ENGINEERING PROFESSORS' COUNCIL

Children as Engineers: Paired Peer Mentors in Primary Schools

Final Report Summary July 2015

"I've really enjoyed this project because not only did I feel like I was teaching a class, I felt like I was teaching a generation".
Student Engineer

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SCU | science communication unit

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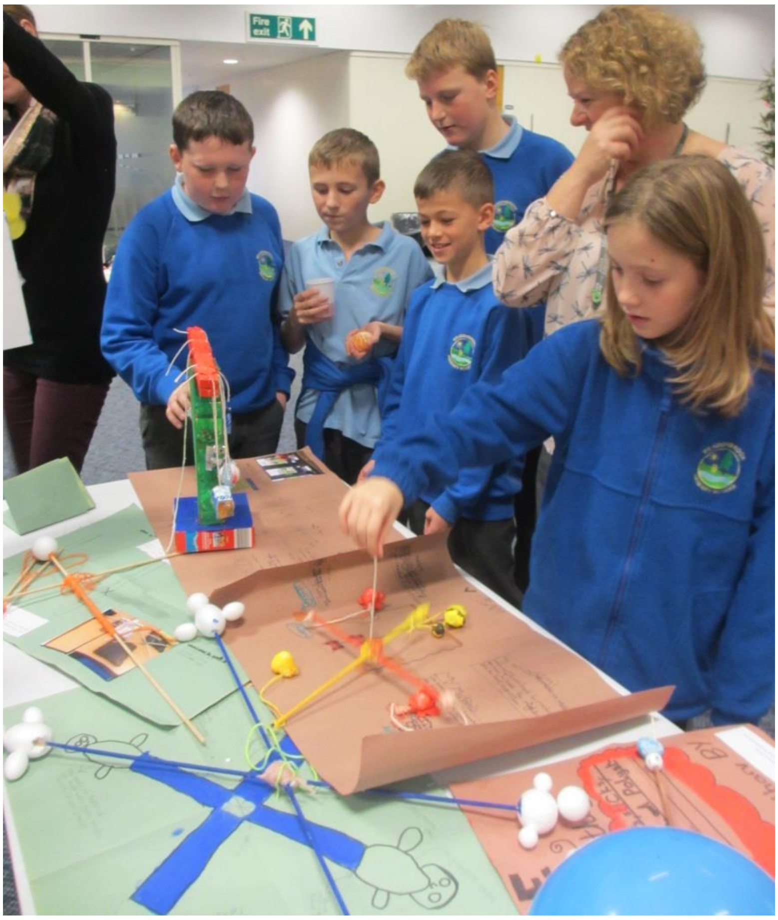


1. Executive Summary

This report describes and evaluates the Paired Peer Mentors project, which has enabled innovative engineering education outreach in primary schools. The project aimed to develop a model of collaborative, sustainable engineering education for Higher Education courses. By pairing pre-service teachers (undergraduate Initial Teacher Education) and student engineers (BEng and MEng), the partnership model aimed to improve the teachers' knowledge and self-efficacy for Science, Technology, Engineering and Mathematics (STEM) subjects, along with the student engineers' public engagement and communication skills. Through delivery into primary schools, the project aimed to improve attitudes and attainment in STEM subjects for young children, ultimately improving the age and gender mix of those participating in engineering.

Engineering as a career and industry is a key contributor to the UK's aims for an innovative knowledge economy (Perkins 2013). However, it is forecasted that a further 100,000 new professionals are needed to countenance a skills gap by 2020 and to increase gender and ethnic diversity in the profession (Royal Academy of Engineering 2012). As such, it is becoming increasingly important that student engineers gain opportunities to practise their public engagement and education outreach skills to influence public perceptions of engineering, and connect science with society (Research Councils UK 2010b; National Coordinating Centre for Public Engagement 2010).

Teachers are a key audience to engage with, as only 5% of primary school teachers have a science related degree (DfE, 2013). Although subject knowledge is not seen as essential for effective pedagogy, a lack of confidence and understanding can result in didactic, 'cautious' teaching (Bleicher & Lindgren, 2005; Neale, Smith & Johnson, 1990) which reduces pupils' performance, engagement and enjoyment with the subject (Ofsted, 2011). Children's attitudes at primary school influence later interest in science in general but also as a career; girls in particular make early value judgements (before aged 11) on the suitability of STEM as a future career choice (EngineeringUK, 2015; Jarvis & Pell, 2001; Murphy & Beggs, 2003). However, teachers who have positive dispositions and are enthusiastic about a subject engage in research based instructional strategies, seek out growth opportunities, stay current and create connections with the subject matter that are meaningful to students (Singh & Stoloff 2008).

In this project, student engineers and pre-service teachers were paired up to mentor each other and enact hands-on challenges designed to demonstrate the Engineering Design Process (EDP) to primary schoolchildren; these challenges were adapted from the European 7TH Framework project, 'brEaking New Ground IN the sciencE Education Realm (ENGINEER). The challenges were delivered over four weeks in 2014 and culminated in a Researching Conference between the project observers, student engineers, pre-service teachers, classroom teachers and the children. In total, eleven student engineers took part in the project, alongside ten pre-service teachers, and 269 Key Stage 2 children. A mixed methods evaluation of the project was conducted, using qualitative and quantitative measures both before and after the intervention to measure change over time for the three participant groups.

The project appeared to be successful on all levels for the different participant groups. The student engineers reviewed the project positively, rating it highly for enjoyment and for meeting their needs and expectations. Quantitatively the student engineers showed an improvement in their perceived level of skills, with a 42% improvement in the proportion who felt they were now 'fairly well equipped' to undertake public engagement; over two-thirds (64%) of the engineers gave this rating following the project. Additionally, 70% of the engineers indicated that they thought they are now likely to be 'more active' in public engagement. Qualitatively, the student engineers indicated that that they had learnt organisational and communication skills through taking part, and felt that they had passed on some of their science and engineering subject knowledge and enthusiasm to the teachers and children.

The paired peer partnership model was also positively reviewed by the pre-service teachers. Quantitative data indicated that the teachers showed significant increases in their science and engineering subject knowledge confidence levels as well as in teaching self-efficacy for both subjects. Prior research indicates that improvements in subject specific knowledge and self-efficacy to teach benefits teachers, their pupils and schools, and changes the teachers' attitudes towards their teaching practice. Indeed, 80% of the pre-service teachers who participated stated that they would undertake similar work with children in the future. Qualitative data indicated how the teachers had benefitted from the science and engineering subject knowledge of the engineers. Collaborating with an 'expert engineer' whilst working through the 'ENGINEER' materials appeared to open up dialogue for the teachers about not only the Engineering Design Process involved but also the science behind the project. Many teachers asserted that this 'expert' knowledge had also benefitted and influenced the pupils in their class.

Children who took part in the project had increased positive attitudes to the subjects of science and engineering in quantitative assessments. The project improved children's knowledge of what an engineer does and their attitudes towards the profession through greater information about engineering and the experience of real life role models. The data also indicated a slight positive shift in children's attitudes to science and engineering career aspirations along with gender and engineering identities. Self-perception of children's abilities in science has been identified as a contributing factor to both girls' and boys' choice of subjects later in their school career. Projects that raise interest, motivation and a feeling of achievement can only be a positive force in the drive to keep pupils in STEM subjects throughout education.

Several embedded elements of the project may have contributed to increasing participants' overall confidence, knowledge, and attitudes to science and engineering; peer support, social interaction, positive feedback from the children, increased security in subject knowledge, collaborative planning, use of materials, and engaging in reflective activities. While the results from the project are positive, there must remain a note of caution due to the low numbers involved; it may be that a longer-term programme and evaluation is needed to bring about significant and long-term change in engineers' and teachers' practical knowledge and self-efficacy. However, these findings need to be explored further to influence student curricula at Higher Education Institutions and in primary schools across the UK.

Recommendations:

- **Continue with the paired peer mentor model for undergraduate engineering and Initial Teacher Education in student curricula at the University of the West of England, Bristol.**
- **Explore how to integrate this model of public engagement training into other engineering and teaching undergraduate curricula in the UK.**
- **Develop a sustainable 'toolkit' and model for the project implementation across other HE Institutions.**
- **Further explore and refine the use of the ENGINEER materials and Paired Peer Model in schools around Bristol and across the UK.**

This project and report is indebted to the support and help of Dr Catherine Hobbs, Professor Penelope Harnett and Susan Hughes at the University of the West of England, Bristol.

2. Paired Peer Mentors Project Toolkit

2.1. Aims

This project aimed to develop a model of collaborative, sustainable engineering education for Higher Education (HE) courses. By pairing pre-service teachers (Initial Teacher Education – undergraduate teaching degrees) and student engineers (BEng and MEng), the aim was for the engineers to mentor and improve the teachers' knowledge and self-efficacy of STEM subjects, while the teachers would mentor and improve engineering students' public engagement and communication skills. Through delivery into primary schools, the project aimed to improve attitudes and attainment in STEM for young children, ultimately improving the age and gender mix of those participating in engineering. See Figure 1 for a visual representation of this process.

Aims for the engineers were to:

- Share their expert knowledge through collaboration with trainee teachers who may not have a science or engineering background, enabling improved future teaching of STEM.
- Develop creative activities that enable them to communicate in new ways (adapting complex specialist knowledge), and to reach new audiences in engineering public engagement (primary school communities).
- Deliver the engineering activities to a class of Key Stage 2 primary schoolchildren, gaining an understanding of the UK education context and curriculum needs which is essential for effective education outreach.

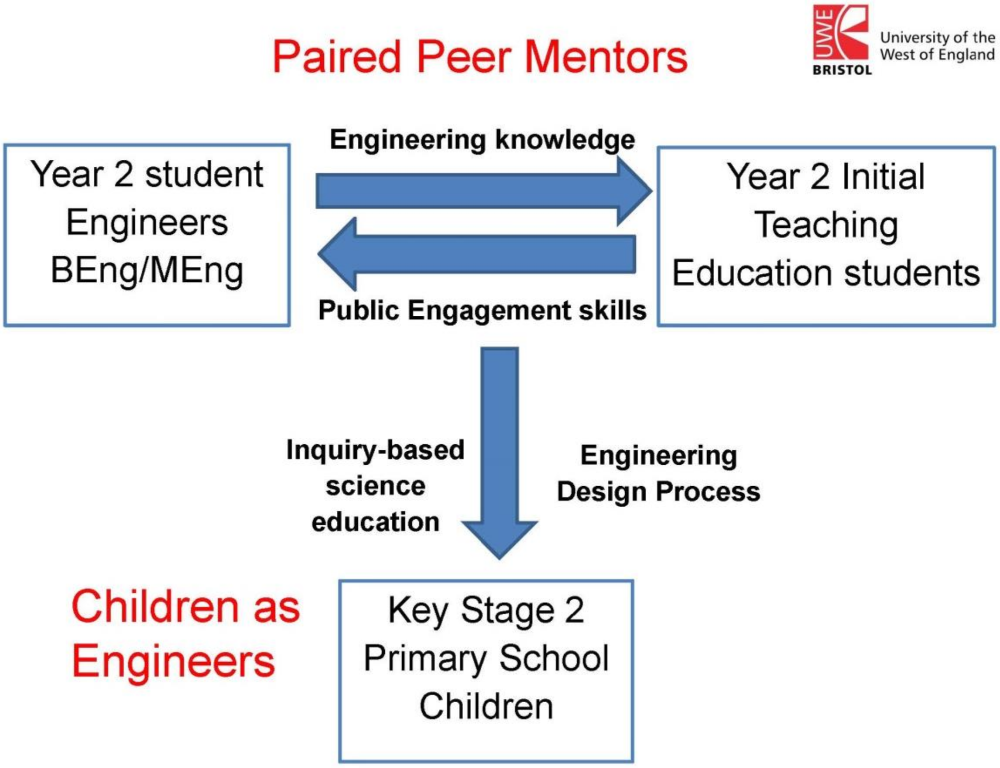
Aims for the teachers were to:

- Gain increased awareness, understanding and confidence in STEM subjects through working with the paired engineers, enabling future exciting and relevant learning opportunities in their professional classrooms.
- Develop creative activities to provide learning experiences in engineering, enriching the STEM curriculum.
- Deliver the engineering activities to a class of Key Stage 2 primary schoolchildren, and assess the learning needs and attainments of the children.
- Network and develop their skills, confidence and knowledge.

Aims for the school children were to:

- Reach four schools with ten classes of Key Stage 2 Pupils (aged 8-12), totalling around 250 children.
- Change attitudes and attainment in STEM and ultimately attract more young people, particularly girls/women, into engineering.

Figure 1: The Paired Peer Mentors Project.



2.2. Resources

The project focussed on developing a novel method to introduce the EU ENGINEER design challenges into the UK teaching curriculum. The materials are freely available to download from this website http://www.engineer-project.eu/download/index.html. The existing ENGINEER programme material was screened for modules which suited the skills of the student engineers at the University of the West of England, Bristol (UWE), while also appealing to primary school children at Key Stage 2. Five key modules were chosen, and the resources and teaching sheets were assembled by the project team.

- Balance and Force
- Electricity
- High Flyers
- Mechanics
- Sinking and Floating

The EU ENGINEER materials are designed to apply across all EU countries; however we found the worksheets to be very wordy and time-consuming for the UK curriculum. Care is therefore needed to reduce down the level of instruction performed in classrooms.

2.3. Student Recruitment and Training

Eleven Year 2 undergraduate student engineers and ten Year 2 pre-service teachers at the University of the West of England, Bristol (UWE) were recruited into the project. Notices were sent to all students in Year 2 of their courses, and short information seminars were given in lectures. Following recruitment, an afternoon training session was conducted by the project team, explaining the necessary project skills, and introducing the mentors to each other and the resources.

The student engineers received training in communication and public engagement, which aimed to improve their skills and self-efficacy to undertake education outreach. The pre-service teachers received training in the Engineering Design Process and the underlying science behind the ENGINEER modules. The students were then paired together and given time to understand and explore their particular ENGINEER module. Following feedback on the project through the evaluation, an adapted timetable for the project can be seen in Appendix A, while the training recruitment materials can be seen in Appendix B.

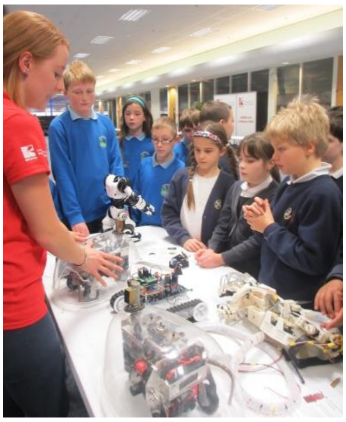
The collaborative 'paired peer' element was a significant factor in the success of this project and should therefore also be a factor in developing further models of this project. Peer coaching, such as that used within this study, may have a great impact as it discourages practitioners from working in isolation and instead encourages discussion (Van Driel et al, 2001). Collaborating with an 'expert engineer' whilst working through the ENGINEER materials appeared to open up dialogue for the pre-service teachers about not only the EDP involved but also the science behind the project. The student engineers also stated that they had benefitted from the organisation and communication skills of the teachers.

Permissions were given to take and share these photos.

2.4. Schools Outreach

Four local primary schools were recruited into the project through networks and contacts with UWE's Department of Education; this gave access to ten classes of primary school children in Years 5 and 6 with 269 children involved. The paired pre-service teachers and student engineers were given time to develop the materials during the training, and then requested to meet independently to plan out their lesson plans and teaching arrangements for the primary school visits.

The visits took place over three consecutive weeks, with 1.5 days spent in the classroom. The school work was observed by the project team and supervised by existing primary school teaching staff to inform the project. The school children and mentors worked towards presenting the results from their modules and engineering creations at a shared Researching Conference.



The final Researching Conference was held at UWE, and aimed to showcase research and cutting-edge engineering taking place in HE, particularly at UWE, thus exposing the children to a university environment. The conference also enabled feedback between pupils working in different schools at the end of the project. Pupils presented their project outcomes in the scientific conference format (poster, exhibition or table-top PowerPoint presentation), providing opportunities for them to communicate their understanding of the scientific process.

Their student mentors were also present to provide feedback and support the children through this process. Feedback from classroom teachers and the children indicated that meeting real university engineers and viewing cutting-edge engineering research projects was a valuable and attractive part of the project. A timetable for the Researching Conference can be seen in Appendix C.

Permissions were given to take and share these photos.

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4. Appendices

4.1. Appendix A: Timetable for the Paired Peers Project

The timelines and recruitment numbers are only suggested models based on the UWE project, and can be adapted according to the needs of the Higher Education Institution.

Timeline	Project	Resources
Month One	• Development of programme and selection of EU ENGINEER units • Preparation of public engagement and Engineering Design Process training • Recruitment and DBS checking of students • Recruitment of local primary schools	• EU ENGINEER units • 10 engineering students • 10 teaching students
Month Two	• Training in public engagement and Engineering Design Process training for students • Co-adaptation of case study materials by students • Assignment and communication with allocated primary schools	• ENGINEER materials

Month Three	• Delivery of hands-on practical challenges to schoolchildren over three weeks. If not integrated into the student curriculum the suggested timetable is for consecutive Wednesday afternoons.
	  ◦ Week one - one whole day of teaching
	  ◦ Week two - a break for children to work on their projects
	  ◦ Week three – preparation for conference presentation
		• Ten classes of Key Stage 2 children

Month Four	• Researching Conference for pupils, teachers and community of practice	• University outreach stands

4.1. Appendix B: Training Materials

University of the West of England
BRISTOL

engineer

‘Children as Engineers’
Project Training Afternoon

When:-

Where:-

Overview

The purpose of the afternoon will be to introduce you to the ‘ENGINEER’ materials and to enable you to meet your fellow students who you will be working with. You will have the opportunity to engage practically with one of the challenges that you will then take into school.

Programme of events

Part 1	Introductions, introduction to the project, project layout
Part 2	**ITE Students:** ‘Engineer in an Envelope’ activity and training on the engineering design process **Engineering Students**: Training on public engagement skills and how children learn.
Part 3	Project practicalities. Pairing of students and allocations to schools etc.
Part 4	Working together practically with paired peer on the ‘ENGINEER’ challenges http://www.engineer-project.eu/
Part 5	Risk assessments and working in schools

4.2. Appendix C: Researching Conference Timetable

The timetable presented here is only a suggested model based on the UWE project, and can be adapted according to the needs of the Higher Education Institution.

Time	Activity	Children		
1130am	Set-up			
1200pm	Children arrive	All		
1215pm	Culmination of project. Introduction to engineering at university, with interactive question and answers.	All		
1pm	Split into three activity groups. Rotate through the activities in half hour intervals.	*Observe* other children’s projects	*Explain* their own projects	*Explore* university projects
230pm	Finish activities	All		
245pm	Depart and pack down			