Institution: Loughborough University

Unit of Assessment: C25 Education

a. Context

The Mathematics Education Centre (MEC) at Loughborough University was formed in 2002. Prior to this date there were a small number of individuals in the School of Mathematics undertaking educational research, with particular focus on the teaching and learning of mathematics in higher education, particularly the large cohorts of engineering undergraduates. In 2002, with the formation of the MEC, the University took a strategic decision to invest in and support this research, and thus a greatly expanded programme of research into the teaching and learning of mathematics began. In our two impact case studies we detail how this research led to significant national and international impact in the areas of university-wide mathematics support and the teaching and learning of mathematics for engineers.

During the assessment period the MEC has reorganised and broadened its research agenda, largely through a series of new appointments, including three staff on externally-funded research fellowships (both Royal Society Mathematics Education Research Fellows are based in the MEC). Indeed, six of the nine staff returned in our submission were appointed since 2008. These new appointments have led to an expansion of our research focus to include work which impacts upon the teaching and learning of mathematics at school level. Our research is conducted across two interest groups, focused on Culture, Pedagogy and Identity, and on Mathematical Cognition. As we demonstrate below, academics from both groups have successfully been encouraged to ensure that our research work has a measurable and positive impact upon mathematics learning in the UK and worldwide.

The three main groups of beneficiaries of the MEC's research are (i) mathematics students and lecturers at both UK and overseas HEIs, including students and lecturers from non-mathematical disciplines (notably engineering); (ii) teachers of mathematics at the school level; and (iii) educational policymakers. Our two impact case studies demonstrate the reach and significance our research has had on teachers, learners and policymakers at the higher education level, but with the increase in scale and scope of our research during the assessment period, we are already beginning to have significant impact upon teachers, learners and policymakers in pre-16 education as well.

We primarily impact upon education by researching and developing novel pedagogical practices, which have been widely adopted by UK and international HEIs, and by influencing policy debates. In the sections below, we describe our approach to facilitating impact from our research.

b. Approach to impact

Over the period of the REF 2014, research and enterprise activity has remained at the heart of Loughborough University's strategic plan "Towards 2016". Increasingly enterprise, defined by the University as the creation of "social, cultural and economic impact through knowledge exchange", is recognised as a core strand of the University's mission alongside research and teaching. The MEC has been proactive in engaging with the research and enterprise agendas. In particular, we document below how staff in the Centre have worked to develop mechanisms for engaging with (a) students and teachers of mathematics in HE; (b) teachers of mathematics at the school level; and (c) educational policymakers.

Approach to Impact: Mathematics Students/Lecturers in HE. Within HE, the MEC actively encourages and rewards (through both the promotions system and our departmental workload model) staff who engage with mathematics lecturers and students to increase the impact of our research work. In 2012 Alcock was recognised for the quality of her work in this area by the Mathematical Association of America (MAA). In their citation for the 2012 Selden Prize, the MAA wrote "Dr. Alcock has done considerable work in translating research in undergraduate mathematics education for different audiences. With the support of the UK's Higher Education Academy, she has produced a book and a DVD designed to allow mathematicians to engage with research-based ideas. In 2013, Oxford University Press published her book *How to Study for a*

Mathematics Degree, which aims to use insights from research to inform and support students as they make the transition to advanced mathematics." (http://bit.ly/13TnGaI). Alcock's book was judged to be of such value that Oxford University Press requested that an adapted version – *How to Study as a Mathematics Major* – be written for the US market. In the nine months since publication (as of September 2013), 2298 copies of the book had been sold, representing approximately 1 sale for every 12 mathematics undergraduates in UK HEIs.

The MEC also organises and financially supports events through which HE practitioners can engage with our research. Since 2006 Croft has co-organised the annual CETL-MSOR conference designed to be a forum for practicing mathematics lecturers to engage with educational research and scholarship. This has attracted over 100 delegates annually during the assessment period, and provides an ideal venue not only to disseminate current research on undergraduate mathematics education to practitioners, but also to gather information about the challenges that practitioners face, thus informing our research agenda. As an example of the success of this approach, the St Andrews University Mathematics Support Centre was set up after a colleague attended a talk by Croft where he explained and evaluated the 'Loughborough Model' of mathematics support. The St Andrews centre led, in turn, to the establishment of the Scottish Mathematics Support Network. We have also developed research projects following engagement with practitioners at such events: our recent research on mathematical reading (Inglis & Alcock, 2012, *Journal for Research in Mathematics Education*) was initiated from a discussion about student difficulties with practitioners at a CETL-MSOR conference. The high value placed on the CETL-MSOR conference in the mathematics community is demonstrated by its continued success despite the end of the CETL programme, and recent reorganisations at the Higher Education Academy (HEA) that threatened its funding source.

In a similar vein, Robinson has co-organised four conferences organised by the European Society for Engineering Education (SEFI) and the Institute of Mathematics and its Applications designed to bring together educational researchers and lecturers involved in teaching mathematics to engineering students. Again, these activities have provided a valuable mechanism for disseminating our research (as well as research from the wider sector) to practitioners, and informs our research agenda. The MEC strongly encourages staff to present their research at such conferences, and provides funding to cover staff attendance costs; since 2008 there have been over 25 sessions at practitioner conferences where the MEC's work was reported.

Approach to Impact: Mathematics Teachers in Schools. At the school level, the MEC has considerably expanded its efforts to engage teachers and policymakers with its research in recent years. We publish a termly newsletter – *MEC Research Update* – to 123 local schools, which reports recent research conducted in the MEC and offers teachers the opportunity to engage with upcoming research projects (http://bit.ly/ZUafUm). Members of the MEC regularly publish work in publications designed to reach teachers (for example, the Association of Teachers of Mathematics's journal *Mathematics Teaching* has a circulation of 4000 teachers worldwide and has reported ongoing MEC research projects) which facilitates interactions that allow us both to influence practice and to be influenced by current teachers' concerns.

Approach to Impact: Policymakers. As well as engaging with teachers and students, we also actively encourage and reward staff who successfully seek out opportunities to engage with the policymaking process, for example through membership of committees which advise government. Jones is currently the only mathematics education researcher to sit on the Royal Society's *Vision for Science and Mathematics Education 5-19* Committee. Led by Professor Sir Martin Taylor FRS, this body seeks to "produce a vision for the future of science and mathematics education", with the aim of having substantial impact upon the UK government's education policy (http://royalsociety.org/education/policy/vision/). In 2011 Jones was invited to present his research work on novel assessment mechanisms to the Swedish National Agency for Education in Stockholm (the body which administers public education in Sweden). Both Inglis (in 2012) and Jones (in 2011) were invited to present their research findings to the Advisory Committee on Mathematics Education (ACME), a body set up by the mathematical community to influence the UK government's education policies. These activities help to ensure that our research work both informs, and is informed by, current policy developments.

c. Strategy and plans

We seek to build on our current strategy, set in 2010, for maximising the impact of our research work. The success of this strategy is evident by considering the impressive level of external income we have received for impact-generating activities during the assessment period. The total of £733k received since 2008 includes awards from the Further Mathematics Support Network (£156k), the HE STEM Programme (£85k), the Higher Education Academy (£15k), HEFCE (£1.1m), JISC (£180k) and the Royal Academy of Engineering (£11k).

Our specific goals for 2014-2020 are to:

- Increase current levels of external funding for impact-generating activities from the current average of £126k per year during the assessment period to £150k per year;
- Maintain and expand the scope of our networks of practitioners (e.g., **sigma** Network, MEC Research Update);
- Be involved in the organisation of at least one major practitioner conference per year (e.g. SEFI/IMA/CETL-MSOR);
- Develop our relationships with key external bodies by (a) encouraging more staff to engage with such groups; and (b) hosting joint events (specifically, we aim to host at least four externally-funded disciplinary seminars between 2014 and 2020).

In order to help reach these goals, we have implemented two important changes to policy. First, we have created the role of 'Enterprise Coordinator', which includes responsibility for (a) seeking out and publicising funding opportunities for impact-generation activities, (b) coordinating applications for enterprise funding within the department, (c) Centre representation on the School of Science's Enterprise Committee, and (d) liaising with the University's Enterprise Office.

Second, we have encouraged individual members of staff to proactively engage with the impact agenda by (a) providing recognition for enterprise activities on our departmental workload model and (b) taking account of impact in decisions about promotion (specifically, the School's Associate Dean for Enterprise sits on all promotion interview panels).

Progress towards these goals are regularly monitored by the MEC Management Group which reports to the School of Science Senior Management Team.

d. Relationship to case studies

The two Case Studies presented arose from research prior to the assessment period, and we have used them to inform the development of our approach. We believe that both case studies took similar, highly successful, pathways to impact. Two key features of both case studies were (1) the successful award of substantial external funding (from HEFCE in both cases) to develop research-based materials and pedagogic approaches, and (2) the development of substantial collaborative networks of practitioners committed to engaging with, using, and further developing these materials and approaches.

Staff were actively supported to achieve both (1) and (2) through time allocations and financial resources, and this approach continues to this day. For example, we are committed to funding staff to attend practitioner conferences (discussed above) where staff can develop collaborative links with practitioners in order to develop networks that will facilitate impact. The development of "MEC Research Update", a newsletter designed for local teachers, was explicitly designed to emulate the success of the **sigma** network at the HE level (see Case Study 2).