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Education**

Report for Engineering UK

Qualitative evaluation of Tomorrow's Engineers 2012/13 – Executive Summary

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Background and evaluation rationale

The Tomorrow's Engineers (TE) programme delivers careers awareness through extra-curricular hands-on engineering activities that give young people in targeted schools, i.e. those who have not yet had the opportunity to take part in such a programme, the opportunity to undertake engineering activities and ask questions about what real-life engineering jobs entail. These are underpinned by curriculum-linked science, technology, engineering and mathematics (STEM) careers information and resources and an Ambassador engagement programme that helps reinforce careers learning and provides signposts to next steps in an engineering career.

The TE activities are delivered across three strands:

- **core** activities which are funded directly by EngineeringUK and the Royal Academy of Engineering
- **regional** activities which are funded by businesses and are delivered on a large scale
- **project** activities which are similar to regional activities but on a localised scale.

The 2012/13 qualitative evaluation was designed to build on the research conducted in 2011/12 and covered the following areas:

Engagement of schools and teachers

How do delivery partners engage with schools?

What motivates schools to engage with Tomorrow's Engineers?

What preparation is undertaken before the activity?

Content and delivery of the activities

What activities are being delivered?

How are activities designed to target specific groups?

What post-activity follow-up work is conducted?

How do the activities link to the curriculum?

Do activities draw on the support of Ambassadors and are schools planning to use Ambassadors to support follow-up activities?

To what extent do delivery partners share good practice?

Impacts on pupils

What is the impact of these activities on pupils?

Tomorrow's Engineers careers materials

How and when are careers materials being used at events?

What are the pupils' perceptions of the careers materials?

Effectiveness of activities

How effective are the activities?

What activities and/or messages most effectively engage and enthuse pupils regarding engineering?

Which activities effectively provide a modern image of engineering?

Eight different Tomorrow's Engineers activities, across nine schools, were selected for a detailed qualitative evaluation. The 2012/13 qualitative research involved: a combination of focus groups with pupils; in-depth interviews with teachers, delivery partners and STEM Ambassadors assisting with the activities; and detailed observations of the activities being delivered, in order to assess the content and method of delivery. The fieldwork was conducted between February and May 2013

Executive summary

Engagement of schools and teachers

Strategies for engagement

Delivery partners' frequent use of their existing school databases helped with the engagement of schools but there is limited evidence of active engagement of new and/or 'hard to reach'¹ schools in the Tomorrow's Engineers programme.

There was limited evidence to suggest that the majority of the delivery partners were actively trying to engage 'hard to reach' schools in the Tomorrow's Engineers programme. Delivery partners frequently reported using their own existing databases of schools with which they had previously worked on projects to provide a list of schools for them to engage in the Tomorrow's Engineers programme. This raises the potential risk that schools without previous, active involvement with STEM enhancement and enrichment (E&E) activities, and other 'hard to reach' schools, may not have been encouraged to engage in the Tomorrow's Engineers programme.

Awareness of the Tomorrow's Engineers programme amongst teachers remains low, a similar finding to the 2011/12 evaluation.

None of the teachers indicated that they had been aware of the Tomorrow's Engineers programme prior to the activities. Last year's evaluation, in 2011/12, identified a similar low level of awareness. However, during the activities awareness of the Tomorrow's Engineers programme was actively promoted by the Tomorrow's Engineers branding which was used at the majority of events.

Motivation for engaging in the Tomorrow's Engineers programme

Inspiring pupils about STEM subjects and enhancing the curriculum were the teachers' main motivations for engaging with the Tomorrow's Engineers programme in most schools.

Teachers' main motivation for engaging in the event was to inspire and excite the pupils' interest in STEM subjects (not just in engineering) and to enhance the curriculum. In one school it was hoped that the activities would inspire the pupils and lead to more of them taking STEM subjects at A-level. Some schools also hoped that Tomorrow's Engineers' activities would help enhance their pupils' transferable skills. However, in two of the case-study schools, engineering was the primary motivating factor for participating in the activities. Finally, Teachers in the two schools serving deprived areas reported that a key motivation for their engagement in the programme was because they expected that the Tomorrow's Engineers' activities would expand their pupils' horizons.

¹ For the purposes of this report, 'hard to reach' schools have been defined as those which are situated in socially deprived areas (the number of children on free school meals is used as a proxy indicator for this) and/or which have had little previous engagement with STEM E&E activities.

Increasing pupils' awareness of STEM careers and exposure to the real life applications of STEM subjects were also factors that motivated teachers to engage in the programme.

Several teachers and delivery partners indicated that an important rationale for engaging in the programme was the opportunity which the Tomorrow's Engineers activities provided for the pupils to learn more about STEM careers.

Teachers were also motivated to participate in the programme in order that the pupils would become more aware of the wider, real-life applications of what they were being taught in the classroom. One delivery partner perceived the very strong links with well-known STEM organisations to be an important factor in schools' decisions to engage in the programme.

Preparing for the Tomorrow's Engineers activities

There was a marked disparity of opinion regarding both the communications about the practical arrangements for, and the substantive content of, the Tomorrow's Engineers activities between; delivery partners who thought it was sufficient and teachers who thought it generally ineffective.

Teachers' views on the communications which they had with delivery partners prior to the Tomorrow's Engineers activities often contrasted with the views of the corresponding delivery partners.

Regarding the practical arrangements for the Tomorrow's Engineers activities, the majority of teachers reported that they had received little or no information about the event prior to it taking place. In a small number of schools, this perceived lack of communications led to some negative impacts such as problems with the IT equipment required by the activities. In contrast, all of the delivery partners considered that the information that they had supplied to schools about the practical arrangements, prior to the Tomorrow's Engineers activities, was sufficient. The majority of delivery partners explained that they had supplied the schools with detailed information about the necessary arrangements.

Regarding the substantive content of the Tomorrow's Engineers activities, the majority of the teachers perceived that delivery partners' communications were minimal. A small number of teachers also reported that if they had had more understanding of the content of the Tomorrow's Engineers activity they could have been more involved in the activities rather than just being there to manage behavioural issues amongst the pupils. In comparison, all of the delivery partners regarded the information that they supplied about the substantive content of the activities to be sufficient.

Content and delivery of activities

Activities delivered

Practical or hands-on activities were the most commonly used delivery methods amongst the delivery providers

All of the Tomorrow's Engineers activities, apart from one case study, included some practical or hands-on activity. The range of activities appeared to be broader and more varied than last year, with a greater inclusion of computer programming, robotics and software related activities. A range of other delivery methods were used to deliver Tomorrow's Engineers activities across all the case studies. These included:

- presentations
- design-based and problem-solving activities
- quizzes and games
- interactive discussions on aspects of engineering
- demonstrations.

The majority of activities emphasised developing transferable skills, such as team work, presentation, creative problem-solving skills and, in some cases, the importance of an understanding of the commercial aspects of engineering

The majority of the case-study activities emphasised and included an opportunity to develop wider, transferable skills, in addition to skills related to STEM. Six of the case-study activities involved a design or problem solving element and three of the delivery partners made explicit reference to the need for engineers to be creative and practical, an emphasis not observed last year. In addition, several case studies required pupils to develop an understanding of the commercial side of engineering.

A diverse range of engineering disciplines were portrayed during the events.

Tomorrow's Engineers' activities focused on a diverse range of engineering types and an even wider range were mentioned during discussion sessions. This evidence indicates that the activities introduced a wider variety of types of engineering than the previous year with no single type of engineering being the primary focus.

Targeting of activities

Tomorrow's Engineers' activities were frequently targeted at particular year groups or key stages and rarely tailored to the individual school or differentiated to take account of pupils with different needs.

The majority of the case-study activities were aimed at a particular year group or key stage and either whole year groups or whole classes attended; targeting of specific group of pupils (e.g. gender, ethnicity) was not a common feature. In most case studies, tailoring² the activities to the individual school or it's local environment was not common practice amongst

² Tailoring activities refers adapting the activity to meet needs of particular group of pupils and not delivering an already developed, standard package of materials.

delivery partners. There was little evidence that any of the activities had been planned so that pupils with different needs and abilities within the same classes or teams were catered for.

However, one event was restricted to girls as the delivery partner has a remit particularly to work with under-represented groups such as girls, pupils from ethnic minorities and pupils whose parents have not attended university.

Event preparation and follow-up

Teachers undertook a limited amount of preparation with pupils and delivery partners made minimal suggestions for preparatory activities.

In most case studies, there was little evidence that any preparation had been undertaken with the pupils, or that the delivery partner had suggested or expected this to have happened. Some delivery partners explained that they did not want to overburden teachers by suggesting any preparatory activities.

Follow-up activities of any kind were not generally planned and was further hindered by the fact that teachers attending the activities were often not those who taught participating pupils.

There was little evidence that follow-up work would occur in many schools. In several case studies, the teachers involved in the day were not those who taught the pupils and thus considered it would be difficult for any follow-up to take place. Very few delivery partners intended for there to be any follow-up.

Curriculum links

The majority of Tomorrow's Engineers activities were linked primarily to the science and mathematics curricula however the majority of teachers placed higher importance on the value of activities which enhanced the curriculum

The majority of the delivery partners and teachers reported that the Tomorrow's Engineers were linked to the science and mathematics, and sometimes technology school curricula. For some teachers, this link was important as they saw that it made the activities relevant for the pupils. However, not all delivery partners thought that curriculum links were important for teachers with one reporting that teachers were looking for events which went beyond the curriculum. The majority of teachers corroborated this view, stating that they did not see a curriculum link as being a priority for them. These teachers placed more value on the way that the activities extended and enhanced the pupils' understanding of science and mathematics. For most teachers another important aspect of the event was the way that the activities developed other transferable skills.

Engagement of STEM Ambassadors

Delivery partners experienced difficulties in engaging STEM Ambassadors with STEM Ambassadors present in only three case studies.

STEM Ambassadors were only present during three case-study activities. Several delivery partners reported that it was becoming more difficult to engage STEM Ambassadors for events and activities. Reason given for this were: that employees had less time to devote to these activities due to increased workloads resulting from staff cuts linked to the recession; and a shift in company priorities which was often due to organisational changes within a company or a company take-over or merger.

STEM Ambassadors are not uniformly equipped with the appropriate skills to effectively engage and work with the pupils at the Tomorrow's Engineers activities.

All delivery partners were asked how they draw upon the support of STEM Ambassadors and how they were prepared for their involvement in Tomorrow's Engineers activities. Delivery partners reported that STEM Ambassadors could be an asset to the day, but they were also cautious and careful to ensure that the Ambassadors were able to effectively engage and work with the pupils. Several delivery partners considered that more training was needed for STEM Ambassadors to help them engage with pupils more effectively.

Sharing good practice

Very few delivery partners share good practice or their experience of effective approaches but the majority of them welcomed the opportunity to do so.

Most delivery partners reported that they were not sharing their experience of effective approaches or good practice with other delivery partners. However the majority indicated they would welcome the opportunity to share good practice with others. A few who had reservations raised concerns about the competitive environment that the delivery partners were working in.

Impacts on pupils

Tomorrow's Engineers activities have led to an increase in pupils' enjoyment of and interest in engineering as well as a small increase in the number of pupils who expressed a wish to become an engineer

In the majority of case studies, pupils reported that participation in the Tomorrow's Engineers activities had led to an increase in their enjoyment of, and/or interest in, engineering. After the activities the pupils had a more positive view of engineering after the activities and were more inclined to describe engineering as fun, interesting and exciting and less inclined to consider it to be complicated and dirty/greasy and messy. A few pupils indicated that as a result of the day they would be more interested in becoming an engineer and others said that they were more interested in engineering generally, but not in becoming an engineer

Through engaging with the Tomorrow's Engineers activities the pupils have gained an increased awareness of different types of engineering and engineering careers, a broader understanding of the role of an engineer and the skills and qualifications required to be an engineer.

The greatest impact that the activities and events had on the pupils was to raise their awareness of the different types of engineering and engineering careers. Teachers and pupils commented that the activities had shown the pupils a range of types of engineering and possible careers. Pupils in all the case studies commented that the activities had given them a broader understanding of what an engineer does, and the skills needed to become an engineer. In particular, there was an increased awareness of the wider, transferable skills which were required.

In a few case studies, the pupils were more aware of the subjects that they would need to study to become engineers. Teachers made comments about how they hoped that the day would impact on the pupils' understanding of what an engineer does and the skills involved.

Participation in the Tomorrow's Engineers activities increased pupils' self-efficacy

A few teachers considered that an important impact of engaging in the activities was that their pupils' confidence, and general self-efficacy increased and that the pupils had a sense of achievement.

Tomorrow's Engineers careers materials

Use and availability of the careers materials

Tomorrow's Engineers careers materials were sometimes available during the event, but were not used as an integral part of the activities. Where they were distributed to teachers during the event, this was at the end of the day.

At a few activities the Tomorrow's Engineers careers materials (though not always the current 2013 pack) were available and pupils were to some extent encouraged to engage with them. For instance, in one case study the delivery partner had laid some Tomorrow's Engineers careers materials out on the activity tables in front of the pupils and, in spare moments, pupils looked through them and the delivery partner made reference to them during a careers talk. In another two case study areas, the careers materials themselves were not used but images from the materials and the Tomorrow's Engineers logo and web address featured on careers presentation slides.

Teachers' anticipated use of the careers materials

Overall, teachers had mixed views on the future usefulness of the careers materials in school.

A few teachers were very positive about using the Tomorrow's Engineers careers materials in the future; about half did not feel strongly that the materials would or would not be useful; and two teachers thought that careers materials in general were not a useful way to inspire young people to take up particular subjects or engineering. In terms of using the materials:

- Most teachers indicated that they would display the posters around their school.
- The leaflets were most likely to be passed on to the school's careers adviser or placed in the careers resource area.
- Several teachers found it difficult to identify a use for the postcards.

Pupils' and teachers' overall perceptions of the careers materials

Pupils and teachers were positive about the overall package of careers materials.

Pupils and teachers were generally positive about the careers materials as a package; pupils were particularly enthusiastic about the visual appeal of the materials. Pupils and teachers thought there was information of interest to both boys and girls and that the materials gave a modern image of engineering.

More specific perceptions about the individual components of the careers materials included:

- pupils found the postcards most useful and appealing, while teachers were most likely to use the themed posters in school.
- pupils and teachers were less enthusiastic about the routes poster and the leaflet.

Effective activities

General effectiveness

Most teachers felt that the activities had effectively engaged pupils.

The majority of the teachers reported that the activities had generally engaged all pupils. They considered that the activities had engaged girls equally as well as boys and also engaged pupils from a wide range of backgrounds and with different ability levels.

Aspects of the day that were reported to be less effective were often related to confusion over arrangements or lack of instructions.

Although the majority of the comments about the day were positive, some pupils and teachers highlighted aspects of the activities which were considered to be less effective at engaging the pupils. The pupils became less engaged when the instructions given during the activity were unclear. Lower levels of engagement also occurred when there were elements of the day which were perceived by the students to be not well planned or organised. For example in one school the pupils became disruptive because the activity was too complex for them. As the task was not appropriate for the pupils, the teachers and the facilitator had to spend time with each group in turn, resulting in other pupils being left with no constructive activity to undertake, which meant they became disengaged.

Activities which effectively engaged pupils

Activities which effectively engaged pupils were interactive, relevant, challenging and included an element of competition.

The activities which engaged the pupils most effectively were, in order of their effectiveness, those which:

- **involved an interactive element.** Many of the interactive activities which were effective at engaging the pupils were practical activities or design activities however not all the activities which effectively engaged the pupils were practical and hands-on activities. Other interactive activities included: interactive discussions, demonstrations and games and quizzes.
- **included an element of competition although the competition element had to be treated with caution.** Most of the events involved some element of competition which was effective in engaging the pupils. Although the inclusion of some competitive element can help engage pupils, it should be used with caution and should not be the main emphasis. The negative effects of competition were witnessed in one case study in which the pupils were unhappy with the day because they did not win the competition and this made them doubt the validity of their ideas.
- **were relevant to pupils.** Several delivery partners and teachers reported that activities which included some situation or product which was relevant to the pupils were effective at engaging the pupils.
- **challenged the pupils and opened up new horizons for them.** Activities which enabled the pupils to realise that they could achieve or do something which they had

not previously thought possible were also thought to effectively engage pupils, as did ones which challenged pupils to think about situations differently.

Activities which effectively provided a modern image of engineering

The use of role models and examples of engineering which pupils were likely to be aware of, but which were still unfamiliar, were effective ways of providing a modern image of engineering.

The use of role models was considered by a few teachers to be an effective way of presenting a modern image of engineering. The role models who were considered to be most effective were those who were similar to the pupils in terms of age and socio-economic status, people the pupils could identify with.

The use of examples of engineering which the pupils were likely to be aware of, but which were still novel and unfamiliar, was also considered to be an effective way of producing a modern image of engineering: for example 'Google glasses' and 3D printers.

Summary of effective practice

The case studies highlighted many examples of effective practice in the delivery of the Tomorrow's Engineers (TE) activities and these have been distilled and summarised in the figure below.

Tomorrow's Engineers Activities

Effective delivery of Tomorrow's Engineers activities occurred when:

- TE activities were interactive.
- competitive activities included positive reinforcement for all the groups and focused on how the pupil completed the activity rather than the winning of the competition.
- activities were adapted and tailored to the individual school context and group of pupils.
- consideration was given to how the activities could be differentiated; extended to challenge more able pupils or simplified so that less able were still engaged and learning from the activity.
- activities extended the school curriculum and the experience of the pupils.
- activities were novel, or significantly extended activities which had been used in schools previously.
- thought had been given to how the activities could develop transferable skills such as team work, presentation skills.
- presentations were short and concise and explicitly linked to the theme of the activity.
- STEM Ambassadors were people who the pupils could identify with, being similar to them in ages and social background.
- TE branding was displayed prominently.
- careers information activities were interactive.

Engaging Schools

Effective practice occurred when the delivery partner:

- looked beyond their existing databases, of schools they had previously engaged with, to engage schools who they had not previously engaged with
- cross referenced their database with that of the local STEMNET provider to highlight schools with low levels of engagement with STEM E&E
- updated its own database of schools to include the level of engagement with STEM E&E for future reference

Working with Schools

Effective practice occurred when the delivery partner:

- briefed schools fully about the TE activities.
- arranged face-to-face meetings with the teacher to discuss the TE activities in advance of the event.
- briefed teachers on the content of the TE activities.
- gave teachers guidance on the age group and ability level for which the TE activity was suitable.
- gave teachers comprehensive requirements regarding the practical arrangements for the day e.g. rooms, timings, equipment necessary and IT arrangements.
- made personal contact with the teacher prior to the event to ensure that all the instructions and guidance about the day had been received and understood.
- ensured that the person delivering the TE activity had made contact with the school prior to the day to discuss the activities.

Liaising with Schools

Effective practice occurred when the delivery partner liaised with the school to establish:

- the school context and history of engagement with STEM
- the ability of the pupils participating in the TE activities
- any adjustments which needed to be made to the TE activity on account of the pupils' or school's particular circumstances
- any curriculum links or other educational messages that the school was keen to emphasise through the TE activity.

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