

Impact case study (REF3b)

Institution: University of Glasgow
Unit of Assessment: C25 - Education
Title of case study: Engineering the Future: Embedding Engineering in the Scottish Curriculum
1. Summary of the impact

Engineering is central to ensuring economic growth in the UK and making sure the country remains competitive in the global economy, yet there is a persistent lack of engagement with the subject in schools. Addressing this challenge, researchers at the University of Glasgow led a collaborative project to achieve sustainable educational change. Working with engineers at the Universities of Glasgow and Strathclyde – as well as with industrialists, teachers and policy-makers – they raised the profile of engineering within the Scottish school curriculum and embedded engineering in teaching and examination.

2. Underpinning research

Research has repeatedly demonstrated that young people have limited or distorted perceptions of engineering. While various causes have been identified, the absence of engineering from the school curriculum in Scotland has contributed to young people's ignorance and misunderstanding of engineering and the diverse career paths it offers. This has led to comparatively few highly qualified school leavers seeking to enter high-level engineering courses.

In order to address this educational issue in a sustainable way, researchers at the University of Glasgow and Strathclyde collaborated on *Engineering the Future* (EtF), a three-year research project funded by the Engineering and Physical Sciences Research Council (EPSRC) from 2006-2009 (extended to March 2010). The Glasgow team included staff from the School of Education: Louise Hayward, (1990-2010 Senior Lecturer; 2010- present Professor of Pedagogy Policy and Practice); George MacBride, Hon. Senior Research Fellow, (2006-present); Ernest Spencer, Hon. Senior Research Fellow, (2002-present); Dr. Nicki Hedge, Director of Learning Innovation (2007-present); as well as Professor C Bryce and colleagues from the Electronic and Electrical Engineering (EEE) Departments. Strathclyde's research team was led by Professors G. Hayward and I. Andonovic.

The researchers made a distinctive and unique contribution to this project based on their extensive previous research and consequent in-depth knowledge of Scottish education, including curriculum, assessment, organisation and structures, and policy formation. In particular, Hayward, Spencer and Hedge investigated how to effect sustainable change and transformations on the ground in the Scottish education system in their outputs in *Assessment in Education: Principles, Policy and Practice* (2005) and the *Curriculum Journal* (2010). This provided vital insights for the EtF project's research design, since a key aim was to explore ways to embed engineering within the school curriculum. This resulted in a model in which School of Education researchers worked collaboratively and formatively with policy communities, practitioners, other education institutions, international engineering corporations (e.g. Agilent, Thales) and local companies (e.g. Alba). Team members from the EEE Departments of the two Universities and from industry brought world-class engineering expertise to inform the engineering content of the project. Industrialists informed priorities in engineering education; in particular, the Agilent Foundation (USA) supported the development of more challenging learning experiences.

The research programme established three-year secondary school-university partnerships as a pilot study. These partnerships typically involved one or two teachers from the school Physics or Technology departments and up to three EEE lecturers. The partnerships identified suitable locations for engineering experiences within existing national curricular guidance and examination syllabuses; the partners then collaboratively developed innovative EEE activities for pupils.

The original sites involved in the pilot investigation included two university engineering departments and 10 schools – two from the private sector and eight from the public sector – spanning a range of communities. Once the research was underway colleagues from the Faculty of

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Engineering in the University of Edinburgh joined the project; subsequently a further eight secondary schools participated in the project, demonstrating its broad appeal.

The University of Glasgow research team designed and led the qualitative research to determine the outcomes of the project. A vast selection of data was gathered through a range of means including: questionnaires issued to secondary school pupils, university students, secondary school teachers, university staff and industrialists; interviews with all secondary school teachers and university staff involved; focus groups of secondary school pupils and university students; classroom observation in secondary school science classes; records of meetings of university and school staff; records of engagement and meetings, both formal and informal, with policy-makers; analysis of government policy documentation; and discussions during a series of invitation-only seminars.

From an early stage of its investigation, the research demonstrated that it was possible to develop challenging and motivating engineering experiences for secondary school learners, despite initial reservations amongst teachers. It confirmed that the formal inclusion of engineering in Scottish national curriculum guidance was essential if all learners were to have access to such experiences. It further determined that it was important to link engineering explicitly to both science and technology at all stages of primary and secondary education. The research confirmed that teachers would require access to different levels of support if they were to introduce engineering to classes. The findings clearly revealed that there was an almost total lack of curricular reference and guidance and resources for pupils and practitioners. There was thus a lack of consonance between Scottish Government policy statements and practice: government economic documents referred to the importance of engineering, for learning and for economic development, but did not carry this over into educational practice. The EtF research concluded that for engineering to contribute strongly to each pupil's learning and to economic development, there must be an explicit and detailed policy that embeds the subject and its associated skills into the education system.

As the research project developed, the academic team worked closely with the policy community to develop curriculum structures through which sustainable opportunities for engineering could be embedded. The team took part in formal consultation exercises and national initiatives, fed back and discussed in detail interim findings, and involved policy makers in the project management.

3. References to the research (indicative maximum of six references)

Hayward, L., and Hedge, Nicki (2005) *Travelling towards change in assessment: policy, practice and research in education*. Assessment in Education: Principles, Policy and Practice, 12 (1). 55-76. ISSN 0969-594X ([doi:10.1080/0969594042000333913](https://doi.org/10.1080/0969594042000333913)).

[Output published in Journal that operates rigorous peer review by referees of national and international standing].

Hayward, G., Hayward, L., Hedge, N., and Magill, J. (2010) *P3A: Promotion of Engineering through Creation of a Structured School-University Interface*. Project Report. EPSRC. [Available from HEI]

Hayward, L. and Spencer, E. (2010) The complexities of change: formative assessment in Scotland. *Curriculum Journal*, 21:2 pp161-177. ([doi:10.1080/09585176.2010.480827](https://doi.org/10.1080/09585176.2010.480827))

[Output published in an international peer-reviewed Journal that publishes original contributions to the study of curriculum, pedagogy and assessment]. **REF2**

MacBride, G., Hayward, E.L., Hayward, G., Spencer, E., Ekevall, E., Magill, J., Bryce, A.C., and Stimpson, B. (2010) *Engineering the future: embedding engineering permanently across the school-university interface*. Institute of Electrical and Electronics Engineers Transactions in Education, 53 (1). pp. 120-127. ISSN 0018-9359 ([doi:10.1109/TE.2009.2025368](https://doi.org/10.1109/TE.2009.2025368))

[Research Output published in an international Journal that operates rigorous peer-review].

4. Details of the impact (indicative maximum 750 words)**Incorporating engineering in education policy and school activities**

In order to embed ideas in the education system, the academic team worked with policy-makers to develop the policy implications of the research. Throughout the project and as its findings and recommendations were disseminated, the curriculum in Scotland was being reformed through the Curriculum for Excellence (CfE) programme. The project team recommended the formal inclusion of engineering in the curriculum and worked to ensure this through: discussions with politicians, including a visit by the Education Minister to an EtF presentation at the Scottish Learning Festival; discussions with senior civil servants responsible for curriculum policy; discussions with CfE subject development officers and with the Scottish Qualifications Authority (SQA) development officer; membership by officials responsible for CfE programme of the EtF Advisory Board; and policy-maker participation in EtF seminars. As a result the final definitive Curriculum for Excellence policy documentation and practitioner guidance explicitly recognises the value of engineering in school education, including [Building the Curriculum 1: The contribution of curriculum areas](#) and [Assessing progress and achievement in learning and technologies](#).

As part of the project team, Hayward and MacBride engaged with policy-makers on the implementation of strategies to ensure that the concepts and activities central to engineering are more than policy aspirations and are embedded in pupils' experiences. In 2010 the Scottish Government extended its commitment to improving science education to explicitly include engineering in the title of its new policy, *Science and Engineering 21 – Action Plan*. This made explicit references to the EtF findings, endorsed and adopted several of its recommendations and made commitments to build on the work of EtF. Michael Russell, Cabinet Secretary for Education, launched the Action Plan on 1 March 2010 in Balfron High School, one of the schools participating in the EtF research, against a background of EtF experiments and in the presence of the EtF research team. Scotland's Chief Scientific Advisor emphasised at the event: 'It's hugely important to our world-leading research base that we continue to attract our best young minds into science and engineering.'

Creation and development of Science, Technology, Engineering, and Maths (STEM) Central

The EtF project found that embedding engineering in schools requires teachers who are confident and informed about contemporary engineering. To that end, the Scottish Government's Action Plan committed Education Scotland to create [STEM Central](#). A one-stop website for STEM education in schools, STEM Central provides online resources for teachers to increase their awareness and support their teaching of engineering. The Action Plan specifically recommended that the outcomes of EtF be taken forward to address the need for practical support for teachers and learners. The Action Plan stipulated the need for: publication of 'support for staff' materials to illustrate engineering as a context for learning through the use of resources produced by *Engineering the Future* and others. Following discussions with Education Scotland, EtF researchers were invited to lead the academic team developing the proposal for this portal.

The researchers then participated in the advisory committee for STEM Central and one member was employed as project manager. The use of real-life examples to support learning in the sciences – a key EtF recommendation – was adopted as a central feature of STEM Central. Education Scotland staff have promoted STEM Central and provided cases studies of its use. The second report of the national Science and Engineering Education Advisory Group welcomed the contribution of STEM Central and recommended that Education Scotland continue to expand its focus.

The teaching resources developed within EtF were uploaded by Education Scotland into the Glow intranet, an online resource open to all teachers in Scottish schools, with a direct link to the project website. The materials made clear links to curricular documentation to ensure consistency with policy guidance that could be used immediately by teachers in their classrooms. For the brief period 01 December 2012 to 18 April 2013, the EtF website had 16,204 hits (4,608 unique hosts) and 7,627 downloads.

Extending the model into primary education

The Scottish Government commissioned Hayward, MacBride and Spencer, as part of the academic team, to extend the EtF model to primary schools and to develop engineering education materials for this age group. This has involved 50 primary teachers and 1100 pupils to date and has resulted in significant interim impacts, including:

- collaborative production of a range of teaching and support materials with primary schools
- collaborative production with engineers in industry and higher education of video materials to support engineering education in primary schools
- introduction to primary teachers of material developed in other collaborative research projects (e.g. FP7 Pollen and Fibonacci)
- building capacity to enable people to learn from one another: teachers working together and teachers and engineers working together.

A number of these materials have been adapted and uploaded to the Education Scotland STEM Central website for use by all teachers, and Education Scotland intends to expand the range of material available online.

Development in the Scottish Qualifications Authority (SQA) Qualifications

Close cooperation between secondary school, university and other education stakeholders ensured that project findings were incorporated in the school qualifications system. EtF findings emphasised the importance of research into real life issues in creating meaningful learning experiences in the sciences and technologies. EtF engaged with the SQA during its development processes and included SQA participation in its Advisory Board and in its seminars. As such, the research findings are reflected in a number of developments in SQA National Qualifications:

- the development of SQA Advanced Higher Physics Practical Investigations related to engineering, designed to be carried out in schools.
- the development of a model for SQA Advanced Higher Physics Practical Investigations in which candidates worked in a university where they used state-of-the-art electronic engineering material and drew on the expertise of the university.
- the development of a 'compressed' interdisciplinary course focusing on engineering and alternative energy through which candidates gained Intermediate 2 awards in Physics, Technological Studies and Economics in the time usually taken for two such courses.
- introduction of a 'Researching Physics' Unit in revised Physics Higher Arrangements.
- restructuring of National Qualifications (NQ) Technologies qualifications to provide a clear and explicit progression route in engineering from National 4 to Advanced Higher.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Influencing education policy

1. 'SCIENCE & ENGINEERING 21 - Action Plan for Education for the 21st Century' (see Workstream 2 on pg 6), available at: [Link](#)
2. EtF Project Advisory Board List and Board Meeting minutes and Project Seminar Presentations to show participation and engagement of civil servants from the Scottish Executive and education officers responsible for development of Curriculum for Excellence with the research. [Available from HEI]

Influencing SQA Qualifications

3. See Qualifications Development Officer, SQA, video and transcript discussing introduction of new Researching Physics Unit in the revised Higher Physics qualification. Available at: [Link](#)
4. EtF Project Seminar Delegate Lists and Final Reports that show engagement with the different stakeholders mentioned. [Available from HEI].
5. Response to EtF Conference from Her Majesty's Inspectorate of Education. [Available from HEI]
6. STEM Central website for example of resources produced by EtF Project Members: [Link](#)
7. In particular, see 'Sound', 'Games' and 'Rescue Vehicles' Learning Resources developed by the EtF Project Team Members, accessible through STEM Central Learning in Context at: [Link](#)