perception (FAC students were new to university). Nonetheless, this led to some students adopting a strategic approach to the course which we termed "gaming the system", whereby they exploited the online delivery and automated assessment to work through the materials only highly selectively, and access worked solutions to questions without first attempting them. Such an approach also seemed to be promoted by a sense of frustration deriving from the specifications (or mastery) grading system used. This grading system imposed unusually high pass marks on weekly tests, the student's combined success in which determined the assessment outcome of the course. Since the automated assessment system did not routinely award partial marks for correct working (as would be done in traditional paper-based assessments), repeated minor slips could seriously affect a student's overall grade. On the other hand, this grading system also seemed to encourage good study habits, since students reported taking greater care over their work and investing time in pursuing

greater understanding. While some reported feelings of isolation, students largely appreciated the flexibility of studying online, allowing them to study at times and places of their choice. This was mentioned of being of particular benefit to students with personal situations (e.g. illness) that would otherwise limit their ability to engage with their studies.

How did you disseminate your findings?

Talks

Gratwick, R., An online course promoting wider access to university mathematics, British Society for Research into Learning Mathematics Spring Conference, University of Cambridge, 7 March 2020.
Kinnear, G., Using quizzes to develop a course online, Teaching and Learning Mathematics Online Workshop, 2 June 2020, link: https://www.youtube.com/watch?v=SG_bUd0ql-s.
Kinnear, G., Teaching mathematics online with STACK, Seminar, University of Dundee, 4 June 2020.
Gratwick, R. and Wood, A. K., An online course promoting wider access to university mathematics, Learning and Teaching Conference, University of Edinburgh, 18 June 2020.
Gratwick, R., Using specifications grading in a fully online course, E-Assessment in Mathematical Sciences, 22 June 2020, link: https://www.youtube.com/watch?v=EcBjMf31fPE.
Kinnear, G., Teaching mathematics online with STACK, Seminar, University of Essex, 26 June 2020.

Publications

Gratwick, R., Kinnear, G., and Wood, A. K., An online course promoting wider access to university mathematics, in Marks, R. (ed), Proceedings of the British Society for Research into Learning Mathematics 40 (1), March 2020.
Kinnear, G., Wood, A. K., and Gratwick R., Designing an online course to support transition to university mathematics, submitted, April 2021.

A further article is in preparation.

What have been the benefits to student learning?

The project has contributed a wide-ranging evaluation of an online mathematics course, providing us with data of its effectiveness in terms of attainment, change in attitudes to the subject, and student experience.

We have statistical evidence that FAC eliminates an attainment gap. Thus in that sense, the course appears to be having precisely the desired effect, and we can confidently promote the course across the entire university as a valuable resource for students studying programmes for which mathematics is useful, but who may lack higher entry qualifications in the subject.

The outcomes of the project helped identify some concerns that could be addressed in the design and delivery of the course, enabling us to make precise and targeted changes. The concerns over apparent high workload and the reporting of some students that they are indeed working much longer than expected indicate that proper ongoing oversight from academic staff is needed for online courses such as FAC, to help monitor students who may be struggling. Furthermore, clearer and stronger messaging upfront has been included about the expected workload. We have

been able to introduce the awarding of partial credit in some questions, by splitting tasks into subparts (where pedagogically appropriate - in some cases one of the skills being tested is that of being able to devise and carry out a solution involving several subtasks) and also building into the online assessment checks for “errors carried forward”. This is an ongoing process as the course materials are refined. The adoption of the “gaming the system” approach indicates the importance of giving clear advice to students about effective study strategies. The responses to the online delivery have offered reassurance that this is a mode welcomed by students, and indeed this research has already helped inform the design of a new online course in the School.

How could these benefits be extended to other parts of the university?

We have demonstrated the effectiveness of a model of an online course which integrates a range of ideas from education research. None of the findings is overtly discipline-specific, or relevant only to undergraduate teaching. In particular many of the findings about the student experience of the course are not discipline-specific. The specific concerns about the limitations of electronic assessment are relevant to other scientific disciplines. The more general responses to the course design and delivery are relevant to any discipline in which a course might be delivered (almost) wholly online. This, the Covid-19 pandemic has taught us, is every discipline.

Financial statement (please delete as appropriate):

This project has utilised the funding awarded to it by the PTAS adjudication committee and the Principal Investigator or School Administrator appropriate can provide financial statements showing the funding usage as and when required by the UoE Development Trusts who may require it for auditing purposes.

Please send an electronic PDF copy of this report to:
Email: iad.teach@ed.ac.uk