Open-Ended Project Work: Sharpening Students' Skills

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SUMMARY

WMG delivered and supported a group project for the Experience Warwick Summer School run by the Warwick Outreach and Widening Participation team. Each group was given the same set of equipment and minimal guidance towards what to create: they were provided with challenge cards to spark imagination but, after the first day, these cards were hardly used with students instead chasing their own inspiration. Participants were supported by University of Warwick student ambassadors and mentors from the WMG Graduate Programme and WMG research staff during the project. Ambassadors coached the students on team work while the WMG mentor helped with technical aspects and realising their imaginative ideas. A showcase, attended by teachers and families, included a smart city model, a radio-based game and several remote-controlled or line-following vehicles.

Two main outcomes from student self-reflections were discernible:

1. *The students self-reported an increase in engineering-related skills.*
2. *Students became more aware of current engineering research areas and the role that research has in shaping modern society.*

This was a successful pilot of a project-based programme of activities for year 10 students. In the summer of 2020 this project will be repeated for a new cohort of year 10 students but also expanded into a full, engineering-based work experience programme.

INTRODUCTION:

An outsider's perception of engineering may be different to reality. Students often have little idea of what an engineer is and no appreciation for the diversity of roles engineers can have (Royal Academy of Engineering, 2016). It is necessary to get students out of classrooms, away from textbooks, and to open their eyes to the many images of an engineer.

Having the opportunity to 'tinker' and explore materials outside of the classroom is an obvious point at which young people build their own engineering identity (Royal Academy of Engineering, 2018). This is obviously a challenge for students in areas of deprivation who might not be able to afford to buy kits and tools to experiment. This is before one considers the extra time burden on such students who might need to take an active role in care and labour around the home with parents potentially having additional or shift-based work.

We aimed to give students from widening participation backgrounds an opportunity to build an '*engineering identity*' by working with practical examples and showing their creations to their families. Only one in ten engineering undergraduate students in the UK are from the lowest quintile and only 24% of engineers are described as 'from a disadvantaged background' (Engineering UK, 2018). These underwhelming numbers clearly demonstrate the necessity of providing additional support to students from widening participation backgrounds: both to widen the talent pool available to recruiters but also to ensure that all young people have equivalent possibilities and opportunities, regardless of their geographical location.

LITERATURE REVIEW

Improving diversity in engineering should be a priority (House of Lords, 2012). Thankfully, an evidence base of 'what works' is growing (*e.g.* [Freeman, 2014]). Potential barriers have been highlighted such as a lack of 'science capital' (Archer 2015). Science capital can be built by access to science kits or experiments at home, conversations between adults and young people about STEM subjects and careers, or visiting a place of learning such as a university; all of these have proven links to aspiration and attainment (Archer 2012, 2015). Additionally, increasing science capital can lead to a snowball effect, wherein more capital can be accrued (Dawson 2014a and 2014b), which will only increase young people's ability and confidence within STEM subjects.

An additional barrier is the range of skills that are needed for engineering jobs (Nair 2009). Soft skills are often built through extra-curricular exercises which may feature advantaged students more prevalently. This creates an additional bias against students from disadvantaged areas and perhaps creates another 'leak in the pipeline'.

Further, once students are in an engineering job, Kumar *et al*. (2007) showed progression into senior positions is more likely if they were taught with innovative pedagogy, *e.g.* problem based learning. This is a key reminder that widening participation does not end at the university application stage: students should be supported throughout their careers to fix the 'leaky pipeline' and, to borrow a phrase from Dasgupta and Stout, "STEM the tide" (2014).

This activity was designed to utilise student voice and provide them with agency over their own work, similar to a previous project the author was involved with (YES for STEM, NERUPI Case Study, 2018) which used mentors to support students designing an outreach activity. It is expected that control over the direction of the project will enable the student to reflect upon their personal impact and, through creating something unique, they can envisage themselves as engineers.

CONTEXT: THE ENGINEERING EDUCATION PROBLEM AND INTERVENTION

To provide students an experience of engineering where they were free to explore in their own style at their own pace, we provided the equipment and tools and then encouraged the students to experiment with what they were interested in. Guidance was provided *via* a set of challenge cards (Figure 1) as a starting point. Mentors were provided to each group to assist with content points but were specifically trained to allow the students to explore without boundaries.

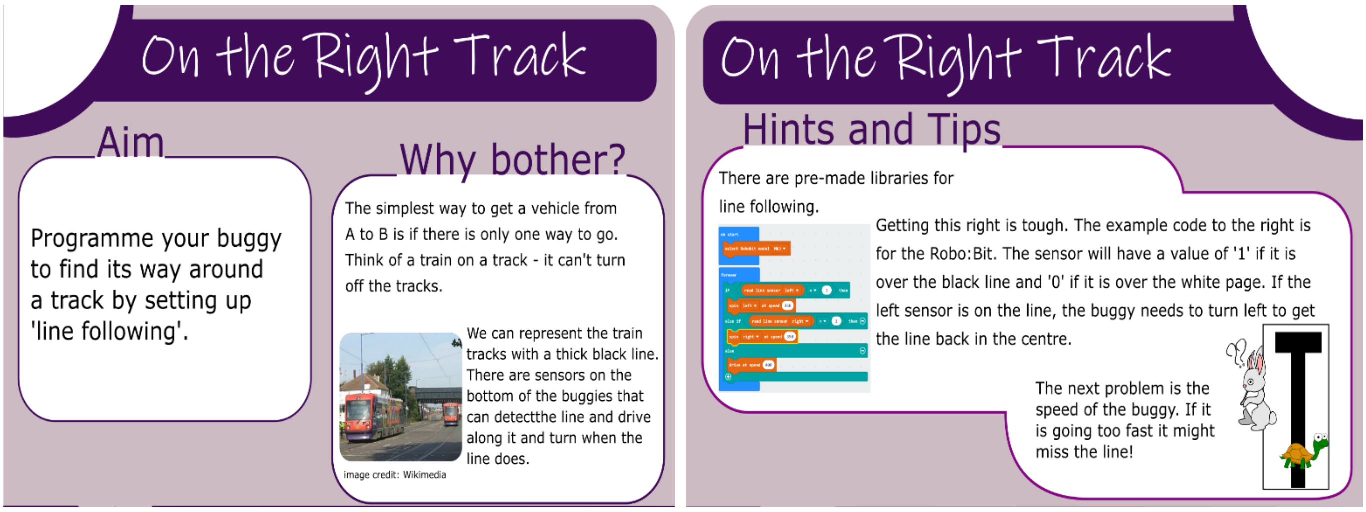


Figure 1: An example of one of the six challenge cards provided to the students.

DESCRIPTION OF INTERVENTION / PRACTICE

Thiry-nine Year 10 students were recruited by the Widening Participation team at the University of Warwick. These students were given accommodation on campus for three nights. The breakdown of Widening Participation indicators within the group is given in Table 1. POLAR (**P**articipation **Of** **L**ocal **Ar**eas) is a measure of the progression rate of a geographical area into Higher Education (HE). Students who live within the lowest two quintiles (Q1 and Q2) are less likely than average to progress into HE. None of the recruited students had parents who had been through HE.

Table 1: Widening Participation indicators in the cohort

Indicator	Number of students	% of group
POLAR4 Q1 or 2	25	64%
First generation in HE	39	100%
Female	24	62%

In total the students had 6 hours over three days to work on their projects. Seven groups of six students were all provided the same starting materials. These were laid out on tables in an identical way. An undergraduate student ambassador was with the group at all times and was responsible for all pastoral matters. Additionally a member of staff from WMG's graduate engineering scheme was placed within each group to assist with the development of the project; though they were instructed not to suggest what the students should work on.

On the first day the students were given an introduction to the work that WMG does and given a task to look for examples of engineering within pictures of the local area. On the second and third days of the project students worked on their projects. The event culminated in a showcase of the students' creations, attended by families and teachers. Examples of their work are shown in Figure 2.

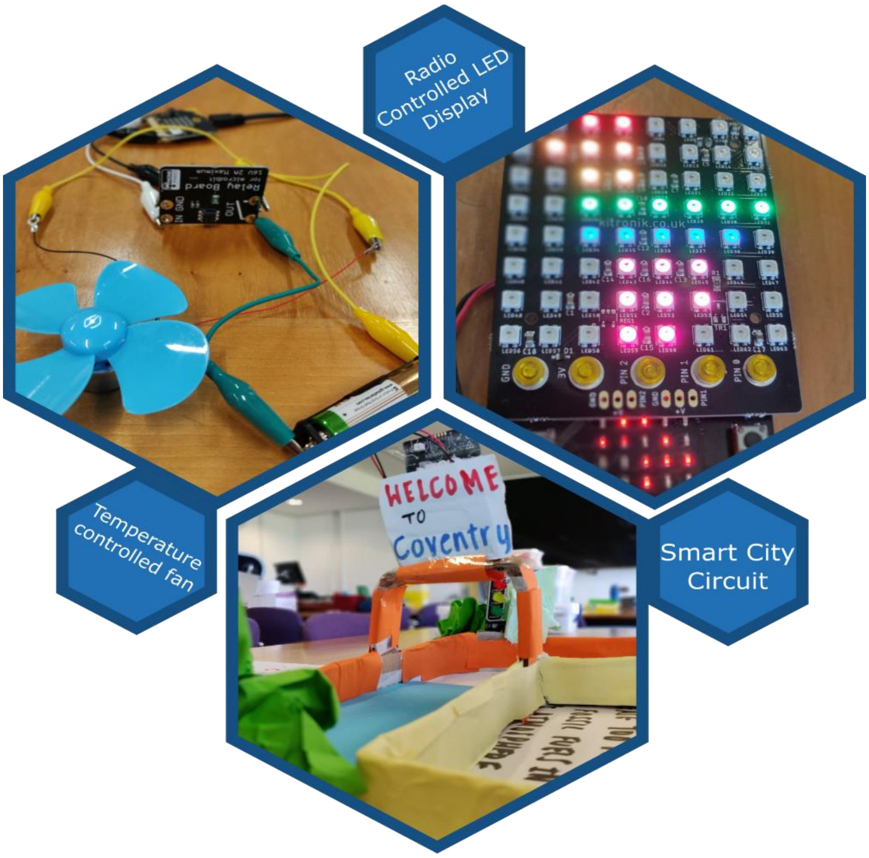


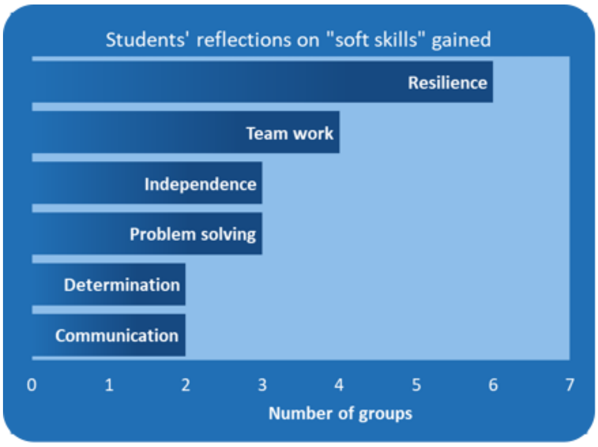
Figure 2: Examples of some of the students' creations

EVALUATION OF INTERVENTION / PRACTICE

A multi-faceted, though light touch, approach to evaluation was taken throughout this event. To gauge participants' subject knowledge and awareness of engineering, they were shown photos of local areas and asked to list the examples of engineering they could see. This was to encourage the students to ground any knowledge they acquired during the summer school in the real world and be more aware of how engineering affects their environment. No in-depth analysis of their responses has been undertaken: the activity was influenced by student ambassadors. However, it is important to note that participants were encouraged from the beginning to reflect on the context of their activities.

Students were encouraged at several points to make notes on their group flipchart of any skills they felt that they had practised and any new things they had learned. This was intended to be a self-reflective task for the students to help them realise how they had grown into the role of engineers and reinforce an engineering identity within them. This approach was taken to avoid formalising our intentions to improve the students' soft skills, given that students can be resistant towards soft skill courses (Pulko, 2003). Photographs of these flipcharts are available.

Recurring themes noted by the students were grouped and their frequencies counted (Figure 3). The data were reported on a group-by-group basis so these responses do reflect the full 42 students but are counted to a maximum of seven.



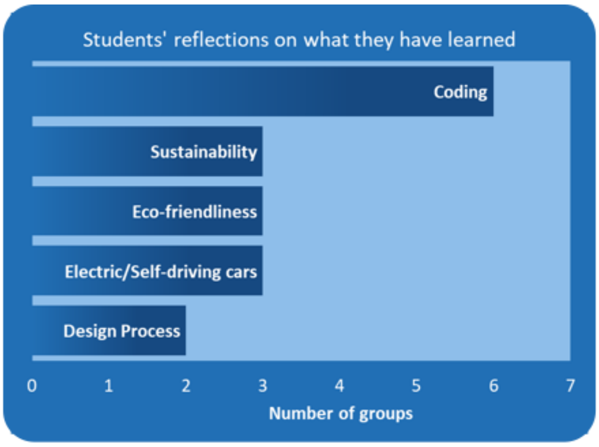


Figure 3: Self-reported reflections by the students on the outcomes of the project. Answers gathered into groups based on the reported frequency. Left: students asked what skills they had learned. Right: students asked what subject areas they learned about.

- ***Outcome 1: Young People Self-Report an Increase in Engineering-Related Skills.***

Self-reported data demonstrate that the experience encouraged students to think about resilience and team work. These skills are crucial to aspiring engineers (Royal Academy of Engineering, 2014), so their presence in these self-reported data suggest the balance of content-heavy activities with time to internalise the process was effective.

- ***Outcome 2: Increased Awareness of Current Engineering Research Areas.***

These responses demonstrate that the students have seen the context for WMG's research. Additionally, the process of designing and improving a product and advanced computer-related skills, such as coding, are crucial skills to modern engineers. These students were from the local area and as such they should feel some ownership over the local research efforts. We hope that the students will see a news item or an autonomous vehicle in the future and relate that item to their own engineering identity.

The student cohort has also been tracked following the event with the intention of inviting them back to the department for an engineering work experience programme. Subsequently the students have provided quotes reflecting on the event:

> *"No coding experience. Challenging trying to get it to work. Learnt how to do it. I feel like I could go home and code stuff."* **(Student)**

> *"Challenging bit, robots…* **(Student)**

Likewise, families and teachers appreciated the opportunity to attend the showcase event:

> *"…thanks so much for giving my [child] such a fantastic experience. [They have] talked about it constantly since [they] got home and it has made [them] more determined than ever to get the grades [they need] to get to University"* **(Parent)**

> *"…how lovely it was to see the students 'graduate' …afterwards, one of my student was explaining [their] robotic engineering and showed such determination to get the task completed."* **(Teacher)**

DISCUSSION

Having groups of six students meant that the groups could split and work on two things at once successfully. We feel that this group size is ideal and we will use it in all future iterations of the project.

Family and teacher responses that students have been talking about their project work implies that providing an opportunity for parents, guardians and teachers to see the creations of the students will facilitate conversations about STEM outside of the classroom in the future. This is one of the factors that increases science capital and therefore may increase the likelihood of these students considering STEM careers.

CONCLUSIONS & RECOMMENDATIONS

This was a successful pilot of a project-based programme of activities for year 10 students. Key findings include:

- A group size of six works well for these projects,
- Having the opportunity for parents, guardians and teachers to see the work the students have created is well-received by those families,
- Students engage when they are able to focus on an aspect of a wider problem that interests them.

A repeat of this event is scheduled for 2020, where a more formal evaluation procedure will be used throughout the event. It will follow the same structure as the data collection utilised here (*i.e.* students will be asked to reflect on the skills and content they have learned and the context that their new skills and knowledge will be useful in) but with a few modifications to account for likely sources of bias, *e.g.* student ambassadors suggesting answers in the 'Where is Engineering?' ice-breaker/knowledge test activity.

Additionally the approach will be expanded further into a full work experience programme, open to the same cohort of students featured in this paper, based around open-ended, mentor-supported group project work with links to active research at WMG.

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